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PURPOSE OF THIS BINDER

The purpose of this binder is to ensure easy and equal access to materials regarding trap checks for all members of the Trapping Advisory Committee. Tabs 2 and 3 are copies of a letter to Montana Fish, Wildlife & Parks authored by NRDC. Tab 2 is an exact copy of the original letter. Tab 3 is a reader-friendly version of the same letter, with footnotes and signatures omitted.

Tabs 4—21 contain the full versions of several articles and other sources that are cited in the letter. These sources are meant to facilitate and support discussion, and have also been provided in excerpted form in numerous smaller binders, also present October 6-7 meeting of the Trapping Advisory Committee. Should questions regarding the meaning and context of excerpts arise, this additional binder will be available. Complete versions of each article can also be made available to interested committee members upon request.

July 15, 2018

Montana Fish, Wildlife & Parks
Wildlife Division
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Re: Proposed 2018-2019 Furbearer and Trapping Regulations, Seasons and Quotas

Dear Montana Fish, Wildlife & Parks:

The undersigned organizations and individuals submit these comments in support of a 24-hour or daily trap inspection requirement for all restraining traps (including foothold traps and foot snares) and kill traps (including Conibear traps and neck snares)[1] set for all species in the state of Montana. Such a requirement is needed for several reasons.

First, Montana is one of only three states in the country with no general trap check requirement. The other two are North Dakota and Alaska.[2] Every other state that allows recreational trapping, as well as all three Canadian provinces that border Montana, require that traps and snares be regularly inspected.

Second, daily trap check requirements are common. Thirty-six states have adopted 24-hour or daily trap inspection requirements for at least some types of traps or trapping situations.[3] These include western states like Washington, California, Arizona, New Mexico, and Colorado.

Third, numerous scientific studies indicate that 24-hour or daily trap inspections would help reduce the severity of injuries inflicted on captured animals.[4] Long restraint time is associated with

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[1] G. Iossa, C. D. Soulsbury, and S. Harris, "Mammal Trapping: A Review of Animal Welfare Standards of Killing and Restraining Traps," *Animal Welfare*, Vo. 16, no. 3 (Aug 2007), pp. 335-352; G. Proulx et al., "Humaneness and Selectivity of Killing Neck Snares Used to Capture Canids in Canada: A Review," *Canadian Wildlife Biology and Management*, Vol. 4, no. 1, pp. 55-65 (2015).

[2] See Appendix.

[3] Id.

[4] See, e.g., Andelt, W. F., R. L. Phillips, R. H. Schmidt, and R. B. Gill. 1999. Trapping furbearers: an overview of the biological and social issues surrounding a public policy controversy. Wildlife Society Bulletin 27(1):53-64; Butterworth, A. (2017). Marine mammal welfare: Human induced change in the marine environment and its impacts on marine mammal welfare. Cham, Switzerland: Springer, p. 553; Cattet, M., J. Boulanger, G. Stenhouse, R. A. Powell, and M. J. Renolds-Hogland, An Evaluation of Long-term Capture Effects in Ursids: Implication for Wildlife Welfare and Research, Journal of Mammalogy, 89(4):973-990 (2008); Halstead, T. D., K. S. Gruver, R. L. Phillips,

increased exertion, struggling, injury, dehydration, starvation, effects of exposure (such as hypothermia and (for nocturnal animals) sunlight[5]), and capture myopathy (physiological imbalances following extreme struggle and stress).[6]

Fourth, requiring that traps be checked each day would also reduce injury to, and unintentional mortality of, "non-target" species. Between 2010 and 2014, for example, traps and snares in Montana unintentionally captured, injured, or killed at least 89 mountain lions, 12 black bears, three grizzly bears,* four wolves, 21 bobcats, 31 river otters, four wolverines,* three lynx,* three fishers,* nine deer, one elk, one pronghorn antelope, 5 raptors,* and ten badgers, among other species.[7, 8] These are just the reported incidents. Requiring traps to be checked frequently would increase the chances that these species would be released alive and less seriously injured.

Fifth, wildlife professionals support daily trap inspections. The Association of Fish and Wildlife Agencies (AFWA) Trapper Education Manual urges trappers to "make a commitment to check your traps at least once every day" in order to reduce suffering, more quickly release non-target animals, and actually improve success (by, for example, reducing the chance of predation on an animal caught in a trap).[9] Likewise, in its online trapping course, AFWA treats daily trap checks as a cornerstone of ethical trapping practice, and consistently instructs trappers to perform them.[10] In addition, AFWA used daily trap checks to develop its Best Management Practices ("BMPs") for trapping in the U.S.[11] Montana Fish, Wildlife & Parks ("FWP") promotes these BMPs on its website.[12] The National Trappers Association recognizes the significance of AFWA as one of the "largest international organizations representing professional wildlife conservation employees and governmental wildlife agencies."[13]

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and R. E. Johnson. 1995. Using telemetry equipment for monitoring traps and snares. Proceedings of the Great Plains Wildlife Damage Control Workshop 12:121-123; Welfare Outcomes of Leg-Hold Trap Use in Victoria. (2008). Nocturnal Wildlife Research Pty Ltd., p. 76; Zuardo, T. (2017). How the United States Was Able to Dodge International Reforms Designed to Make Wildlife Trapping Less Cruel. Journal of International Wildlife Law & Policy, 20(1), 73-95. doi:10.1080/13880292.2017.1315278.

[5] Nocturnal species that are trapped in Montana include bobcats, raccoons, beavers, muskrat, mink, marten, wolverine, and swift fox. See Foresman, K. R. (2012). *Mammals of Montana* (2nd ed.). Missoula, MT: Mountain Press Pub.

[6] See, e.g., M. Cattet et al., "An Evaluation of Long-Term Capture Effects in Ursids: Implications for Wildlife Welfare and Research," *Journal of Mammalogy* 89, no. 4 (Aug 2008); Proulx et al.

[7] See https://www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/sa_reports/sa_pdrs (last visited July 15, 2018); Montana Fish, Wildlife & Parks, Incidental Captures in Montana 2009-2014 License Years (provided Jan. 2016; latest data available).

[8] Those species with an asterisk (*) following their name are currently designated as "species of concern" in Montana. From records provided by Montana Fish, Wildlife & Parks, it is not clear which raptors were captured; multiple raptor species are designated as species of concern in the state.

[9] See Association of Fish and Wildlife Agencies, Trapper Education Manual, p. 97 (2005).

[10] See Association of Fish and Wildlife Agencies, North American Basic Trapper Course, Introduction, available at https://conservationlearning.org/ (last visited July 15, 2018).

[11] See Association of Fish and Wildlife Agencies, "Best Management Practices for Trapping in the United States: Introduction," (2006), p. 4.

[12] See http://fwp.mt.gov/hunting/trapping/ (last visited July 14, 2018).

[13] See http://www.nationaltrappers.com/trappingfacts.html (last visited July 15, 2018).

Further, in its guidelines for the use of wild animals in research, the American Society of Mammalogists states that most traps should be checked at least once a day,[14] and restraining traps like snares and foothold traps must be checked "twice daily or more often depending upon target species and potential for capture of non-target species."[15] The American Veterinary Medical Association opposes the use of conventional foothold traps and states that traps should be checked "at least once every 24 hours."[16]

Finally, in 2017, FWP itself recommended a mandatory trap-check interval:

> FWP should have a maximum time allowed legally between trap checks as a means of dealing with the occasional instance of negligence. Such a regulation would allow enforcement to pursue clear cases of negligence and would likely encourage reduced trap check intervals for some who currently check at "too long of an interval."[17]

In sum, in order to minimize stress, struggling, exertion, injury, and unnecessary mortality to target and non-target species, and in order to improve enforcement and discourage negligent trap check intervals, we respectfully request that FWP adopt a regulation requiring that all restraining and kill traps and snares set for all species in Montana be visually inspected at least once each day or every 24 hours.

Thank you for considering this request.

Sincerely,

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[14] See Sikes, R.S., W. L. Gannon, and the Animal Care and Use Committee of the American Society of Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research, Journal of Mammalogy, 92(1):235-253, 244.

[15] Id. at 242.

[16] See https://www.avma.org/KB/Policies/Pages/Trapping-and-Steel-jawed-Leghold-Traps.aspx (last visited July 15, 2018).

[17] See Montana Fish, Wildlife & Parks, "Public Comment Summary for June 2017 Trapping Proposal" available at http://fwp.mt.gov/doingBusiness/insideFwp/commission/meetings/agenda.html?coversheet&topicId=41849575 (last visited July 14, 2018).

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Appendix A: *Trap Check Requirements in the United States*

Table 1: General Trap Check Intervals by State for Live Sets*

	INTERVAL:	BY STATUTE/REGULATION:
ALABAMA	24 hours[1]	Ala. Code § 9-11-266
ALASKA	None	N/A
ARIZONA	Daily	Ariz. Admin. Code § 12-4-307(G)(1)
ARKANSAS	Daily	002-00-001 Ark. Code R. §17.02
CALIFORNIA	Daily	Cal. Code Regs. tit. 14, § 465.5(g)(2)
COLORADO	Daily[2]	Colo. Code Regs. § 406-3 #302(B)(2)
CONNECTICUT	24 hours	Conn. Gen. Stat. § 26-72
DELAWARE	24 hours[3]	Del. Code tit. 7, § 705
FLORIDA	24 hours	Fla. Admin. Code r. 68A-24.002(1)
GEORGIA	24 hours	Ga. Code § 27-3-63(a)(3)
HAWAII	No furbearer trapping	Haw. Admin. Code § 13-123-22
IDAHO	72 hours[4]	Idaho Admin. Code § 13.01.16.200.01
ILLINOIS	Daily	520 Ill. Comp. Stat. 5/2.33a
INDIANA	24 hours	Ind. Code § 14-22-6-4
IOWA	24 hours	Iowa Code § 481A.92
KANSAS	Daily	Kan. Admin. Regs. § 115-6-5(c)(13)
KENTUCKY	24 hours	Ky. Rev. Stat. § 150.410(2)
LOUISIANA	Daily	La. Rev. Stat. § 56:260(A)
MAINE	Daily	Me. Rev. Stat. tit. 12, § 12255(1)
MARYLAND	Daily[5]	Md. Code Regs. 08.03.06.03(E)
MASSACHUSETTS	Daily	321 Mass. Code Regs. 3.02(e)(11)
MICHIGAN	Daily[6]	Mich. Wildlife Conservation Order § 3.600(12)(a)
MINNESOTA	Daily	Minn. R. 6234.2200
MISSISSIPPI	36 hours	Miss. Code Ann. § 49-7-13(4)(d)
MISSOURI	Daily	Mo. Code Regs. tit. 3, § 10-8.510(2)
MONTANA	None	N/A
NEBRASKA	Daily	163 Neb. Admin. Code § 4-001.03A1
NEVADA	96 hours[7]	Nev. Admin. Code § 503.570(3)
NEW HAMPSHIRE	Daily	N.H. Rev. Stat. § 210:13
NEW JERSEY	24 hours	N.J. Admin. Code § 7:25-5.12(i)
NEW MEXICO	Daily	N.M. Code R. § 19.32.2.11(A)
NEW YORK	24 hours[8]	N.Y. Comp. Codes R. & Regs. tit. 6, § 6.3(a)(3)
NORTH CAROLINA	Daily	15A N.C. Admin. Code 10B.0110
NORTH DAKOTA	None	N/A
OHIO	Daily	Ohio Admin. Code 1501:31-15-09(G)
OKLAHOMA	24 hours	Okla. Stat. tit. 29, §5-502(C)
OREGON	48 hours[9]	Or. Rev. Stat. § 498.172(1)
PENNSYLVANIA	36 hours	34 Pa. Cons. Stat. § 2361(a)(10)

RHODE ISLAND	24 hours	20 R.I. Gen. Laws § 20-16-9
SOUTH CAROLINA	Daily	S.C. Code § 50-11-2440
SOUTH DAKOTA	72 hours[10]	S.D. Admin. R. 41:08:02:03
TENNESSEE	36 hours	Tenn. Fish and Wildlife Comm. Proclamation 18-05, § III (9)
TEXAS	36 hours	31 Tex. Admin. Code § 65.375(c)(2)(E)
UTAH	48 hours	Utah Admin. Code r. 657-11-9(12)
VERMONT	Daily	Vt. Admin. Code 16-4-137:4.1
VIRGINIA	Daily	4 Va. Admin. Code § 15-40-195
WASHINGTON	24 hours	Wash. Admin. Code § 220-417-030(4)(c)
WEST VIRGINIA	Daily	W. Va. Code R. § 58-53-3.3
WISCONSIN	Daily	Wis. Admin. Code NR § 10.13(2)
WYOMING	72 hours[11]	040-0001-4 Wyo. Code R. § 9(a)

* “Live sets” are traps or snares intended to capture the animal alive.

Table 2: General Trap Check Intervals by State for Kill Sets**

	INTERVAL:	**BY STATUTE/REGULATION:**
ALABAMA	24 hours[1]	Ala. Code § 9-11-266
ALASKA	None	N/A
ARIZONA	Daily	Ariz. Admin. Code § 12-4-307(G)(1)
ARKANSAS	72 hours	002-00-001 Ark. Code R. §17.02
CALIFORNIA	Daily	Cal. Code Regs. tit. 14, § 465.5(g)(2)
COLORADO	Daily[2]	Colo. Code Regs. § 406-3 #302(B)(2)
CONNECTICUT	24 hours	Conn. Gen. Stat. § 26-72
DELAWARE	24 hours[3]	Del. Code tit. 7, § 705
FLORIDA	24 hours[12]	Fla. Admin. Code r. 68A-24.002(1)
GEORGIA	24 hours	Ga. Code § 27-3-63(a)(3)
HAWAII	No furbearer trapping	Haw. Admin. Code § 13-123-22
IDAHO	72 hours[4]	Idaho Admin. Code § 13.01.16.200.01
ILLINOIS	Daily	520 Ill. Comp. Stat. 5/2.33a
INDIANA	24 hours	Ind. Code § 14-22-6-4
IOWA	24 hours[13]	Iowa Code § 481A.92
KANSAS	Daily	Kan. Admin. Regs. § 115-6-5(c)(13)
KENTUCKY	24 hours	Ky. Rev. Stat. § 150.410(2)
LOUISIANA	Daily	La. Rev. Stat. § 56:260
MAINE	Daily[14]	Me. Rev. Stat. tit. 12, § 12255(1)
MARYLAND	Daily[5]	Md. Code Regs. 08.03.06.03(E)
MASSACHUSETTS	Daily	321 Mass. Code Regs. 3.02(e)(11)
MICHIGAN	None	Mich. Wildlife Conservation Order § 3.600(12)(a)
MINNESOTA	Every three days	Minn. R. 6234.2200
MISSISSIPPI	36 hours	Miss. Code Ann. § 49-7-13(4)(d)
MISSOURI	48 hours	Mo. Code Regs. tit. 3, § 10-8.510(2)
MONTANA	None	N/A
NEBRASKA	Every two days	163 Neb. Admin. Code § 4-001.03A1
NEVADA	96 hours[7]	Nev. Admin. Code § 503.152
NEW HAMPSHIRE	Daily[15]	N.H. Rev. Stat. § 210:13
NEW JERSEY	24 hours	N.J. Admin. Code § 7:25-5.12(i)
NEW MEXICO	Daily	N.M. Code R. § 19.32.2.11(A)
NEW YORK	24 hours[8]	N.Y. Comp. Codes R. & Regs. tit. 6, § 6.3(a)(3)
NORTH CAROLINA	Daily[16]	15A N.C. Admin. Code 10B.0110
NORTH DAKOTA	None	N/A
OHIO	Daily	Ohio Admin. Code 1501:31-15-09(G)
OKLAHOMA	24 hours	Okla. Stat. tit. 29, §5-502(C)
OREGON	48 hours[9]	Or. Rev. Stat. § 498.172
PENNSYLVANIA	36 hours	34 Pa. Cons. Stat. § 2361(a)(10)
RHODE ISLAND	24 hours	20 R.I. Gen. Laws § 20-16-9

SOUTH CAROLINA	Daily[17]	S.C. CODE § 50-11-2440
SOUTH DAKOTA	72 hours[10]	S.D. ADMIN. R. 41:08:02:03
TENNESSEE	72 hours	Tenn. Fish and Wildlife Comm. Proclamation 18-05, § III (9)
TEXAS	36 hours	31 TEX. ADMIN. CODE § 65.375(c)(2)(E)
UTAH	96 hours[18]	UTAH ADMIN. CODE R. 657-11-9(12)(a)–(c)
VERMONT	Daily[13]	Vt. Admin. Code 16-4-137:4.1
VIRGINIA	Daily[19]	4 VA. ADMIN. CODE § 15-40-195
WASHINGTON	72 hours	WASH. ADMIN. CODE § 220-417-030(4)(c)
WEST VIRGINIA	Daily	W. VA. CODE R. § 58-53-3.3
WISCONSIN	Daily	WIS. ADMIN. CODE NR § 10.13(3)(a)
WYOMING	Weekly[11]	040-0001-4 WYO. CODE R. § 9(a)

** “Kill sets” are traps or snares intended to kill the animal instantly or by asphyxiation or drowning.

Table 3: Survey of Trap Check Requirements in the United States

The number of states which have adopted:

24-hour or daily check requirements for at least some traps	**36**
48-hour (or more frequent) check requirements for at least some traps	**44**
72-hour (or more frequent) check requirements for at least some traps	**47**
24-hour or daily check requirements for *all* traps	**16**
48-hour (or more frequent) check requirements for *all* traps	**25**
72-hour (or more frequent) check requirements for *all* traps	**30**
check requirements for *all* traps	**33**
***no* general check requirements**	**3**

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[1] 72 hours for water sets.

[2] Most sets are constitutionally prohibited in Colorado. See COLO. CONST. art. XVIII, § 12b. An exemption from the constitutional prohibition and the normal trap check requirements is granted to persons on their own land primarily used for commercial agriculture, to protect that agriculture. See id.; COLO. REV. STAT. § 33-6-207.

[3] Muskrat traps exempted.

[4] "Unprotected rodents" exempted; in effect, all rodents except for beavers. *Compare* IDAHO ADMIN. CODE § 13.01.16.010.01 *with id.* § 13.01.16.010.03 (definitions of "furbearing animals" and "unprotected wildlife").

[5] Every two days for water sets.

[6] Except: 1) in Michigan's Upper Peninsula ("Zone 1"), where the interval is 48 hours; and 2) for licensed trappers using multi-animal cage sets, for whom there is no requirement. *See* Mich. Wildlife Conservation Order § 1.2(21) – (23) for the definitions of Zones 1, 2, and 3.

[7] Generally, some units require an interval of every other day for some sets.

[8] 48 hours for some wildlife management units ("WMU"), 48 hours for some sets in other WMUs.

[9] Predator trapping exempted, though must still be checked "on a regular basis."

[10] 96 hours if west of the Missouri River.

[11] Snares and quick-kill body traps exempted. These must be checked once each calendar week except for the first week in which the trap was set.

[12] Only snares allowed.

[13] Drowning sets exempted.

[14] Drowning sets every three days, or every five days in unincorporated/unorganized areas; sets under ice set for beaver or muskrat exempted.

[15] Except sets for beaver under ice, then every three days.

[16] Except for drowning set Conibears, then 72 hours.

[17] 48 hours for drowning sets.

[18] Except for lethal snares without a relaxing lock or stop set to an immovable object, which have a 96 hour requirement.

[19] Drowning set Conibears exempted.

Re: Proposed 2018-2019 Furbearer and Trapping Regulations, Seasons and Quotas

[COPY of LETTER without Footnotes or Signatures]

Dear Montana Fish, Wildlife & Parks:

The undersigned organizations and individuals submit these comments in support of a 24-hour or daily trap inspection requirement for all restraining traps (including foothold traps and foot snares) and kill traps (including Conibear traps and neck snares) set for all species in the state of Montana. Such a requirement is needed for several reasons.

First, Montana is one of only three states in the country with no general trap check requirement. The other two are North Dakota and Alaska. Every other state that allows recreational trapping, as well as all three Canadian provinces that border Montana, require that traps and snares be regularly inspected.

Second, daily trap check requirements are common. Thirty-six states have adopted 24-hour or daily trap inspection requirements for at least some types of traps or trapping situations. These include western states like Washington, California, Arizona, New Mexico, and Colorado.

Third, numerous scientific studies indicate that 24-hour or daily trap inspections would help reduce the severity of injuries inflicted on captured animals. Long restraint time is associated with increased exertion, struggling, injury, dehydration, starvation, effects of exposure (such as hypothermia and (for nocturnal animals) sunlight), and capture myopathy (physiological imbalances following extreme struggle and stress).

Fourth, requiring that traps be checked each day would also reduce injury to, and unintentional mortality of, “non-target” species. Between 2010 and 2014, for example, traps and snares in Montana unintentionally captured, injured, or killed at least 89 mountain lions, 12 black bears, three grizzly bears, four wolves, 21 bobcats, 31 river otters, four wolverines, three lynx, three fishers, nine deer, one elk, one pronghorn antelope, 5 raptors, and ten badgers, among other species. These are just the reported incidents. Requiring traps to be checked frequently would increase the chances that these species would be released alive and less seriously injured.

Fifth, wildlife professionals support daily trap inspections. The Association of Fish and Wildlife Agencies (AFWA) Trapper Education Manual urges trappers to “make a commitment to check your traps at least once every day” in order to reduce suffering, more quickly release non-target animals, and actually improve success (by, for example, reducing the chance of predation on an animal caught in a trap). Likewise, in its online trapping course, AFWA treats daily trap checks as a cornerstone of ethical trapping practice, and consistently instructs trappers to perform them. In addition, AFWA used daily trap checks to develop its Best Management Practices (“BMPs”) for trapping in the U.S. Montana Fish, Wildlife & Parks (“FWP”) promotes these BMPs on its website. The National Trappers Association recognizes the significance of AFWA as one of the "largest international organizations representing professional wildlife conservation employees and governmental wildlife agencies."

Further, in its guidelines for the use of wild animals in research, the American Society of Mammologists states that most traps should be checked at least once a day, and restraining traps like snares and foothold traps must be checked "twice daily or more often depending upon target species and potential for capture of non-target species." The American Veterinary Medical Association opposes the use of conventional foothold traps and states that traps should be checked "at least once every 24 hours."

Finally, in 2017, FWP itself recommended a mandatory trap-check interval:

> FWP should have a maximum time allowed legally between trap checks as a means of dealing with the occasional instance of negligence. Such a regulation would allow enforcement to pursue clear cases of negligence and would likely encourage reduced trap check intervals for some who currently check at "too long of an interval."

In sum, in order to minimize stress, struggling, exertion, injury, and unnecessary mortality to target and non-target species, and in order to improve enforcement and discourage negligent trap check intervals, we respectfully request that FWP adopt a regulation requiring that all restraining and kill traps and snares set for all species in Montana be visually inspected at least once each day or every 24 hours.

Thank you for considering this request. Sincerely,

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Mammal trapping: a review of animal welfare standards of killing and restraining traps

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Abstract

Millions of wild mammals are trapped annually for fur, pest control and wildlife management. Ensuring the welfare of trapped individuals can only be achieved by trapping methods that meet accepted standards of animal welfare. At the international level, the assessment of mechanical properties of killing and restraining traps is set out in two documents published by the International Organization for Standardization (ISO). Few traps currently in use have been tested according to the ISO standards and, in addition, new traps have been designed and old traps modified since the publication of the standards. In this paper we review trapping methods used in Europe and North America to see whether they meet the ISO standards and examine ways to improve the welfare performance of traps. In addition, international legislation is assessed to determine whether this ensures a sufficient level of welfare for trapped animals. Finally, trapping practices used in academic research are reviewed. We conclude that many of the practices commonly used to trap mammals cannot be considered humane. Current legislation fails to ensure an acceptable level of welfare for a large number of captured animals. New welfare standards for trapping wild mammals need to be established so that in future a minimum level of welfare is guaranteed for all trapped individuals.

Keywords: *animal welfare, international legislation, ISO standards, mammals, trapping standards, trap types*

Introduction

Historically, mammals were trapped mainly for fur and meat, but in recent times trapping has also been used as a management tool to resolve human-wildlife conflicts, for wildlife research and for conservation purposes. Worldwide, tens of millions of mammals each year are trapped legally. In the USA alone, up to two million muskrats (*Ondatra zibethicus*) are trapped every year (Fox 2004a). Additionally, an unknown number of animals are trapped illegally and, moreover, for every target animal captured, a varying number of non-target animals are injured or killed.

There are two basic types of traps: killing traps are used on land or underwater and render an animal unconscious within a certain time prior to death, whereas restraining traps hold the individual until contact is made by the trapper. The level of welfare of trapped animals (hereafter welfare performance) varies according to the type of trap. For instance, leg-hold traps are banned in 80 countries (Fox 2004a), including the European Union (The Council of European Communities 1991), because of their impacts on animal welfare.

Opposition of animal welfare groups in Europe and North America to trapping for fur culminated in the first effort by the International Organization for Standardization (ISO) to define humane international standards for killing and restraining traps (Harrop 2000; Princen 2004). However, no consensus could be reached on key thresholds for animal welfare standards, eg time to unconsciousness for animals trapped in killing traps, or levels of injuries for animals captured in restraining traps. Despite this, two documents were produced by the ISO to provide an agreed process for testing trap performance (safety and capture efficiency) and killing effectiveness for killing traps (ISO 10990-4 1999), and trap performance and trauma levels for physical injuries caused by restraining traps (ISO 10990-5 1999). Although the ISO standards do not offer any definition of acceptable standards of animal welfare, they are an initial step towards ensuring and improving welfare of wild mammals (Harrop 2000). The results collated from the tests as set by the ISO can, in fact, be interpreted in terms of the impact on animal welfare and the level of impact on animal welfare can, in turn, be used to make a decision on whether a trap falls below or above a threshold of acceptable standards of animal welfare. When the killing trap standards were published, the technical committee drafting the standards recommended a review of killing methods after five years so that all technical advancements could be incorporated. Similarly, for restraining traps it was recognised that physical injury represents only one component of welfare, and that the lack of data on other components such as behaviour, physiology, immunology and molecular biology prevented their use in welfare assessments. The technical committee advocated, therefore, that in future all these components of animal welfare should be integrated to provide a more comprehensive measure of welfare. Thus, the aim of this paper is two-fold. First, we review trapping methods of wild mammals in Europe and North America, assessing accepted standards of welfare and welfare performance of traps and taking into account the evaluation of trap devices as set by the ISO standards. Throughout this paper we review the extent to which the ISO standards provide a process for evaluating accepted standards of animal welfare *at present*, rather than when they were initially developed. We suggest ways to improve the welfare performance of traps that are currently used and examine the existing legislation on trapping and welfare of captured animals. Mason and Littin (2003) have already investigated the humaneness of control methods applied to rodents, so this review does not include rodent species. Whilst trappers and wildlife officers have discussed at length the implication of these regulations on the way trapping is carried out (eg Schmidt & Bruner 1981; Bluett 2001; British Association for Shooting & Conservation 2002), as yet there has been very little debate as to how standards for the welfare of trapped animals compare with other animal welfare standards. Thus we also compare welfare standards for trapped wild animals with other welfare standards such as those set for the slaughter of farm animals, shooting and bowhunting. Secondly, we analyse standards for trapping animals used in scientific research, as defined by guidelines published by leading scientific journals in the fields of zoology, behaviour and animal welfare.

Killing traps

Types of killing traps

There are five main categories of killing traps in use: deadfall traps, spring traps, snares, drowning traps and pitfall traps (Federation of Field Sports Associations of the European Union [FACE] 1998; Proulx 1999a; Powell & Proulx 2003). Deadfall traps use gravity to kill an animal by crushing its skull, vertebral column or other vital organs. There are two types of spring traps; one has spring-powered bars that kill an animal by crushing a vital region of the body, generally the neck; the other has rotating jaws which have two hinged metal frames that allow a torsion spring to rotate the frames in a scissor-like action (Garrett 1999; Powell & Proulx 2003). There are two kinds of killing snares: in self-locking snares an animal pulls against the snare, tightening it until asphyxiation occurs, as apposed to stopped and free-running snares which restrain the animal (see the section on restraining traps). Power snares similarly kill by asphyxiation, but use powerful springs to tighten the noose quickly. Drowning traps restrain an animal underwater, and kill by hypoxia-induced death. Finally, less commonly used traps include pitfall traps with water at the bottom, to drown small rodents (Proulx 1999a).

Assessing welfare performance of killing traps

Killing traps are widely used to catch a range of species, ranging in size from rodents to lynx. Here we analyse methods commonly utilised to kill furbearers and mammals other than rodents. The ability to kill an individual effectively depends on species, size, trap type and also, to great extent, trapper skill. In order to evaluate welfare performance of killing traps, we used four welfare measures: time to unconsciousness, the likelihood of escape of injured animals, the percentage of mis-strikes and selectivity. In the next section we focus on only the first three and analyse selectivity later. In laboratory conditions, killing methods approved as humane are those that minimise the time between the application of the killing procedure and the onset of unconsciousness (eg Beaver *et al* 2001). In field conditions however, the fast-acting killing methods used in laboratory settings (eg stunning, cervical dislocation, carbon dioxide) are not always feasible and the period of consciousness and thus, the potential for poor welfare, can last longer.

The welfare performance of killing traps in current use

Table 1 lists trap models which have been tested against accepted standards of animal welfare. Effectively, there is no research on trap welfare performance for most of the European species apart from the stoat (*Mustela erminea*) and muskrat. *M. erminea* is known as stoat in Eurasia and as short-tailed weasel in North America. Despite being the same species, the two populations differ in bodyweight and traps suitable for short-tailed weasels are unsuitable for stoats (Warburton *et al* 2002). As shown in Table 1, most of the tests were undertaken on North American species and the criteria for acceptability of a trap require 70% of animals tested to be unconscious within 60 seconds (stoat), 120 seconds (American pine marten [*Martes americana*], Canadian lynx [*Lynx canadensis*] and fisher [*Martes pennanti*]) and 180 seconds (all others) (Powell & Proulx 2003).

Two further parameters that are likely to have a significant impact on trap welfare performance, are the likelihood of escape of injured animals and the percentage of mis-strikes. However, data on these two parameters are scarce. Amongst the traps passing the welfare performance tests in Table 1, mis-strike varied between 0-10%. Data available for other species suggest that both parameters vary greatly according to trap type, species and, probably, trap setting. In neck snares set for coyote (*Canis latrans*) mis-strikes varied from 8 to 14%; of these the percentage of animals still alive in the traps varied from 17 to 86% and escapes varied from 3 to 13% (Phillips 1996). In spring traps set for red foxes (*Vulpes vulpes*) and stone martens (*Martes foina*) mis-strikes equalled 15 and 13% respectively (Pohlmeyer *et al* 1995). Few studies report the number of animals escaping from killing traps; about 50% of American martens escaped from snares set for snowshoe hares (Proulx *et al* 1994a), whilst in possums (*Trichosurus vulpecula*) escapes varied from 0 to 6% depending on the type of spring trap (Miller 1993; Warburton & Orchard 1996). The welfare of escaped (injured) animals is of concern; moreover, if an escaped animal is likely to become trap-shy, this is undesirable from a trapper's perspective.

To improve welfare performance of killing traps, the time lapse between the killing device being triggered and the onset of unconsciousness of the caught animal should be minimised. The vast majority of traps currently in use were

Table 1 Accepted standards of animal welfare for killing traps.

Species	Trap model	Mis-strike	Time limits to unconsciousness					Reference
			Current technology	n	Criterion	Pass	Fail	
Canis latrans	King necksnare[1]	-	> 180 s	-	180 s		×	Garrett 1999; Proulx 1999a
	Mosher necksnare[1]	-	> 180 s	-	180 s		×	
*Canis lupus**	-	-	-	-	180 s	-	-	
*Castor canadensis**	Conibear 330™	-	> 180 s	6	180 s		×	Novak 1981a
	Modified Conibear 330™	-	< 180 s	6	180 s	×		
Lontra canadensis	-	-	-	-	180 s	-	-	
Lynx rufus	-	-	-	-	180 s	-	-	
Lynx canadensis	Conibear 330™	1	> 180 s	9	180 s		×	Proulx *et al* 1995
	Modified Conibear 330™	1	67.2 ± 4.0 s	9	180 s	×		
Martes americana	Conibear 120™	3	> 180 s	6	120 s		×	Barrett *et al* 1989; Proulx *et al* 1989a,b
	Conibear 120 Magnum™	2	68 ± 8.2 s	14	120 s		×	
	Conibear 160™	3	> 180 s	16	120 s	×		
	Sauvageau 2001-5™	-	> 180 s	14	120 s		×	
Martes pennanti	Bionic[2]	0	< 55 s	9	180 s	×		Proulx & Barrett 1993a,b; Proulx 1999b
	Conibear 220™	-	> 180 s	4	180 s		×	
	Modified Conibear 220™	0	> 180 s	4	180 s		×	
*Ondatra zibethicus**	Leprich spring trap	0	31.5 ± 16.3 s	12	180 s	×		Inglis *et al* 2001
	Conibear 110™	3	184.0 ± 31.7 s[3]	12	180 s		×	
*Procyon lotor**	Conibear 160™	-	> 180 s	5	180 s		×	Novak 1981a; Proulx & Drescher 1994; Sabean & Mills 1994
	Conibear 280™	0	> 180 s	6	180 s		×	
	Conibear 330™	5	> 180 s	5	180 s		×	
	Sauvageau 2001-8™	0	> 180 s	3	180 s		×	
Taxidea taxus	-	-	-	-	180 s	-	-	
Castor fiber	-	-	-	-	180 s	-	-	
Lutra lutra	-	-	-	-	180 s	-	-	
Lynx lynx	-	-	-	-	180 s	-	-	
Martes martes	-	-	-	-	120 s	-	-	
Martes zibellina	-	-	-	-	120 s	-	-	
Meles meles	-	-	-	-	180 s	-	-	
Mustela erminea[4]*	Fenn Mk IV	-	> 180 s	-	60 s		×	Warburton *et al* 2002; Poutu & Warburton 2003; Warburton & O'Connor 2004
	Fenn Mk VI	-	> 180 s	-	60 s		×	
	Victor Snapback[5]	1	37.3 ± 5.0 s	7	60 s		×	
	Waddington backcracker	4	113 s	8	60 s		×	
Nyctereutes procyonoides	-	-	-	-	180 s	-	-	

Mis-strike refers to the number of animals struck in a non-target body part; time limits to unconsciousness refer to loss of corneal and palpebral reflexes; n is the number of animals tested.

Most of the tests were conducted in North America under the criteria that ≥ 70% of animals should be unconscious in ≤ 60, 120 or 180 seconds (eg Proulx 1999a; review in Powell & Proulx 2003). This is therefore used to assess passes and failures. The line divides North American from European species.

* Species found in both continents; [1] the trap failed because of high number of mis-strikes; [2] not tested in the field: in a different experiment 2/10 animals escaped and 1/10 mis-strike; [3] time to loss of heartbeat; [4] see main text for stoat; [5] the trap failed because of high number of escapes.

developed by trappers and so trap performance reflects the need to obtain undamaged pelts, with welfare of trapped animals being a secondary issue or one that was not even considered (Garrett 1999; Fox & Papouchis 2004a). However, recent research in New Zealand and Australia (eg see Littin *et al* 2004) has started incorporating animal welfare into trap development and, in our opinion, this should become common practice.

To assess the welfare performance of killing traps it has been suggested that trap performance should be evaluated following the ISO guidelines. Killing traps are tested in a laboratory environment on anaesthetised animals as well as in a compound designed to simulate field settings. However, time to loss of consciousness of anaesthetised animals is shorter than for unanaesthetised animals (Hiltz & Roy 2001). In artificial compounds animals are usually enticed to the trap through a channel to ensure strike precision (eg Inglis *et al* 2001). However, in the field, animals behave in unpredictable ways and all too often traps that deliver quick and effective kills in artificial compounds fail in the field

Table 2 Trauma scales developed by various authors; numbers represent scores given to each injury.

	van Ballenberghe (1984)	Tullar (1984)	Olsen *et al* (1988)	Onderka *et al* (1990)	Hubert *et al* (1996)	Phillips (1996)
Oedematous swelling and/or haemorrhage	Class 1	5	-	1-5	1-5	5-15
Avulsed nail	-	-	-	-	5	-
Cutaneous laceration ≤ 2 cm long	Class 2 (< 2.5 cm)	5	5	5	5	3
Cutaneous laceration > 2 cm long	Class 3 (> 2.5 cm)	10	10	10	10	10
Permanent tooth fracture exposing pulp cavity	-	-	-	-	10	-
Subcutaneous muscle laceration or maceration	Class 3	-	-	10-20	10-20	10-30
Tendon or ligament maceration with partial severance	Class 3	20	20	20-40	20-40	25
Damage to periosteum	-	-	-	-	30	10-30
Partial fracture of metacarpi or metatarsi	Class 4	-	-	30	30	-
Fracture of digits	Class 4	-	-	30-40	30-50	-
Joint subluxation	Class 4	30	30	-	100	-
Joint luxation	-	50	50	50	50	30-100
Luxation at elbow or hock	-	-	-	200-300	200	-
Compression fracture above or below carpus or tarsus	-	-	30	-	-	100
Simple fracture below carpus or tarsus	Class 3	50	100	100	100	100
Simple fracture above carpus or tarsus	Class 4	50	50	50	50	50
Damage or severance of tensons below carpus or tarsus	Class 4	-	-	50	20-50	-
Major laceration on footpads	-	-	-	-	-	30
Amputation of digit(s)	-	150	50-200	30-40	30-50	25-100
Compound fracture below carpus or tarsus	-	100	-	75	75	100
Compound fracture above carpus or tarsus	-	200	200	200	200	100
Amputation of limb	-	400	400	400	400	100

(eg Proulx *et al* 1989a, 1995; Proulx & Barrett 1990). These difficulties bring into question the usefulness of ISO standards for testing killing trap performance.

Drowning traps

Submersion or drowning traps are mainly used to kill semi-aquatic species, mostly muskrat and American mink (*Mustela vison*) in Europe and North American beaver (*Castor canadensis*) and river otter (*Lontra canadensis*), amongst others, in North America. Some of these species show physiological adaptations to aquatic life such as slower heart rates (bradycardia), and therefore can dive for prolonged periods. For instance, the Eurasian otter (*Lutra lutra*) dives for up to 22 minutes (Conroy & Jenkins 1986), the muskrat for 12-17 minutes (Inglis *et al* 2001) and the North American beaver for 15 minutes (Irving & Orr 1935). Death by drowning-induced hypoxia is a slow process for these species and even after struggling, which consumes oxygen more quickly, electroencephalogram loss occurs after an average of 4 minutes for the muskrat, and 9 minutes for the beaver (Gilbert & Gofton 1982). The animals show an indicator of distress because they struggle to get to the surface (Gilbert & Gofton 1982). Moreover, death by drowning-induced hypoxia is not considered an acceptable method of euthanasia by veterinary and laboratory researchers (Close *et al* 1996; Beaver *et al* 2001) and does not meet the presently accepted standards for killing traps (Ludders *et al* 1999).

Table 3 Trauma scale developed by ISO Technical Committee 191.

Pathological observation	Score
Mild trauma	
1) Claw loss	2 points
2) Oedematous swelling or haemorrhage	5 points
3) Minor cutaneous laceration	5 points[1]
4) Minor subcutaneous soft tissue maceration or erosion	10 points
5) Major cutaneous laceration, except on footpads or tongue	10 points
6) Minor periosteal abrasion	10 points
Moderate trauma	
7) Severance of minor tendon or ligament	25 points
8) Amputation of 1 digit	25 points
9) Permanent tooth fracture exposing pulp cavity	30 points
10) Major subcutaneous soft tissue laceration or erosion	30 points
11) Major laceration on footpads or tongues	30 points
12) Severe joint haemorrhage	30 points
13) Joint luxation at or below the carpus or tarsus	30 points
14) Major periosteal abrasion	30 points
15) Simple rib fracture	30 points
16) Eye lacerations	30 points
17) Minor skeletal degeneration	30 points
Moderately severe trauma	
18) Simple fracture at or below the carpus or tarsus	50 points
19) Compression fracture	50 points
20) Comminuted rib fracture	50 points
21) Amputation of two digits	50 points
22) Major skeletal degeneration	50 points
23) Limb ischaemia	50 points
Severe trauma	
24) Amputation of three or more digits	100 points
25) Any fracture or joint luxation on limb above the carpus or tarsus	100 points
26) Any amputation above the digits	100 points
27) Spinal cord injury	100 points
28) Severe internal organ damage (internal bleeding)	100 points
29) Compound or comminuted fracture at or below the carpus or tarsus	100 points
30) Severance of a major tendon or ligament	100 points
31) Compound or rib fractures	100 points
32) Ocular injury resulting in blindness of an eye	100 points
33) Myocardial degeneration	100 points
34) Death	100 points

The terms and definitions are taken from ISO 10990-5: 1999 Animal (mammal traps) – Part 5: Methods for testing restraining traps, Annex C, C.1 Trauma scale (www.iso.org), and are reproduced with the permission of the International Organization for Standardization, ISO. Copyright ISO.

[1] maximum 15.

Restraining traps

Types of restraining traps

Five kinds of restraining traps are widely used: stopped neck snares, leg-hold snares, leg-hold traps, box or cage traps and pitfall traps (FACE 1998; Proulx 1999a; Powell & Proulx 2003). Neck snares are made of a wire loop set vertically, so the head of the animal enters the wire loop, which then tightens around the neck of the animal. In snares set for restraint, a stop prevents the noose closing below a certain diameter, thereby preventing asphyxiation. Within Europe, neck snares must be stopped or free-running to prevent strangulation (FACE 1998). Leg-hold snares are used extensively to capture animals in scientific studies. Leg-hold snares are also made of a wire loop, but placed horizontally and designed to close upon the animal's leg(s) to restrain it

Table 4 The percentage categories of injuries caused by neck snares, leg-hold snares and box traps.

Species	Sample size	Trap type	No injuries	Minor injuries	Major injuries	Mortality	Reference
Bassiriscus astutus	8	Box trap	75%	25%	-	0%	IAFWA 2003
Canis latrans	22	Box trap	83%	17%	-	0%	Way *et al* 2002
Didelphis virginiana	-	Box trap	61%	39%	-	-	IAFWA 2000
Gulo gulo	12	Box trap	100%	-	-	0%	Copeland *et al* 1995
Lynx canadensis	89	Box trap	100%	-	-	0%	Kolbe *et al* 2003
Lynx canadensis	19	Box trap	68%	32%	-	0%	Mowat *et al* 1994
Meles meles	5964	Box trap	88%	10%	2%	0%	Woodroffe *et al* 2005*
Panthera pardus	18	Box trap	-	39%	-	-	Frank *et al* 2003
Procyon lotor	-	Box trap	52%	43%	5%	-	IAFWA 2000
Urocyon cinereoargenteus	16	Box trap	13%	87%	-	0%	IAFWA 2003
Ursus americanus	25	Box trap	92%	8%	-	0%	Reagan *et al* 2002
Vulpes velox	125	Box trap	88%	12%	-	0%	Moehrenschlager *et al* 2003
Canis latrans	20	Leg-hold snare	5%	-	-	-	Onderka *et al* 1990
Canis latrans	-	Leg-hold snare	-	83%	9%	-	IAFWA 2003
Canis latrans	23	Leg-hold snare	-	60%	40%	0%	Shivik *et al* 2000*
Canis latrans	38	Leg-hold snare	6%	25%	69%	0%	Shivik *et al* 2000*
Canis familiaris, Vulpes vulpes	117	Leg-hold snare	55%	41%	4%	3%	Fleming *et al* 1998
Lynx canadensis	-	Leg-hold snare	-	80%	-	-	IAFWA 2003
Lynx canadensis	201	Leg-hold snare	48%	46%	6%	> 1%	Mowat *et al* 1994
Lynx rufus	-	Leg-hold snare	-	100%	-	-	IAFWA 2003
Panthera leo	27	Leg-hold snare	-	100%	-	0%	Frank *et al* 2003
Panthera tigris	19	Leg-hold snare	-	91%	9%	0%	Goodrich *et al* 2001
Procyon lotor	49	Leg-hold snare	82%	16%	2%	-	Novak 1981b
Puma concolor	209	Leg-hold snare	15%	83%	2%	1%	Logan *et al* 1999
Ursus americanus	340	Leg-hold snare	-	97%	3%	-	Powell 2005
Ursus americanus	37	Leg-hold snare	70%	30%	-	0%	Reagan *et al* 2002
Vulpes vulpes	-	Leg-hold snare	-	76%	5%	-	IAFWA 2003
Vulpes vulpes	117	Leg-hold snare	80%	14%	6%	0%	Englund 1982
Vulpes vulpes	81	Leg-hold snare	69%	31%	-	-	Novak 1981b
Canis latrans	51	Neck snare	-	-	2%	2%	Pruss *et al* 2002
Canis latrans	-	Neck snare	-	-	-	16%	Nellis 1968
Canis latrans	24	Neck snare	17%	53%	30%	4%	Shivik *et al* 2000*
Castor canadensis	132	Neck snare	-	-	-	5%	McKinstry & Anderson 1998

Major injuries include mortality; where given by the authors mortality is presented separately.
* Studies that used the trauma scale published by ISO (Table 4).

(Powell & Proulx 2003). In both cases, snares are usually anchored.

Leg-hold traps may be padded or unpadded. Leg-hold traps have two jaws that open to 180° when set, and clamp together to hold an animal's foot or leg when triggered. The trap is attached to the ground or an anchor by a chain or cable. The anchor restrains the animal by snagging on surrounding vegetation.

Box traps are constructed from a wide variety of materials including plastics, wire mesh and wood (Meyer 1991; Proulx 1999a) and all work on the same principle. An animal enters the trap through an opening attracted by bait, and triggers a device (eg treadle) that causes the door to close and lock. Box traps vary in size, and their design depends primarily on the target species (Powell & Proulx 2003).

Table 5 The pattern of injuries caused by leg-hold traps.

Species	Sample size	Trap type	No injuries	Minor injuries	Major injuries	Mortality	Study
Procyon lotor	62	EGG trap	8%	56%	36%	-	Hubert *et al* 1996
Lontra canadensis	155	leg-hold	-	44%	56%	-	Tocidlowski *et al* 2000
Canis lupus	116	offset jaws leg-hold	-	65%	35%	-	Kuehn *et al* 1986
Canis lupus	129	offset jaws leg-hold	-	72%	28%	-	Kuehn *et al* 1986
Canis lupus	40	offset jaws leg-hold	-	100%	-	-	Kuehn *et al* 1986
Canis latrans	31	padded leg-hold	-	84%	16%	-	Olsen *et al* 1988
Canis lupus	48	padded leg-hold	-	-	48%	-	van Ballenberghe 1984
Canis familiaris	313	padded leg-hold	-	89%	11%	-	Fleming *et al* 1998
Canis familiaris	280	padded leg-hold	-	82%	18%	-	Fleming *et al* 1998
Lontra canadensis	87	padded leg-hold	16%	58%	26%	-	Serfass *et al* 1996
Lutra lutra	43	padded leg-hold	-	86%	14%	9%	Fernández-Morán *et al* 2002
Lynx canadensis	39	padded leg-hold	63%	8%	29%	-	Kolbe *et al* 2003
Lynx canadensis	23	padded leg-hold	34%	26%	40%	-	Mowat *et al* 1994
Lynx rufus	31	padded leg-hold	-	77%	23%	-	Olsen *et al* 1988
Procyon lotor	100	padded leg-hold	-	52%	48%	-	Olsen *et al* 1988
Urocyon cinereoargenteus	27	padded leg-hold	-	67%	33%	-	Olsen *et al* 1988
Vulpes vulpes	30	padded leg-hold	-	93%	7%	-	Olsen *et al* 1988
Vulpes vulpes	19	padded leg-hold	-	79%	21%	-	Meek *et al* 1995
Vulpes vulpes	28	padded leg-hold	36%	21%	43%	-	Englund 1982
Vulpes vulpes	91	padded leg-hold	53%	43%	4%	-	Travaini *et al* 1996
Alopex lagopus	155	unpadded leg-hold	41%	64%	23%	10%	Proulx *et al* 1994b
Canis latrans	36	unpadded leg-hold	-	47%	53%	-	Olsen *et al* 1988
Canis lupus	269	unpadded leg-hold	-	65%	35%	-	Kuehn *et al* 1986
Canis familiaris	73	unpadded leg-hold	-	69%	32%	5.5%	Fleming *et al* 1998
Canis familiaris	20	unpadded leg-hold	-	90%	10%	-	Fleming *et al* 1998
Lynx canadensis	12	unpadded leg-hold	23%	42%	25%	-	Kolbe *et al* 2003
Lynx rufus	47	unpadded leg-hold	-	79%	21%	-	Olsen *et al* 1988
Didelphis virginiana	15	unpadded leg-hold	67%	13%	20%	-	Berchielli & Tullar 1980
Mephitis mephitis	30	unpadded leg-hold	40%	10%	50%	-	Novak 1981b
Procyon lotor	17	unpadded leg-hold	41%	24%	6%	-	Berchielli & Tullar 1980
Procyon lotor	22	unpadded leg-hold	50%	27%	23%	-	Novak 1981b
Procyon lotor	40	unpadded leg-hold	2%	24%	74%	-	Hubert *et al* 1996
Procyon lotor	133	unpadded leg-hold	-	30%	70%	-	Olsen *et al* 1988
Urocyon cinereoargenteus	13	unpadded leg-hold	46%	54%	-	-	Berchielli & Tullar 1980
Urocyon cinereoargenteus	38	unpadded leg-hold	-	39%	61%	-	Olsen *et al* 1988
Vulpes vulpes	22	unpadded leg-hold	23%	45%	32%	-	Novak1981b
Vulpes vulpes	15	unpadded leg-hold	20%	67%	13%	-	Berchielli & Tullar 1980
Vulpes vulpes	48	unpadded leg-hold	-	63%	37%	-	Olsen *et al* 1988
Vulpes vulpes	115	unpadded leg-hold	61%	9%	30%	-	Englund 1982

Many studies do not combine whole body scores, but assess limb and oral injuries separately (eg Kuehn *et al* 1986); only limb scores are given in this table. When scoring, most researchers do not specify the number of animals with no injuries, which are usually pooled with animals with no or slight injuries.

Table 6 Selectivity (number of non-target animals relative to total captures), mortality and injury caused to non-target species in various types of traps.

Trap type	Target species	Non-target species	Selectivity	Mortality	Injury	Reference
Killing traps						
Drowning trap	*Ondatra zibethicus*	*Anas platyrhynchos, Rattus* spp*, Mustela erminea*	1.44-7.40%[1]	-	-	Crasson 1996
Spring trap in tunnels	*Mustela erminea, M. nivalis, M. vison*	*Alectoris rufus, Erinaceus europaeus, Oryctolagus cuniculus, Mustela putorius*	5%	100%[2]	-	Short & Reynolds 2001
Tunnel traps/snare	-	*Mustela putorius*	-	61%	39%	Birks & Kitchener 1999
Spring trap	*Trichosurus* spp	*Erinaceus europaeus, Mustela putorius, Rattus* spp	23%	50%	50%	Warburton & Orchard 1996
Leg-hold snare/coil spring trap	*Oryctolagus cuniculus, Vulpes vulpes*	*Lynx pardinus*	-	64%	22.5%	García-Perea 2000
Neck snare	*Canis latrans*	*Odocoileus hemionus, O. virginianus, Bos taurus*	21%	33-63%	-	Phillips 1996
Neck snare	*Lepus americanus*	*Martes americana*	50%	0%	0%	Proulx *et al* 1994a
Rotating jaw-trap	*Martes americana*	*Perisoreus canadensis, Glaucomys sabrinus*	43%	100%	-	Naylor & Novak 1994
Rotating jaw trap	*Martes americana*	*Corvus brachyrhynchos, Rattus* spp*, Felis catus*	30%	-	-	Proulx & Barrett 1993a
Restraining traps						
Box trap	*Felis silvestris, Lynx lynx*	*Meles meles, Ursus arctos*	64%	0%	0%	Potočnik *et al* 2002
Box trap	*Canis familiaris*	*Corvus brachyrhynchos, Felis catus, Procyon lotor, Mephitis mephitis*	93%	-	-	Way *et al* 2002
Box trap	*Martes pennanti*	*Martes americana, Gulo gulo, Vulpes vulpes*	94%	1%	-	Weir 1997
Leg-hold snare	*Panthera leo*	*Hyaena hyaena, Crocuta crocuta, Acinonyx jubatus*	32%	0%	17%	Frank *et al* 2003
Leg-hold snare	*Puma concolor*	*Odocoileus hemionus, Canis latrans, Bos taurus*	45%	17%	-	Logan *et al* 1999
Neck snare	*Vulpes vulpes*	*Canis familiaris, Felis catus, F. sylvestris, Meles meles, Martes martes, Lutra lutra, Lepus europaeus*	46%	-	-	Chadwick *et al* 1997

[1] The relative % of injured and dead animals is not known. [2] Mortality and injury combined.

Table 7 Trapping statistics (annual captures) from Canada (Statistics Canada 2004), Europe (FACE 1998), Russia (Dronova & Shestakov 2005) and USA (Fox 2004b) for the 19 mammal species included in the Agreement (Anonymous 1998a).

Species	Canada	Europe	Russia	United States
Canis latrans	55,500	-	-	110,000
Canis lupus	2,700	-	300*	1,200
Castor canadensis	260,000	300	-	300,000
Castor fiber	-	1,500	-	-
Lontra canadensis	19,000	-	-	25,000
Lutra lutra	-	-	2,000	-
Lynx canadensis	11,300	-	-	2,700
Lynx lynx	-	-	180*	-
Lynx rufus	2,100	-	-	27,000
Martes americana	120,000	-	-	14,000
Martes martes	-	45,000	-	-
Martes pennanti	23,500	-	-	8,300
Martes zibellina	-	-	250,000	-
Meles meles	-	43,000	-	-
Mustela erminea	30,000	27,200	105,000	14,000[1]
Nyctereutes procyonoides	-	90,000	4,100*	-
Ondatra zibethicus	290,000	700,000	1,100,000	2,000,000
Procyon lotor	72,000	7,000	-	2,100,000
Taxidea taxus	490	-	-	17,000
Total	886,590	914,000	1,461,580	4,619,200

Estimates from Europe include animals caught in both killing and restraining traps. Data from Canada and Russia do not include methods of capture. Russian statistics are official harvests and do not represent animals taken illegally which may be > 150% of the official harvest (Dronova & Shestakov 2005). * Data from Russian Far-east only; [1] data include *Mustela frenata* and *M. erminea*.

Pitfall traps are predominantly used to capture small terrestrial mammals such as shrews. The pitfall trap is a smooth-sided container, usually > 40 cm deep and between 20-40 cm in diameter. These can be unbaited or animals can be attracted to the trap by bait or by using barriers to force animals into the pit.

Assessing welfare performance of restraining traps

The purpose of a restraining trap is to hold the animal unharmed and with minimum stress until the trap is checked. The animal can then be despatched or released. There are two principle considerations when assessing welfare performance of restraining traps: mortality of trapped animals (target and non-target species) and injuries suffered by restrained individuals. To compare traps directly, a quantitative approach is needed, and several studies over the last couple of decades have used injury scales to assess welfare performance (Table 2). Most injury-scoring systems correspond to a detailed evaluation of pathological changes. However, some studies examine only specific body areas rather than the whole body, and this may affect the assessment of welfare performance (eg van Ballenberghe 1984; Onderka *et al* 1990).

Since the first injury scales were developed, the number of injury classes has increased from 12 to more than 15. Each study has added injury classes or altered scoring and this makes both the direct comparison of the standards of traps and the repeatability of studies difficult (Engeman *et al* 1997). In 1999, the ISO developed a standardised method for assessing welfare performance of restraining traps (ISO 10990-5 1999; Table 3). This improves on earlier injury scales in three ways: it has a larger number of categories, incorporating examination of all body areas including areas previously not covered (eg ocular injuries); it advocates examination of injuries by veterinary pathologists; and as an overall international standard for assessing restraining traps, it allows better comparative assessment of welfare performance. The ISO trauma scale constitutes a significant step towards improving assessment of trap welfare performance, though few studies have utilised it (Table 4).

Currently there are few objective criteria for interpreting the impact of injuries to animals, and so human-based scales are used to assess the importance of injuries (Kirkwood *et al* 1994). Regardless of the scoring system, injuries that have the potential to reduce survival of released animals always receive a high score, typically in excess of 50 points (Tables 2 and 3). In this respect, they have much in common with trauma scales used to assess life-threatening human injuries (Greenspan *et al* 1985). However, while these scales assess injury, they do not incorporate variables such as pain. Human trauma scales only examine the life-threatening nature of the injury (Greenspan *et al* 1985); separate scales exist to assess pain (Turk & Melzack 1992). Thus, while broken teeth receive relatively low trauma scores

(Tables 2 and 3), orofacial pain is some of the most intense and excruciating, rating highly on pain scales in humans (Tandon *et al* 2003).

Assessing injuries is a method that allows a quantitative assessment of trap performance to be made. Assessments can be made for those animals that are caught and killed or caught and released. However, there are reservations about how injuries can be directly related to welfare. Currently, injury-based trauma scales are the best available method (Proulx 1999a), but in our opinion different approaches are needed to assess accepted welfare standards. These should incorporate a) the individual animal and context (species, size, age, sex, season), b) location(s) of the wound(s), c) the nature and pain associated with the injuries, and most importantly if being released, d) the long-term survival and fecundity of the individual and the impacts of removal of animals from the population (such as those on dependants). As has already been shown in Rüppel's fox (*Vulpes rueppellii*), the majority of individuals received low injury scores when caught in padded leg-hold traps, yet subsequent survivorship was significantly reduced, possibly due to predation caused by temporary limping (Seddon *et al* 1999). Damage caused by the pressure of neck snares on tissue may take days to appear, often after individuals are released; such tissue necrosis can lead to death of the individual (Stocker 2005). For carnivores broken teeth have been linked to the inability to catch wild prey and increased livestock predation (Patterson *et al* 2003). Even such factors as claw loss may impact on subsequent ability to catch prey. Future assessment of trap performance must include an assessment of the longer-term impact on the individuals after release. Any negative impacts on survival or fecundity would have serious implications for the validity of many scientific studies and/or the post-release survival of non-target species.

Physical injury and pain comprise only one facet of the distress associated with trapping. Anxiety caused by confinement and physical exertion related to struggling will also affect the welfare of the animal (Marks *et al* 2004). When prolonged, this distress can have a deleterious effect on an animal's health and subsequent survival (Moberg 1999). As a consequence, an important, but often overlooked component of trap welfare performance involves assessing the physiological changes caused by trapping. There are three physiological responses to the psychological stress of being trapped, the pain of any injuries and exertion from struggling against or within the trap (Warburton *et al* 1999). Stress and pain of capture cause significant changes in hormones, enzymes and electrolytes, as well as muscle pH. Trapped animals have increased levels of serum cortisol (Hamilton & Weeks 1985; Kreeger *et al* 1990; White *et al* 1991; Cross *et al* 1999; Warburton *et al* 1999; Inglis *et al* 2001), indicating a stress response to being trapped. During the initial moments of capture, animals have increased activity as they struggle and move around (White *et al* 1991; Inglis *et al* 2001). This causes increased heart rate and body temperature (Kreeger *et al* 1990; White *et al* 1991; Inglis *et al* 2001). For scientists, this affects handling techniques. Individuals with higher body temperatures require larger dosages of anaesthetic (Cattet *et al* 2003; McLaren *et al* 2005). Increased activity causes a physiological response and may even cause long-term muscle damage (Duncan *et al* 1994); typically, enzymes and metabolites such as creatine kinase and circulating phosphate increase in the blood of trapped animals as a result of physical activity (Kreeger *et al* 1990; Hubert *et al* 1996; Huber *et al* 1997; Warburton *et al* 1999; Cattet *et al* 2003). Whilst it can be seen that many studies have examined the physiological changes caused by particular types and/or makes of traps, there is a need for more comparative studies between the principal trapping methods.

The welfare performance of restraining traps in current use

Trap-based injuries are rarely reported in scientific papers and, as such, this makes it hard both to improve and to compare trapping techniques. To assess welfare performance of restraining traps two factors must be considered: the nature and severity of injuries suffered by target and non-target species and the long-term impact on survival and fecundity for an individual (Kirkwood *et al* 1994; Littin *et al* 2004).

Neck snares are widely used both for pest control and fur trapping, but are less commonly used for scientific studies. Few studies have evaluated the humaneness of neck snares in the same way as has been done for leg-hold snares, leg-hold traps and box traps (eg Sala *et al* 1993; Lovari *et al* 1994; Lucherini & Lovari 1996). Those that do apparently pool categories of wounds or fail to provide information on numbers of individuals with no or minor injuries (van Ballenberghe 1984; McKinstry & Anderson 1998; Pruss *et al* 2002). When set correctly, serious injuries are purported to be relatively uncommon, though mortality of trapped individuals is higher than with both leg-hold snares and box traps (Table 4). One further difficulty in assessing welfare standards of neck and leg-hold snares stems from certain insidious injuries manifesting themselves days after the release of an individual. Pressure from the wire ligature can damage cellular structures, which can in turn lead to necrosis of tissues (pressure necrosis) and ultimately death in the days following release (Stocker 2005). Great concern also arises from the incorrect setting of neck snares (National Federation of Badger Groups 2002). While training and codes of practice are freely available (British Association for Shooting & Conservation 2002), deliberate setting of non-stopped snares where they are illegal, snares set where they may catch protected species or where animals may kill themselves, and snares not checked daily, are common (MacNally 1992; National Federation of Badger Groups 2002). In the UK, neck snares are the commonest form of restraining trap because they are cheap and require minimum effort to set and maintain. Reports of misuse are frequent; despite this, there are no quantified data on the level of use/misuse of snares (Department for Environment Food and Rural Affairs [Defra] 2005; League

Against Cruel Sports 2005). Even when neck snares are set and utilised correctly, they commonly catch non-target species and these can have high mortality (see later section) (Phillips 1996; Chadwick *et al* 1997; Defra 2005). Modification of neck snares may increase target specificity and reduce capture of non-target species (Pruss *et al* 2002; Luengos Vidal *et al* 2003), but overall the lack of data on the use of snares makes it difficult to assess their welfare impact.

In comparison to neck snares, the effectiveness and welfare performance of leg-hold snares is more commonly reported in the scientific literature (Table 4). In general, leg-hold snares appear to have an acceptable effect on welfare, with little target species mortality (Table 4). However, the same cannot be said for non-target species, which may experience high mortality (see later section). One further problem arises from foot swelling; several studies highlight that most individuals have a swollen foot caused by the noose, yet do not classify these as serious (Logan *et al* 1999; Frank *et al* 2003). Since snares may cause subsequent pressure necrosis, and even temporary limping may have a negative impact on an individual, further work is needed to examine the long-term welfare impact of leg-hold snares.

Leg-hold traps are considered inhumane and banned within the EU and 80 countries worldwide (Fox 2004a); nonetheless, they are a common capture device in North America and Canada. Across the literature, the majority of studies show a significant percentage of trapped individuals suffering major injuries (Table 5). If the criterion used is that 80% of individuals have nothing more than minor injuries (Anonymous 1998a), it is clear that both padded and unpadded leg-hold traps fail in this respect. Comparative studies have shown that padded leg-hold traps cause fewer injuries than unpadded leg-hold traps, but at the same time different studies on the same species have found contrasting welfare performance results (Table 5). For example, welfare performance of leg-hold traps for red foxes has been assessed extensively in different locations around the world, yet red foxes have very different bodyweights in different locations. Since smaller body size may increase the levels of injuries sustained using the same leg-hold traps (Seddon *et al* 1999), location differences of trap tests may confound results (International Association of Fish and Wildlife Agencies [IAFWA] 2003). In addition, the many different kinds of leg-hold traps (padded, unpadded, off-set jaws, double jaws, various sizes, different numbers of springs) and contrasting methods of assessing injuries make true comparisons difficult (Engeman *et al* 1997). What is clear is that 28/38 studies on leg-hold traps (Table 5) fall outside currently accepted standards of welfare (eg Proulx 1999a; Powell & Proulx 2003). Physiological studies demonstrate that they are more stressful than other capture techniques (Kreeger *et al* 1990; White *et al* 1991; Cross *et al* 1999; Warburton *et al* 1999), can have poor capture specificity (Table 6), and can reduce long-term survivorship of released individuals (Seddon *et al* 1999). Leg-hold traps are clearly not the most humane capture technique, yet where legal, for example in many states in the USA, they are widely used for a range of species (Fox & Papouchis 2004b).

Box and cage traps are one of the most widely used trapping techniques. Animals captured in these traps appear to undergo fewer traumas than those captured in snares and leg-hold traps (Table 4) (Powell & Proulx 2003). Significantly, if checked regularly and used correctly, mortality rates approach zero (Table 4). Wounds appear to be less severe, with most injuries confined to skin abrasions and broken teeth, often reduced by improved trap design and reduced mesh size (Short *et al* 2002; Powell & Proulx 2003). Box traps can capture a range of species, but unlike other trap methods, non-target species are typically released unharmed, the only distress experienced generally being that of restraint (Table 4). On the other hand, for large species, box traps can be bulky to transport and not practical to use in remote areas.

To date, there have been few comparative studies examining the physiological response to snares and box traps, other than a study comparing darting and leg-hold snares when capturing free-ranging brown bears (*Ursus arctos*) (Cattet *et al* 2003). Most studies compare physiological responses between leg-hold traps and box traps. The majority show that box traps are less stressful than leg-hold traps. Box traps caused an increase in cortisol compared to untrapped individuals (White *et al* 1991), but this was lower than individuals caught in leg-hold traps (Kreeger *et al* 1990; White *et al* 1991; Cross *et al* 1999; Warburton *et al* 1999). Significantly this was not related to injuries and therefore pain (Warburton *et al* 1999). Both box traps and leg-hold traps caused an increase in body temperature, heart rate and some blood metabolites, associated with increased activity, but box traps showed lower values than leg-hold traps, indicating lower physical activity when trapped (White *et al* 1991; Warburton *et al* 1999). Thus, box traps seem the most favourable option because the number of injuries is lowest and physiologically box traps appear to be the least stressful.

Trap selectivity

An important side-effect of both killing and restraining traps is selectivity, usually measured as the number of individuals of the target species caught relative to the number of non-target animals. It is evident from Table 6 that selectivity varies widely with trap type. However, whilst with killing traps all or the majority of non-target individuals captured are killed, restraining traps vary in mortality rates from 0% in box traps to 17% in leg-hold snares (Logan *et al* 1999; Potočnik *et al* 2002). It has long been recognised that non-target captures can be very high in comparison to target captures (eg it has been noted previously that the number of non-target to target animals can vary from 0-18.1) depending on trapping device used, season, bait and the way in which the trap is set in the field (Novak 1987; Proulx *et al* 1993). The capture of non-target individuals can also pose a serious threat to species of conservation concern. For instance, studies on museum specimens and necropsies of golden eagle (*Aquila chrysaeotos*), bald eagle (*Haliaeetus* *leucocephalus*) and Iberian lynx (*Lynx pardinus*) showed 42, 14 and 64% respectively died as a result of trapping or because of injuries caused by trapping (Bortolotti 1984; García-Perea 2000). However, not all mortality is immediately apparent at the time of the capture. For example, post-traumatic stress of capture can cause subsequent cardiac myopathy in ungulates (Putman 1995); moreover, post-release pressure necrosis may affect non-target species captured in snares (Stocker 2005). Guidelines to avoid capture of non-target species are available from organisations such as the British Association for Shooting and Conservation (2002), Defra (2005) and IAFWA (2006).

Making killing and restraining traps more humane

The development of higher welfare performance of traps should be a priority. Recently, much research has been devoted to testing the animal welfare impacts (reviews in Powell & Proulx 2003; Warburton & O'Connor 2004) and efficiency of killing traps (Pawlina & Proulx 1999), and integrating ethics and animal welfare in trapping research (IAFWA 1997; Broom 1999; Powell & Proulx 2003; Fox & Papouchis 2004a). In contrast, much less effort has been devoted to excluding non-target species from killing traps (Short & Reynolds 2001; Reynolds *et al* 2004).

Most of the killing traps currently in use fall below accepted standards of welfare (see next section on the Agreement), or may be effective when tested in compounds and ineffective in the field (Powell & Proulx 2003; Fox & Papouchis 2004b; Warburton & O'Connor 2004). Technical improvements may improve efficiency of some killing traps (Proulx & Barrett 1993a; Proulx *et al* 1995; Warburton & Hall 1995; Warburton *et al* 2000). For instance, improving strike precision of spring traps to target the neck and avoid back strikes can reduce the impact force needed to kill quickly (Nutman *et al* 1998; Warburton *et al* 2002). Increasing strike power is of concern for user safety but both strike precision and mechanical advances can avoid the use of increased power. Rotating-jaw traps can be further enhanced by offsetting the trap jaws (Zelin *et al* 1983) without the need to increase power. Some traps are quicker and more efficient killing devices than others. A trap designed to kill by shutting off the blood supply to the brain (a neck-hold trap) rather than one that aims to suffocate the animal by clamping its back (such as body-catch traps), will kill more quickly and more effectively (Proulx & Barrett 1991; Phillips 1996), although this may depend on the species (Copeland *et al* 1995). However, the trapping community seems to be resistant to the adoption of new devices and old and illegal methods are still widely used across the globe (Powell & Proulx 2003; Dronova & Shestakov 2005). An understanding of the biology of the target species, and extensive trapper training, are therefore essential to increase trap efficiency and improve animal welfare (Powell & Proulx 2003).

Many studies report slight species-specific modifications that can enhance the welfare of restraining traps. To reduce teeth breakage, box traps can be constructed from natural materials (Copeland *et al* 1995), mesh size or air hole size can be reduced (Arthur 1988; Powell & Proulx 2003), or box bars (a bar placed at the entrance of the trap to prevent biting of the door) can be added (Woodroffe *et al* 2005). For skin abrasions, smooth material can be used to construct traps or smooth coatings added to abrasive materials (Woodroffe *et al* 2005). Longer periods of time spent in the trap are often associated with greater exertion and more serious injuries (Powell & Proulx 2003). Most European countries and some North American states require traps (both killing and restraining) to be checked daily (although this may mean circa 36 hours, if traps are checked at dawn and then at dusk the following day [FACE 1998; Fox & Papouchis 2004a]). This is a minimum standard; reducing the time in traps by either checking more frequently (Proulx *et al* 1993) or monitoring traps with electronic devices can reduce the number of serious injuries (Kaczensky *et al* 2002; Potočnik *et al* 2002; Larkin *et al* 2003). The closure or tying open of traps during adverse weather conditions can reduce freezing damage or hypothermia in colder climes (de Vos & Gunther 1952). Welfare performance may also be improved in both neck and leg-hold snares. Increasing the diameter of the cable can reduce laceration injuries (Garrett 1999). The addition of swivels gives a struggling animal more flexibility and makes it more difficult to entangle or twist the snare (eg Nellis 1968; Logan *et al* 1999). Adding a breakaway snare lock, snare stops and pan tension devices can both minimise capture of non-target species, and ensure that stronger non-target species can escape from the snare (Garrett 1999). Altering the breaking tension of the cable itself can also minimise capture of some non-target species (Fisher & Twitchell 2003). A plastic coating around the wire noose can reduce injuries (Englund 1982). Careful site selection can prevent individuals becoming entangled in surrounding vegetation, and thus injured (Logan *et al* 1999). Some studies have shown that tranquillisers attached to snares can also reduce injuries (Garrett 1999; Pruss *et al* 2002; Marks *et al* 2004). Perhaps the greatest advancement to snare welfare would be better training for users and prosecution of those deliberately setting snares illegally. In future, new remote-controlled teleinjection methods (ie a blowgun remotely monitored and triggered up to 400 m away, shooting anaesthetised darts), which are being developed to catch large mammals with minimum stress and high selectivity, could be extremely useful for research and conservation purposes (Ryser *et al* 2005).

International legislation on mammal trapping

The ISO standards for killing and restraining traps were drafted by representatives of countries with an interest in trapping standards, members of the trapping community and animal welfare organisations (Harrop 1998, 2000). Since no agreement could be reached on either time to the onset of unconsciousness for killing traps or the use of non-physiological indicators of distress, which were perceived as two measures to assess humaneness (Harrop 1998, 2000), the European Union signed two international documents: the Agreement on International Humane Trapping

Standards (Anonymous 1998a), signed between the EU, Canada and the Russian Federation (hereafter the Agreement) to facilitate the trade in fur and traps as well as to ensure the good welfare of trapped mammals (Harrop 1998), and the Agreed Minute between the EU and the USA on humane trapping standards (Anonymous 1998b), a document that differed only in small technical details from the Agreement (see Harrop 1998, 2000).

It is beyond the scope of this review to cover all national legislation on mammal trapping. Nonetheless it is important to mention a few pieces of legislation dealing with specific trap types. For instance, mammal trapping in Europe is also regulated by the Leg-hold Trap Regulation (The Council of European Communities 1991), which bans the use of leg-hold traps within the EU and prevents the import of fur from countries that employ leg-hold traps. Leg-hold traps are also completely or partially banned in eight US states (Arizona, California, Colorado, Florida, Massachusetts, New Jersey, Rhode Island and Washington) (Fox 2004b). At a national level, only five European countries (Belgium, France, Ireland, Spain, and the UK) still allow the use of neck snares (FACE 1998; Fox 2004b). Snares (all kinds) are banned in Arizona, Connecticut, Massachusetts, New York, Rhode Island and Vermont, whilst colony traps, a type of drowning trap or restraining trap underwater, are not allowed in Illinois, Delaware, Massachusetts, Missouri, New York, Pennsylvania and Wisconsin (Fox 2004b). This highlights the fragmented nature of trapping legislation at national and international level and is in part inconsistent with other animal welfare legislation. For instance, different pieces of legislation concerning the welfare of farm animals cover all stages of the process from housing, to transport and slaughter. In the controlled conditions of slaughterhouses the period of pain and distress before the loss of consciousness is often less than 60 seconds, and yet ongoing research aims to further shorten this time (Mellor & Littin 2004). Countries such as Australia have established humane standards for even the control of introduced pest species (Sharp & Saunders 2005). Codes of conduct developed by shooting or bowhunting organisations require hunters to target vital areas of an animal's body so that killing is fast acting; moreover hunters should aim to produce an immediate kill (Gregory 2005; British Association for Shooting & Conservation 2006; North Dakota Bowhunters Association 2006). In contrast, 300 seconds is considered as an acceptable time of suffering for wild mammals caught in killing traps and in some cases the period permitted between two visits to check restraining traps is 72 hours (Fox 2004b).

Limitations of the international legislation

The current legislation on trapping standards does not promote good animal welfare performance. For instance, some procedures in the ISO standards to test killing and restraining traps are less than ideal. Testing traps in an artificial compound is assumed to recreate actual field settings for both killing and restraining traps, whereas all conditions as well as individual animal behaviour cannot be easily recreated. This could lead to traps failing in the field and poor welfare of trapped animals (Powell & Proulx 2003; Fox & Papouchis 2004a; Warburton & O'Connor 2004). Moreover, the killing traps standards fail to recognise drowning traps as inhumane and ban their use. Despite the fact that the ISO standards advocate the need for target specificity, no actual guidelines are given to avoid capture of non-target species (but see British Association for Shooting and Conservation 2002; Defra 2005; IAFWA 2006). The ISO standards currently provide the best available information upon which a decision can be made regarding acceptability/humaneness of restraining traps. However, the long-term impact of some injuries, pain and physiological stress are not incorporated into this assessment.

The main aim of the Agreement is to facilitate the trade of fur amongst the participant countries. Consequently, several mammal species (eg red fox, coypu [*Myocastor coypus*]) and many rodents (Mason & Littin 2003) are commonly trapped in Europe to reduce numbers but are not included in the Agreement. Equally, several mammals trapped for fur in Canada and Russia (eg wolverine [*Gulo gulo*], red squirrel [*Sciurus vulgaris*]) are not included in the Agreement. While the Agreement sets welfare standards for 19 species (Table 7), there are no specific guidelines for the majority of species not included in the Agreement. In addition, when the Agreement was signed in 1997, different time limits to unconsciousness were set; smaller species must be rendered unconscious in shorter time limits (60 or 180 seconds) than larger ones (300 seconds). However, the time limits to unconsciousness adopted in the Agreement now fail to account for higher welfare standards currently accepted in trap research. Indeed, the traps currently available for American beaver, American pine marten, Canadian lynx, fisher and muskrat may kill within time limits shorter than those adopted by the Agreement (Powell & Proulx 2003; Table 1). By allowing the use of traps that fall below the accepted standards of animal welfare, the time limits set by the Agreement cannot be considered acceptable. Lastly, the Agreement considers killing and restraining traps to be humane if time to unconsciousness (for killing traps) and no indicators of poor welfare (for restraining traps) are achieved in a minimum of 80% of cases; for the remaining 20% or less of trapped animals, any level of welfare is acceptable. A minimum estimated 7,880,000 animals (excluding unrecorded and illegally trapped animals) of the mammal species included in the Agreement are trapped in killing and restraining traps in Canada, Europe, Russia and the USA annually (Table 7) and this implies that, at the very least, poor welfare for hundreds of thousands of animals each year is acceptable. A key goal should be to reduce this number substantially.

One missing aspect from the legislation concerns the methods of euthanasia of animals trapped in restraining traps. Trappers' magazines often advocate suffocation, drowning, gassing and hitting with clubs to minimise pelt damage (Minnesota Trapper Association 2000; Fox & Papouchis 2004c; Orr 2005). No formal guidelines are provided for pest control officers, and while some may use guns or other humane killing devices to despatch trapped animals (The Fund for Animals 2001), some will undoubtedly use less humane methods. Scientists, in contrast, follow precise guidelines on euthanasia, and only humane methods are allowed (Close *et al* 1996; Beaver *et al* 2001). Similarly, farmed animals must be stunned before slaughter in the vast majority of commercial slaughterhouses in Australia, Europe and the USA so that the period of distress before killing is minimised (Gregory 1989/1990); some forms of ritual slaughter also allow stunning prior to slaughter in certain contexts (Mellor & Littin 2004). There are no guidelines on how to kill a trapped animals humanely in either of the ISO documents or the Agreement. To improve welfare, this aspect of trapping needs to be addressed.

Mammal trapping for research

The welfare of animals used in research has become increasingly important in the last half century and is the subject of great public concern and debate among scientists (Broom 1988; Putman 1995; Dawkins 1998; Clutton-Brock 2003). In general, for a scientific journal to accept original research conducted using wild animals, authors must have complied with the laws and regulations of the country where the research was undertaken. If research techniques affect the animals under study, the value of the data collected is reduced, possibly significantly. When animals were kept confined temporarily in a laboratory, researchers must have followed guidelines such as *Guide to the Care and Use of Experimental Animals* (Canadian Council on Animal Care 1993), *Guide to the Care and Use of Laboratory Animals* (Institute for Laboratory Animal Research 1996), *Guidelines for the use of animals in behavioural research and teaching* (Anonymous 2003) by The Association for the Study of Animal Behaviour, and *Guidelines for the capture, handling and care of mammals* (American Society of Mammalogists Animal Care and Use Committee 1998). These guidelines are published to help researchers design studies that have minimum impact on the individuals, populations or communities under examination. This includes minimising sample sizes for statistical analyses, choosing live-capture methods which are humane or killing traps that kill as quickly and painlessly as possible, assuming responsibility for dependent offspring, and minimising the length of confinement to avoid disruption to social interactions (American Society of Mammalogists Animal Care and Use Committee 1998; Anonymous 2003). Researchers are responsible for all animals involved in their study: should restraining traps be laid out, only the number of traps that can be checked daily should be employed; where the target species is nocturnal, traps should be checked at dawn and closed during the day to avoid capture of diurnal non-target species; great care must be taken when small mammals are to be captured, as they are very sensitive to extreme temperature, dehydrate very quickly due to high metabolism, and may starve in short time spans; when research involves endangered species, researchers must work in co-operation with official agencies such as CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) or IUCN (The World Conservation Union); sampling must be restricted to the smallest number of individuals and, whenever possible, conducted as far apart as possible so that recolonisation may take place from neighbouring populations (American Society of Mammalogists Animal Care and Use Committee 1998); in some instances during a study, animals might need to be killed; in such circumstances the accepted methods of euthanasia are those published by organisations such as American Veterinary Medical Association (Beaver *et al* 2001) or the Federation of European Laboratory Animal Associations (Close *et al* 1996).

In conclusion, there is no distinct definition of humane trapping; whoever undertakes the research is responsible for the welfare of the animals involved and must minimise disruption to the species at all levels ie individuals, groups, populations and communities, and at all stages of the study. These principles should be the basis for establishing welfare standards for trapping undertaken for other than research purposes.

Animal welfare implications

A large number of killing and restraining traps currently in use for mammals do not meet accepted standards of animal welfare. The methods currently in place to test trap devices are inconsistent. Testing restraining and/or killing traps in controlled systems is less than ideal; physiological responses of anaesthetised animals have been shown to differ from the responses of unanaesthetised animals (Hiltz & Roy 2001), and the full range of behaviours of animals in the wild cannot be recreated in captive conditions. With regard to restraining traps, there is no clear understanding of the injury scoring system or how this relates to animal welfare. Very few (if any) studies present good behavioural or physiological measures of animals in different trap types. Many facets of the welfare of trapped animals such as behaviour, physiology, immunology and molecular biology still need to be incorporated into trap evaluation to achieve a more complete assessment of welfare. The welfare of wild animals caught for fur or population control lags a long way behind other welfare standards, such as those set for slaughtering farm animals (Mellor & Littin 2004), trapping standards for scientific research or those for shooting and bowhunting. There is no logic for contrasting welfare standards for wild animals and captive animals or for different welfare standards for the same species when trapped either for scientific research or for pest control. The ISO standards should be seen as a baseline to set higher welfare standards. This can be achieved by reviewing the time to unconsciousness following improvements to killing traps, banning inhumane killing methods such as drowning traps, identifying acceptable methods for euthanasia of trapped animals and collecting new data on stress responses to different trap types. In conclusion, we believe that animal welfare standards for trapping should be the highest achievable whatever the need (for fur, population control or scientific research), should not fall below current accepted standards for other animal uses and, finally, that further improvements should always be sought.

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References

American Society of Mammalogists Animal Care and Use Committee 1998 Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. *Journal of Mammalogy 79:* 1416-1431

Anonymous 1998a Agreement on international humane trapping standards between the European Community, Canada and the Russian Federation. *Official Journal of the European Communities L42:* 43-57

Anonymous1998b International Agreement in the form of an Agreed Minute between the European Community and the United States of America on humane trapping standards. *Official Journal of the European Communities L219:* 26-37

Anonymous 2003 Guidelines for the treatment of animals in behavioural research and teaching. *Animal Behaviour 65:* 249-255

Arthur SM 1988 An evaluation of techniques for capturing and radiocollaring fishers. *Wildlife Society Bulletin 16:* 417-421

Barrett MW, Proulx G, Hobson D, Nelson D and Nolan JW 1989 Field evaluation of the C120 magnum trap for martens. *Wildlife Society Bulletin 17:* 299-306

Beaver BV, Reed W, Leary S, McKiernan B, Bain F, Schultz R, Bennett BT, Pascoe P, Shull E, Cork LC, Francis-Floyd R, Amass KD, Johnson R, Schmidt RH, Underwood W, Thornton GW and Kohn B 2001 2000 Report of the AVMA Panel on Euthanasia. *Journal of the American Veterinary Medical Association 218:* 669-696

Berchielli LT and Tullar BF 1980 Comparison of a leg snare with a standard leg-gripping trap. *New York Fish and Game Journal 27:* 63-71

Birks JDS and Kitchener AC 1999 *The Distribution and Status of the Polecat* Mustela putorius *in Britain in the 1990s.* The Vincent Wildlife Trust: London, UK

Bluett RD 2001 Drowning is not euthanasia: springboard or siren's song? *Wildlife Society Bulletin 29:* 744-750

Bortolotti GR 1984 Trap and poison mortality of golden eagles *Aquila chrysaetos* and bald eagles *Haliaeetus leucocephalus*. *Journal of Wildlife Management 48:* 1173-1179

British Association for Shooting & Conservation 2002 *Codes of practice*. BASC: http://www.basc.org.uk/ content/codes_of_practice (accessed 24 February 2006)

British Association for Shooting & Conservation 2006 *Deer stalking a code of practice*. BASC: http://www.basc.org.uk/ content/stalkingpractice (accessed 10 May 2006)

Broom DM 1988 The scientific assessment of animal welfare. *Applied Animal Behaviour Science 20:* 5-19

Broom DM 1999 The welfare of vertebrate pests in relation to their management. In: Cowan PD and Feare CJ (eds) *Advances in Vertebrate Pest Management* pp 309-329. Filander: Fürth, Germany

Canadian Council on Animal Care 1993 *Guide to the Care and Use of Experimental Animals, 2nd Edition*. Canadian Council on Animal Care: Ottawa, Ontario, Canada

Cattet MRL, Christison K, Caulkett NA and Stenhouse GB 2003 Physiologic responses of grizzly bears to different methods of capture. *Journal of Wildlife Diseases 39:* 649-654

Chadwick AH, Hodge SJ, Ratcliffe PR and Great Britain Forestry Commission 1997 *Foxes and forestry*. Forestry Commission: Edinburgh, UK

Close B, Banister K, Baumans V, Bernoth E-M, Bromage N, Bunyan J, Erhardt W, Flecknell P, Gregory N, Hackbarth NGH, Morton D and Warwick C 1996 Recommendations for euthanasia of experimental animals: Part 1. *Laboratory Animals (London) 30:* 293-316

Clutton-Brock J 2003 Risk assessment for animals: should the routine assessment of negative effects of intervention in wild animals be built into research projects? *Journal of Zoology 260:* 117-118

Conroy JWH and Jenkins D 1986 Ecology of otters in northern Scotland UK. IV. Diving times and hunting success of otters (*Lutra lutra*) at Dinnet Lochs, Aberdeenshire and in Yell Sound, Shetland. *Journal of Zoology 209A:* 341-346

Copeland JP, Cesar E, Peek JM, Harris CE, Long CD and Hunter DL 1995 A live trap for wolverine and other forest carnivores. *Wildlife Society Bulletin 23:* 535-538

Crasson D 1996 *Study into trapping in five European Union countries.* Unpublished Licenciée en Biologie Université de Louvain-la-Neuve, Belgium

Cross ML, Swale E, Young G and Mackintosh C 1999 Effect of field capture on the measurement of cellular immune responses in wild ferrets (*Mustela furo*), vectors of bovine tuberculosis in New Zealand. *Veterinary Research 30:* 401-410

Dawkins MS 1998 Evolution and animal welfare. *Quarterly Review of Biology 73:* 305-328

de Vos A and Gunther SE 1952 Preliminary live-trapping studies of marten. *Journal of Wildlife Management 16:* 207-214

Department for Environment Food and Rural Affairs 2005 Defra code of practice on the use of snares in fox and rabbit control. DEFRA: http://www.defra.gov.uk/wildlife-countryside/vertebrates/snares/pdf/snares-cop.pdf (accessed 4 May 2006)

Dronova N and Shestakov A 2005 *Trapping a living: conservation and socio-economic aspects of the fur trade in the Russian Far East.* TRAFFIC Europe-Russia: Moscow, Russian Federation

Duncan JR, Prasse KW and Mahaffey EA 1994 *Veterinary Laboratory Medicine: Clinical Pathology, 3rd Edition*. Iowa State University Press: Ames, Iowa, USA

Engeman RM, Krupa HW and Kern J 1997 On the use of injury scores for judging the acceptability of restraining traps. *Journal of Wildlife Research 2:* 124-127

Englund J 1982 A comparison of injuries to leg-hold trapped and foot-snared red foxes. *Journal of Wildlife Management 46:* 1113-1117

Federation of Field Sports Associations of the European Union 1998 *Technical support for the preparation of the implementation of the Agreement on international humane trapping standards between the European Community, Canada, and the Russian Federation – Evaluation of the situation in the Member States*. Final report B7 – 8110/98/000576/MAR/D2. FACE: Brussels, Belgium

Fernández-Morán J, Saavedra D and Manteca-Vilanova X 2002 Reintroduction of the Eurasian otter (*Lutra lutra*) in northeastern Spain: trapping, handling, and medical management. *Journal of Zoo and Wildlife Medicine 33:* 222-227

Fisher JT and Twitchell C 2003 *Quantifying the differences in tension and torque between snared American marten* (Martes americana) *and snowshoe hare* (Lepus americanus). *Final report.* Alberta Research Council Inc: Vegreville, Alberta, Canada

Fleming PJS, Allen LR, Berghout MJ, Meek PD, Pavlov PM, Stevens P, Strong K, Thompson JA and Thomson PC 1998 The performance of wild-canid traps in Australia: efficiency, selectivity and trap-related injuries. *Wildlife Research 25:* 327-338

Fox CH 2004a Trapping in North America: a historical overview. In: Fox CH and Papouchis CM (eds) *Cull of the Wild. A Contemporary Analysis of Wildlife Trapping in the United States.* pp 1-22. Bang Publishing: Brainerd, Minnesota, USA

Fox CH 2004b State trapping regulations. In: Fox CH and Papouchis CM (eds) *Cull of the Wild. A Contemporary Analysis of Wildlife Trapping in the United States.* pp 71-111. Bang Publishing: Brainerd, Minnesota, USA

Fox CH and Papouchis CM 2004a *Cull of the wild. A contemporary analysis of wildlife trapping in the United States.* Bang Publishing: Brainerd, Minnesota, USA

Fox CH and Papouchis CM 2004b Trapping devices, methods, and research. In: Fox CH and Papouchis CM (eds) *Cull of the Wild. A Contemporary Analysis of Wildlife Trapping in the United States.*. pp 31-41. Bang Publishing: Brainerd, Minnesota, USA

Fox CH and Papouchis CM 2004c Refuting the myths. In: Fox CH and Papouchis CM (eds) *Cull of the Wild. A Contemporary Analysis of Wildlife Trapping in the United States.* pp 23-30. Bang Publishing: Brainerd, Minnesota, USA

Frank L, Simpson D and Woodroffe R 2003 Foot snares: an effective method for capturing African lions. *Wildlife Society Bulletin 31:* 309-314

García-Perea R 2000 Survival of injured Iberian lynx (*Lynx pardinus*) and non-natural mortality in central-southern Spain. *Biological Conservation 93:* 265-269

Garrett T 1999 *Alternative Traps.* Animal Welfare Institute: Washington, DC, USA

Gilbert FF and Gofton N 1982 Terminal dives in mink, muskrat and beaver. *Physiology and Behavior 28:* 835-840

Goodrich JM, Kerley LL, Schleyer BO, Miquelle DG, Quigley KS, Smirnov YN, Nikolaev IG, Quigley HB and Hornocker MG 2001 Capture and chemical anesthesia of Amur (Siberian) tigers. *Wildlife Society Bulletin 29:* 533-542

Greenspan L, McLellan BA and Greig H 1985 Abbreviated injury scale and injury severity score: a scoring chart. *Journal of Trauma 25:* 60-64

Gregory NG 1989/90 Slaughtering methods and equipment. *Veterinary History 6:* 73-84

Gregory NG 2005 Bowhunting deer. *Animal Welfare 14:* 111-116

Hamilton GD and Weeks HP 1985 Cortisol and aldosterone comparisons of cottontail rabbits collected by shooting, trapping, and falconry. *Journal of Wildlife Diseases 21:* 40-42

Harrop SR 1998 The Agreement on international humane trapping standards - Background, critique and the texts. *Journal of International Wildlife Law and Policy 1:* 387-394

Harrop SR 2000 The international regulation of animal welfare and conservation issues through standards dealing with the trapping of wild mammals. *Journal of Environmental Law 12:* 333-360

Hiltz M and Roy LD 2001 Use of anaesthetized animals to test humaneness of killing traps. *Wildlife Society Bulletin 29:* 606-611

Huber D, Kusak J, Žvorc Z and Rafaj RB 1997 Effects of sex, age, capturing method, and season on serum chemistry values of brown bears in Croatia. *Journal of Wildlife Diseases 33:* 790-794

Hubert Jr GF, Hungerford LL, Proulx G, Bluett RD and Bowman L 1996 Evaluation of two restraining traps to capture raccoons. *Wildlife Society Bulletin 24:* 699-708

International Association of Fish and Wildlife Agencies 1997 *Improving Animal Welfare in U.S. Trapping Programs: Process Recommendations and Summaries of Existing Data.* IAFWA, Fur Resources Technical Subcommittee, Trapping Work Group: Washington DC, USA

International Association of Fish and Wildlife Agencies 2000 *Summary of Progress. Testing Restraining Traps for the Development of Best Management practices for Trapping in the United States.* IAFWA, Furbearer Resources Technical Work Group: Washington DC, USA

International Association of Fish and Wildlife Agencies 2003 *Summary of Progress 1999-2000 Field Season. Testing Restraining and Body-Gripping Traps for Development of Best Management Practices for Trapping in the United States.* IAFWA, Furbearer Resources Technical Work Group: Washington, DC, USA

International Association of Fish and Wildlife Agencies 2006 *Best Management Practices for Trapping in the United States.* IAFWA, Furbearer Resources Technical Work Group: Washington, DC, USA

Inglis IR, Pelz H-J, Solmsdorff K and Talling JC 2001 *Final Report for: Study contract (Ref: B7-8500/2001/330989/Mar/E3) for the exploration of physiological and behavioural criteria for muskrat (*Ondatra zibethicus*).* Unpublished

Institute for Laboratory Animal Research 1996 *Guide to the Care and Use of Laboratory Animals.* ILAR, National Academy Press: Washington DC, USA

Irving L and Orr MD 1935 The diving habits of the beaver. *Science 82:* 569

ISO 10990-4 1999 *Animal (mammal) traps: Part 4: Methods for testing killing trap systems used on land or underwater.* International Organization for Standardization: Geneva, Switzerland

ISO 10990-5 1999 *Animal (mammal) traps: Part 5: Methods for testing restraining traps.* International Organization for Standardization: Geneva, Switzerland

Kaczensky P, Knauer F, Jonozovic M, Walzer C and Huber T 2002 Experiences with trapping, chemical immobilization, and radiotagging of brown bears in Slovenia. *Ursus 13:* 347-356

Kirkwood JK, Sainsbury AW and Bennett PM 1994 The welfare of free-living wild animals: methods of assessment. *Animal Welfare 3:* 257-273

Kolbe JA, Squires JR and Parker TW 2003 An effective box trap for capturing lynx. *Wildlife Society Bulletin 31:* 980-985

Kreeger TJ, White PJ, Seal US and Tester JR 1990 Pathological responses of red foxes to foot hold traps. *Journal of Wildlife Management 54:* 147-160

Kuehn DW, Fuller TK, Mech LD, Paul WJ, Fritts SH and Berg WE 1986 Trap-related injuries to gray wolves in Minnesota. *Journal of Wildlife Management 50:* 90-91

Larkin RP, Van Deelen TR, Sabick RM, Gosselink TE and Warner RE 2003 Electronic signaling for prompt removal of an animal from a trap. *Wildlife Society Bulletin 31:* 392-398

League Against Cruel Sports 2005 The killing game: out of control predator control http://www.league.uk.com/killing_game/report1.pdf (accessed 9 May 2006)

Littin KE, Mellor DJ, Warburton B and Eason CT 2004 Animal welfare and ethical issues relevant to the humane control of vertebrate pests. *New Zealand Veterinary Journal 52:* 1-10

Logan KA, Sweanor LL, Smith JF and Hornocker MG 1999 Capturing pumas with foot-hold snares. *Wildlife Society Bulletin 27:* 201-208

Lovari S, Valier P and Lucchi MR 1994 Ranging behaviour and activity of red foxes (*Vulpes vulpes*, Mammalia) in relation to environmental variables, in a Mediterranean mixed pinewood. *Journal of Zoology 232:* 323-339

Lucherini M and Lovari S 1996 Habitat richness affects home range size in the red fox *Vulpes vulpes*. *Behavioural Processes 36:* 103

Ludders JW, Schmidt RH, Dein FJ and Klein PN 1999 Drowning is not euthanasia. *Wildlife Society Bulletin 27:* 666-670

Luengos Vidal M, Lucherini M and Casanave E 2003 An evaluation of three restraining devices for capturing pampas foxes. *Canid News 6:* 1-9. http://www.canids.org/canidnews/6/Devices_for_capturing_pampas_foxes.pdf (accessed 4 May 2006)

MacNally L 1992 Deer management at Abernethy an RSPB reserve. *Deer 8:* 587-590

Marks CA, Allen L, Gigliotti F, Busana F, Gonzalez T, Lindeman M and Fisher PM 2004 Evaluation of the tranquilliser trap device (TTD) for improving the humaneness of dingo trapping. *Animal Welfare 13:* 393-399

Mason G and Littin KE 2003 The humaneness of rodent pest control. *Animal Welfare 12:* 1-37

McKinstry MC and Anderson SH 1998 Using snares to live-capture beaver, *Castor canadensis*. *Canadian Field-Naturalist 112:* 469-473

McLaren GW, Thornton PD, Newman C, Buesching CD, Baker SE, Mathews F and Macdonald DW 2005 High rectal temperature indicates an increased risk of unexpected recovery in anaesthetized badgers. *Veterinary Anaesthesia and Analgesia 32:* 48-52

Meek PD, Jenkins DJ, Morris B, Ardler AJ and Hawksby RJ 1995 Use of two humane leg-hold traps for catching pest species. *Wildlife Research 22:* 733-739

Mellor DJ and Littin KE 2004 Using science to support ethical decisions promoting humane livestock slaughter and vertebrate pest control. *Animal Welfare 13:* S127-S132

Meyer S 1991 *Being kind to animal pests*. Meyer: Garrison, Iowa, USA

Miller CJ 1993 An evaluation of two possum trpa types for catch-efficiency and humaneness. *Journal of the Royal Society of New Zealand 23:* 5-11

Minnesota Trapper Association 2000 *Trap checking*. MNTA: http://www.mntrappers.com/trapchecking.html (accessed 24 February 2006)

Moberg GP 1999 When does stress become distress? *Laboratory Animals (London) 28:* 22-26

Moehrenschlager A, Macdonald DW and Moehrenschlager C 2003 Reducing capture-related injuries and radio collaring effects on swift fox. In: Sovada MA and Carbyn L (eds) *The swift fox: ecology and conservation of swift foxes in a changing world* pp 107-113. Canadian Plains Research Center: Regina, Canada

Mowat G, Slough BG and Rivard R 1994 A comparison of three live capturing devices for lynx: capture efficiency and injuries. *Wildlife Society Bulletin 22:* 644-650

National Federation of Badger Groups 2002 *The case for a ban on snares*. NFBG: http://www.badger.org.uk/action/The-case-for-a-ban-on-snares.pdf (accessed 24 February 2006)

Naylor BJ and Novak M 1994 Catch efficiency and selectivity of various traps and sets used for capturing American martens. *Wildlife Society Bulletin 22:* 489-496

Nellis CH 1968 Some methods for capturing coyotes alive. *Journal of Wildlife Management 32:* 402-405

North Dakota Bowhunters Association 2006 North Dakota Bowhunters Code of Ethics. NDBA: http://www.ndbowhunters.org/code.htm (accessed 10 May 2006)

Novak M 1981a Capture tests with underwater snares, leg-hold, Conibear, and Mohawk traps. *Canadian Trapper, April:* 18-23

Novak M 1981b The foot-snare and the leg-hold traps: a comparison. In: Chapman JA and Pursley D (eds) *Worldwide furbearer conference proceedings* pp 1671-1685. Frostburg: Maryland, USA

Novak M 1987 Traps and trap research. In: Novak M, Baker JA, Obbard ME, Malloch B, Ontario, Ministry of Natural Resources and Ontario Trappers Association (eds) *Wild furbearer management and conservation in North America* pp 941-970. Ontario Trappers Association: Toronto, Canada

Nutman AW, Gregory NG and Warburton B 1998 A comparison of the effectiveness of three neck-hold killing traps in occluding carotid arteries in the neck of the brushtail possum. *New Zealand Veterinary Journal 46:* 177-181

Olsen GH, Linscombe RG, Wright VL and Holmes RA 1988 Reducing injuries to terrestrial furbearers by using padded foot hold traps. *Wildlife Society Bulletin 16:* 303-307

Onderka DK, Skinner DL and Todd AW 1990 Injuries to coyotes and other species caused by four models of footholding devices. *Wildlife Society Bulletin 18:* 175-182

Orr MD 2005 *Pest animal control - humane options*. Lifestyle block. http://www.lifestyleblock.co.nz/articles/weeds/18_Pest_control.htm (accessed 24 February 2006)

Patterson BD, Neiburger EJ and Kasiki SM 2003 Tooth breakage and dental disease as causes of carnivore-human conflicts. *Journal of Mammalogy 84:* 190-196

Pawlina IM and Proulx G 1999 Factors affecting trap efficiency: a review. In: Proulx G (ed) *Mammal trapping* pp 95-115. Alpha Wildlife Research & Management Ltd: Alberta, Canada

Phillips RL 1996 Evaluation of 3 types of snares for capturing coyotes. *Wildlife Society Bulletin 24:* 107-110

Pohlmeyer K, Drommer W, Kaup FJ, Fehlberg I and Ott N 1995 Efficiency of instant killing traps used in hunting martens and foxes under huntsman-like conditions. *Deutsche Tierarztliche Wochenschrift 102:* 133-137

Potočnik H, Kljun F, Račnik J, Skrbinšek T, Adamič M and Kos I 2002 Experience obtained from box trapping and handling wildcats in Slovenia. *Acta Theriologica 47:* 211-219

Poutu N and Warburton B 2003 *Evaluation of the effectiveness of the Waddington backcracker trap for killing stoats*. Rep No DOC Science Internal Series 132. New Zealand Department of Conservation: Wellington, New Zealand

Powell RA 2005 Evaluating welfare of American black bears (*Ursus americanus*) captured in foot snares and in winter dens. *Journal of Mammalogy 86:* 1171-1177

Powell RA and Proulx G 2003 Trapping and marking terrestrial mammals for research: integrating ethics, performance criteria, techniques, and common sense. *ILAR Journal 44:* 259-276

Princen S 2004 EC compliance with WTO law: the interplay of law and politics. *European Journal of International Law 15:* 555-574

Proulx G 1999a Review of current mammal trap technology in North America. In: Proulx G (ed) *Mammal Trapping* pp 1-46. Alpha Wildlife Research & Management Ltd: Alberta, Canada

Proulx G 1999b The Bionic® : an effective marten trap. In: Proulx G (ed) *Mammal Trapping* pp 79-87. Alpha Wildlife Research & Management Ltd: Alberta, Canada

Proulx G and Barrett MW 1990 Assessment of power snares to effectively kill red fox. *Wildlife Society Bulletin 18:* 27-30

Proulx G and Barrett MW 1991 Evaluation of the Bionic® trap to quickly kill mink (*Mustela vison*) in simulated natural environments. *Journal of Wildlife Diseases 27:* 276-280

Proulx G and Barrett MW 1993a Evaluation of mechanically improved Conibear-220™ traps to quickly kill fisher (*Martes pennanti*) in simulated natural environments. *Journal of Wildlife Diseases 29:* 317-323

Proulx G and Barrett MW 1993b Evaluation of the Bionic® trap to quickly kill fisher (*Martes pennanti*) in simulated natural environments. *Journal of Wildlife Diseases 29:* 310-316

Proulx G, Barrett MW and Cook SR 1989a The C120 Magnum: an effective quick-kill trap for marten. *Wildlife Society Bulletin 17:* 294-298

Proulx G, Cook SR and Barrett MW 1989b Assessment and preliminary development of the rotating-jaw Conibear 120 trap to effectively kill marten (*Martes americana*). *Canadian Journal of Zoology 67:* 1074-1079

Proulx G and Drescher RK 1994 Assessment of rotating-jaw traps to humanely kill raccoons (*Procyon lotor*). *Journal of Wildlife Diseases 30:* 335-339

Proulx G, Kolenosky AJ, Badry MJ, Cole PJ and Drescher RK 1993 Assessment of the Sauvageau 2001-8 trap to effectively kill Arctic fox. *Wildlife Society Bulletin 21:* 132-135

Proulx G, Kolenosky AJ, Badry MJ, Cole PJ and Drescher RK 1994a A snowshoe hare snare system to minimize capture of marten. *Wildlife Society Bulletin 22:* 639-643

Proulx G, Pawlina IM, Onderka DK, Badry MJ and Seidel K 1994b Field evaluation of the number 1 1/2 steel-jawed leg-hold and the Sauvageau 2001-8 traps to humanely capture Arctic fox. *Wildlife Society Bulletin 22:* 179-183

Proulx G, Kolenosky AJ, Cole PJ and Drescher RK 1995 A humane killing trap for lynx (*Felis lynx*): the Conibear 330™ with clamping bars. *Journal of Wildlife Diseases 31:* 57-61

Pruss SD, Cool NL, Hudson RJ and Gaboury AR 2002 Evaluation of a modified neck snare to live-capture coyotes. *Wildlife Society Bulletin 30:* 508-516

Putman RJ 1995 Ethical considerations and animal welfare in ecological field studies. *Biodiversity and Conservation 4:* 903-915

Reagan SR, Ertel JM, Stinson P, Yakupzack P and Anderson D 2002 A passively triggered foot snare design for American black bears to reduce disturbance by non-target animals. *Ursus 13:* 317-320

Reynolds JC, Short MJ and Leigh RJ 2004 Development of population control strategies for mink *Mustela vison*, using floating rafts as monitors and trap sites. *Biological Conservation 120:* 533-543

Ryser A, Scholl M, Zwahlen M, Oetliker M, Ryser-Degiorgis MP and Breitenmoser U 2005 A remote-controlled teleinjection system for the low-stress capture of large mammals. *Wildlife Society Bulletin 33:* 721-730

Sabean B and Mills J 1994 *Raccoon – 6” × 6” body gripping study*. Nova Scotia Department Natural Resources Publications, unpublished

Sala L, Sola C, Spampanato A, Tongiorgi P and Magnanini M 1993 Capture and identification techniques of marmot on Mount Cimone (Northen Appenines). *IBEX Journal of Mountain Ecology 1:* 14-16

Schmidt RH and Bruner JG 1981 A professional attitude toward humaneness. *Wildlife Society Bulletin 9:* 289-291

Seddon PJ, Van Heezik Y and Maloney RM 1999 Short- and medium-term evaluation of foot-hold trap injuries in two species of fox in Saudi Arabia. In: Proulx G (ed) *Mammal Trapping* pp 67-78. Alpha Wildlife Research & Management Ltd: Alberta, Canada

Serfass TL, Brooks RP, Swimley TJ, Rymon LM and Hayden AH 1996 Considerations for capturing, handling, and translocating river otters. *Wildlife Society Bulletin 24:* 25-31

Sharp I and Saunders G 2005 *Humane pest animal control – codes of practice and standard operating procedures*. New South Wales Department of Primary Industries: Orange, New South Wales, Australia

Shivik JA, Gruver KS and DeLiberto TJ 2000 Preliminary evaluation of new cable restraints to capture coyotes. *Wildlife Society Bulletin 28:* 606-613

Short J, Turner B and Risbey D 2002 Control of feral cats for nature conservation. III. Trapping. *Wildlife Research 29:* 475-487

Short MJ and Reynolds JC 2001 Physical exclusion of non-target species in tunnel-trapping of mammalian pests. *Biological Conservation 98:* 139-147

Statistics Canada 2004 *Fur statistics*. Rep No 23-013-XIE. Statistics Canada: Ottawa, Canada

Stocker L 2005 *Practical wildlife care, 2nd Edition*. Blackwell: Oxford, UK

Tandon OP, Malhotra V, Tandon S and D’Silva I 2003 Neurophysiology of pain: insight to orofacial pain. *Indian Journal of Physiology and Pharmacology 47:* 247-269

The Council of European Communities 1991 Council Regulation (EEC) No 3254/91 of 4 November 1991 prohibiting the use of leg-hold traps in the Community and the introduction into the Community of pelts and manufactured goods of certain wild animal species originating in countries which catch them by means of leg-hold traps or trapping methods which do not meet international humane trapping standards. *Official Journal of the European Communities L308:* 1-4

The Fund for Animals 2001 *Suggested guidelines for working with a nuisance wildlife control operator*. The Fund for Animals: http://www.fundforanimals.org/library/documentViewer.asp?ID=467&table=documentsref (accessed 24 February 2006)

Tocidlowski ME, Spelman LH, Sumner PW and Stoskopf MK 2000 Hematology and serum biochemnistry paramenters of North American river otters (*Lontra canadensis*). *Journal of Zoo and Wildlife Medicine 31:* 484-490

Travaini A, Laffitte R and Delibes M 1996 Leg-hold trapping red foxes (*Vulpes vulpes*) in Doñana national park: efficiency, selectivity, and injuries. *Journal of Wildlife Research 1:* 52-56

Tullar Jr BF 1984 Evaluation of a padded foot-hold trap for capturing foxes and raccoons. *New York Fish and Game Journal 31:* 97-103

Turk DC and Melzack R 1992 *Handbook of Pain Assessment.* Guilford Press: New York, USA

van Ballenberghe V 1984 Injuries to wolves sustained during live-capture. *Journal of Wildlife Management 48:* 1425-1429

Warburton B, Gregory NG and Bunce M 1999 Stress response of Australian brushtail possums captured in foot-hold and cage traps. In: Proulx G (ed) *Mammal Trapping* pp 53-66. Alpha Wildlife Research & Management Ltd: Alberta, Canada

Warburton B, Gregory NG and Morriss G 2000 Effect of jaw shape in kill-traps on time to loss of palpebral reflexes in brushtail possums. *Journal of Wildlife Diseases 36:* 92-96

Warburton B and Hall JV 1995 Impact momentum and clamping force thresholds for developing standards for possum kill traps. *New Zealand Journal of Zoology 22:* 39-44

Warburton B and O’Connor C 2004 Research on vertebrate pesticides and traps: do wild animals benefit? *Alternatives to Laboratory Animals 32:* 229-234

Warburton B and Orchard I 1996 Evaluation of five kill traps for effective capture and killing of Australian brushtail possums (*Trichosurus vulpecula*). *New Zealand Journal of Zoology 23:* 307-314

Warburton B, Poutu N and Domigan I 2002 *Effectiveness of the Victor snapback trap for killing stoats*. DOC Science Internal Series 83. New Zealand Department of Conservation: Wellington, New Zealand

Way JG, Ortega IM, Auger PJ and Strauss EG 2002 Box-trapping eastern coyotes in southeastern Massachusetts. *Wildlife Society Bulletin 30:* 695-702

Weir RD 1997 *Inventory of fishers in the sub-boreal forests of North-Central British Columbia Phase 1: capture and marking*. Rep No 130. Peace/Williston Fish and Wildlife Compensation Program: Westwold, British Columbia, Canada

White PJ, Kreeger TJ, Seal US and Tester JR 1991 Pathological responses of red foxes to capture in box traps. *Journal of Wildlife Management 55:* 75-80

Woodroffe R, Bourne FJ, Cox DR, Donnelly CA, Gettinby G, McInerney JP and Morrison WI 2005 Welfare of badgers (*Meles meles*) subjected to culling: patterns of trap-related injury. *Animal Welfare 14:* 11-17

Zelin S, Jofriet JC, Percival K and Abdinoor DJ 1983 Evaluation of humane traps: momentum thresholds for four furbearers. *Journal of Wildlife Management 47:* 863-868

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Wildlife Management Technique — Review

Humaneness and Selectivity of Killing Neck Snares Used to Capture Canids in Canada: A Review

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Abstract

Although killing neck snares are used on traplines in Canada to capture gray wolves (*Canis lupus*), coyotes (*C. latrans*), and red foxes (*Vulpes vulpes*), they are not subject to trap performance criteria set out in the Agreement on International Humane Trapping Standards (AIHTS). This paper reviews scientific information related to the humaneness and selectivity of killing neck snares used to capture canids. All past studies demonstrated that manual and power killing neck snares were inadequate to consistently and quickly render canids unconscious. Furthermore, killing neck snares are non-selective, and impact seriously on the welfare of non-target animals. We recommend that the AIHTS be modified to allow only killing neck snares that kill quickly and consistently, and in the absence of such snares, to phase-out all killing snares for which efficient and more humane alternatives exist.

Key Words: *Canis latrans*, *Canis lupus*, Coyote, Gray Wolf, Humaneness, Killing Neck Snares, Red Fox, Standards, Trapping, *Vulpes vulpes*.

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INTRODUCTION

To address animal welfare concerns about trapping in Canada, intensive research was conducted in Canada during the 1970s through the 1990s (Federal Provincial Committee for Humane Trapping – FPCHT – 1981; Proulx 1999). This research identified and developed several humane trapping devices for killing or restraining furbearers (Proulx *et al.* 2012). Yet, despite significant technological improvements, many antiquated trapping systems are still used today (Proulx and Santos-Reis 2012). Killing neck snares are one example. They are popular in Canada where they are set on traplines to harvest canids, i.e., gray wolves (*Canis lupus*), coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) (Proulx *et al.* 2012; Fédération des Trappeurs Gestionnaires du Québec – FTGQ – 2014; Sinnema 2014). Killing neck snares are commercially available (e.g., Halford's 2014) and their use is being taught by professional trappers (e.g., Trapper Gord 2014). They are popular among trappers because they are cheap, lightweight, easy to set and camouflage (except power snares), and efficient at capturing a diversity of furbearers. Furthermore, some trappers claim that they are humane, as they compress the carotid arteries, thereby reducing blood flow to the brain, quickly leading to unconsciousness and then death (Sinnema 2014). In this paper, we review research related to the humaneness and capture selectivity of killing neck snares used to capture and kill canids.

KILLING NECK SNARE TECHNOLOGY

There are 2 types of killing neck snares. Both are usually made of braided, galvanized stainless steel wire (diameter: 1/16 to 1/8 inch – 1.6 to 3.2 mm). They are placed on animal trails or in enclosed areas with lures or baits. Ten or more killing neck snares may be set around large draw baits ("saturation snaring") to catch most of a wolf pack.

Manual killing neck snares – for which an animal provides the energy necessary to tighten the noose. One end of the snare is formed into a loop with a one-way locking tab that only allows the loop to tighten (Figure 1a). The more a captured animal struggles, the tighter the loop becomes, if the lock functions properly (e.g., malfunction may result from the animal's hair being pulled into the lock as the snare tightens). The other end of the snare is anchored to a fixed object (e.g., a tree) or, because the trapper wants to minimize disturbance at the trap site, to a "drag" that allows the snared animal to leave the location. Specific loop diameters and heights are recommended to capture canids in open or in forested sites (e.g., FTGQ 2014). The efficacy of killing neck snares to kill animals may be improved by using the smallest possible cable wire diameter for the target species, better one-way locking tabs that only allow the loop to tighten, locks with compression or quick kill springs to increase clamping force, and swivels to avoid cable torsion and breaking (FTGQ 2014; Klassen 2014) (Figure 1b).

Power killing neck snares – for which one or two springs provide the energy necessary to tighten the noose. No locks are needed because the clamping force is supplied by the spring pulling on the snare wire (Figure 2). Manufacturers of power killing neck snares claim without providing data that these devices are more selective than manual snares, and captured animals cannot chew the wire (e.g., Ram Power Snare Systems 2014).

KILLING NECK SNARES *VS.* TRAPPING STANDARDS

According to trapping performance requirements set out in the Agreement on International Humane Trapping Standards (AIHTS) signed by the European Community, Canada, and Russia in 1997, killing devices used for the capture of canids should render the animals irreversibly unconscious within 300 sec (Official Journal of the European Communities 1998). A killing trap would meet the standard if at least 80% of 12 animals are unconscious and insensitive within the time limit, and remain in this state until death. Therefore, at a 95% confidence level (one-tailed binomial test), such a killing trap would render ≥58% of target animals irreversibly unconscious in ≤5 min (Powel and Proulx 2003). However, a footnote to Article 7 in the AIHTS stipulates that the standards do not prevent individuals from constructing and using traps (which may not pass the 300 sec test), provided that such traps comply with designs approved by the relevant competent authority. Although killing neck snares are commonly manufactured and sold on the open market, they are deemed by all relevant Canadian competent agencies to be non-commercial devices and therefore not subject to the AIHTS. As a result, they may be used throughout Canada in accordance with provincial and territorial regulations. For example, in Alberta, Environment and Sustainable Resource Development (ESRD) is the relevant competent authority and it dictates the appropriate design for neck snares as: "Neck snares must be equipped with a locking device that is designed and set to prevent the snare loop from loosening again after it has tightened on the neck of the fur-bearing animal" (Craig Brown, Information Officer, ESRD, personal communication, April 22, 2014).

Proulx and Barrett's (1994) stricter standards for killing devices is considered to be the most representative of state-of-the-art technology (Powell and Proulx 2003; Proulx *et al.* 2012). This standard requires that, at a 95% confidence level, humane killing traps render ≥70% of target animals irreversibly unconscious in ≤3 min. It has been used in the past to test traditional trap designs, and to develop new trapping devices (Proulx 1999). Killing neck snares have not been evaluated according to Proulx and Barrett's (1994) standard.

A trap selectivity standard has also been developed by the International Organization for Standardization (ISO 1999a, b). The selectivity of a trap for a particular species is based on

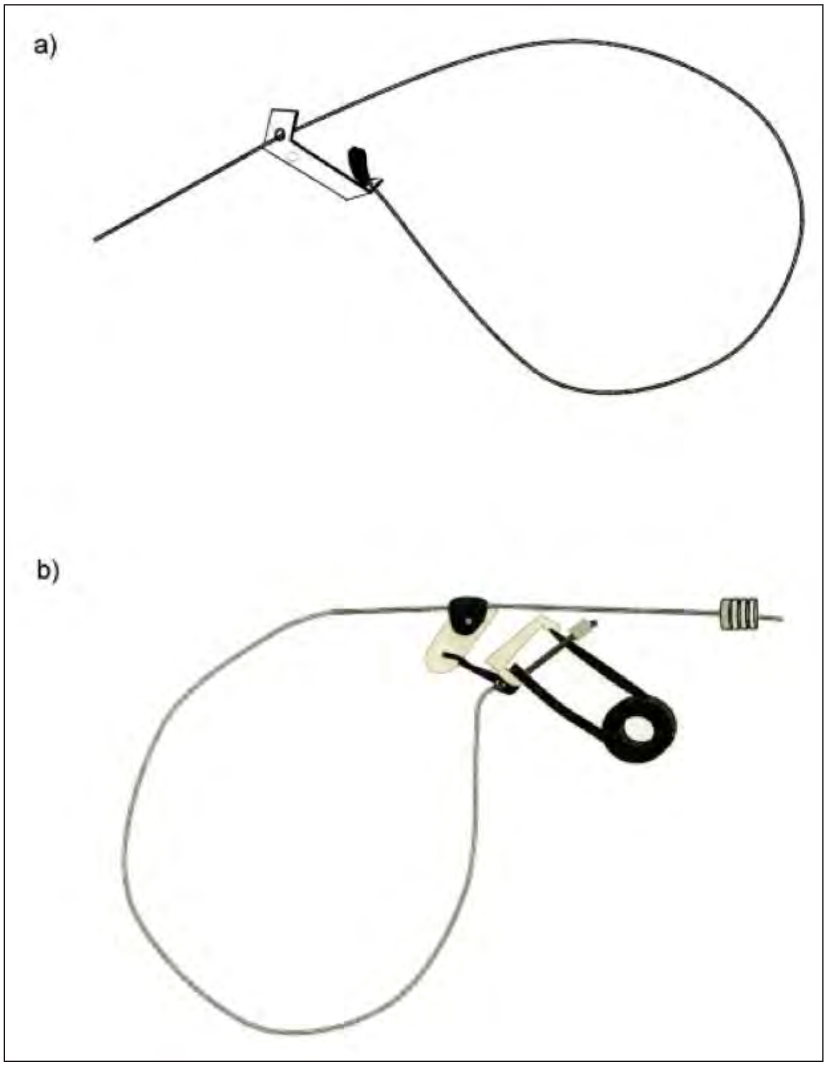

Figure 1. Manual killing neck snares: a) basic construction with a one-way lock; b) improved device with a Cam-Lock and a Senneker Stinger (http://martysenneker.com/) kill spring.

a comparison with the selectivity level of control (commonly used) traps (ISO 1999a, b). Trap selectivity is calculated as the number of captured target animals divided by the total number of captured animals. There is no minimum acceptable percentage of selectivity.

SCIENTIFIC ASSESSMENTS OF KILLING NECK SNARES TO HUMANELY KILL CANIDS

Manual killing neck snares

FPCHT (1981) first assessed the ability of manual killing neck snares to kill anaesthetized red foxes quickly. Researchers provided the power required to tighten the nooses, and although they attempted to simulate snare actions as described by an experienced trapper, the animals continued to breathe for 30-40 min after snaring. Even after tightening the snare to 2-3 cm less than the diameter of an animal's neck, researchers were able to push a swab into the trachea of animals while the snare was still tight. On the basis of laboratory kill tests, FPCHT (1981) concluded that killing neck snares could not be condoned as humane trapping devices for foxes. While it is best to snare canids behind the jaw where the carotid artery and the trachea are maximally exposed, FPCHT researchers failed to achieve exact positioning in the laboratory, and concluded that it would be even more difficult to accomplish in the field. Although trapper experience and expertise on the proper use and placement of snares is important in capturing animals properly, previous studies showed that it was impossible to restrict captures to the neck area. Guthery and Beasom (1978) reported that of 65 snared coyotes, 59% were neck catches, 20% flank, and 10% foot. Also, nearly half of the animals were alive the morning after being snared. Phillips' (1996) evaluation of killing

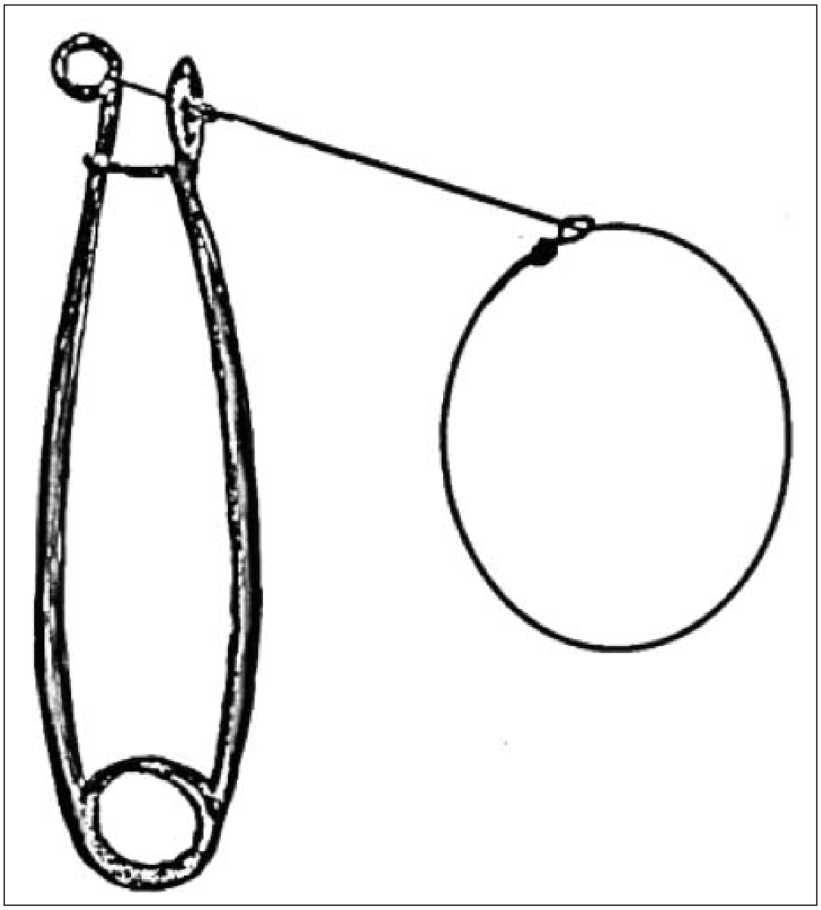

Figure 2. A power killing neck snare.

neck snares showed that out of 301 snared coyotes, 25 (7%) were captured by the body, and 12 (4%) by the leg. Phillips (1996) also reported that 5% to 32% of the animals captured in various snare models were still alive when found. Snare location on an animal is influenced by many factors such as the behaviour of the animal when entering the loop (Proulx and Barrett 1990), snare height and loop diameter, positioning of the lock, preload on the loop (i.e., a little tension is put into the loop to force it to close quicker), and environmental and maintenance factors (rust, twists in the snare cable, snowfall), etc. (G. Proulx and D. Rodtka, personal observations).

To gain more information on snared canids, FPCHT (1981) also examined 3 red foxes, 25 coyotes and 12 wolves captured on traplines in manual killing neck snares. Whereas many animals were still alive when found, some ≥12 h after being captured, post mortem examinations and observations by the trapper suggested that, in most cases, animals did not die within 300 sec. The pathologist on the Committee could not estimate the time to irreversible loss of consciousness.

It is often claimed that capture sites that show little disturbance are indicative of a quick death by asphyxiation (e.g., Phillips 1996). Nonetheless, FPCHT (1981) observed that snared animals could, in fact, react quite violently to capture without causing significant disturbance to the capture site. On traplines, Proulx also observed cases where captured animals remained conscious for several hours without disturbing the trapping site. Captured animals may remain conscious but physically inactive due to distress, shock, injury or pain.

Power killing neck snares

FPCHT (1981) tested the King Power Snare (Western Creative Services Ltd., Winnipeg, Manitoba) with 2 red foxes in enclosures. One fox remained conscious after 5 min, while the other had a weak corneal reflex at 5 min and was euthanized.

A more thorough evaluation of power killing neck snares was conducted by Proulx and Barrett (1990) who evaluated the King (1.6 mm diameter cable), Mosher (1.6 mm diameter cable; W. C. Mosher, Mayerthorpe, Alberta), and Olecko (1.2 mm diameter cable; R. Olecko, Winnipeg, Manitoba) power killing neck snares. All 3 models rendered at least 4 out of 5 anaesthetized red foxes irreversibly unconscious within 10 min, and were selected for tests with non-anaesthetized animals in semi-natural environments. Proulx and Barrett (1994) found it was difficult to capture foxes behind the jaw with power killing neck snares, and to cause an irreversible loss of consciousness within 300 sec. Both the King and Mosher power killing neck snares failed, i.e., they did not render irreversibly unconscious 2 neck-captured foxes in ≤5 min or they did not consistently capture the animals by the neck. Out of 7 tests with the Olecko killing neck snares, 2 animals lost consciousness within 5 min, 2 within 6 min, and 3 animals were euthanized. Proulx and Barrett (1990) questioned the ability of power killing neck snares to humanely kill canids, and they did not recommend them as humane trapping devices. As in FPCHT's (1981) studies with manual killing neck snares, Proulx and Barrett (1990) were unable to consistently capture the animals by the neck.

Anatomical and physiological considerations – It is difficult to constrict the trachea of a fox because of its rigid cartilaginous rings and adjacent musculature. In fact, the percentage of compression achieved by power killing neck snares as opposed to manual snares is not significantly different (FPCHT 1981). Rowsell (1981) noted that, although a 2-mm probe could not be passed down the trachea of 2 foxes captured in power killing neck snares, good aeration was present in the inflated lungs of each animal as evidenced by the organ's pinkish-red colour. Like many terrestrial mammals, foxes will gasp reflexively when carbon-dioxide levels in the blood rise and oxygen levels fall (Loufbourrow *et al.* 1957; Barrett *et al.* 2009). Gasping is a normal physiological response to stimulate a return to regular breathing (Guntheroth and Kawabori 1975; Coleridge and Coleridge 1994). Any slight passage left in the trachea allows air to reach the lungs in response to the reflexive gasp (FPCHT 1981).

Laboratory tests with dogs show that canids have the ability to continue to circulate blood to the brain after bilateral ligation of the common carotid arteries because of the ability of other arteries (e.g., vertebral arteries) situated more deeply within the neck to compensate (Moss 1974; Clendenin and Conrad 1979a, b). Collateral circulation also occurs within the venous blood flow from the brain such that drainage can continue if the internal jugular veins are occluded (Andeweg 1996; Daoust and Nicholson 2004). Because of collateral blood circulation, it is difficult, if not impossible, to stop blood flow to and from the brain by tightening a snare on the neck. To reinforce this point, Daoust and Nicholson (2004) reported the case of a 2-year-old male coyote found in a moribund state on Prince Edward Island, 1 month after the official end of the trapping season, with a snare deeply embedded in the ventral portion of its neck. The killing neck snare had presumably malfunctioned and the cable had cut through the soft tissues of the neck, transecting the full diameter of the trachea, and was embedded in scar tissue between the trachea and the esophagus. The snare had also completely obstructed both jugular veins and both common carotid arteries.

Coyotes captured in snares may break the lock or chew through the cable if the lock does not tighten sufficiently to cause death (Phillips 1996). Repanshek (2008) reported the case of 2 wolves that had been snared outside Denali National Park and Preserve, Alaska, and had then escaped with the tightened loops around their necks. Both wolves were spotted by park staff a few days before 1 of them was immobilized with a tranquilizer dart. The snare was deeply embedded in the wolf's neck (Figure 3). The other wolf was not relocated. Injuries and animal suffering resulting from escapes from a snare are known to occur (Table 1), but the majority of animals that escape killing neck snares and subsequently die likely go undetected by people.

CAPTURE SELECTIVITY

Killing neck snares are efficient at capturing canids (Haber 1996; Phillips 1996) but they are not selective. Selectivity rates of 52% (Guthery and Beasom 1978) and 77% (Phillips 1996) have been reported for coyote snares. Moose (*Alces alces*), caribou (*Rangifer tarandus*), and Sitka black-tailed deer (*Odocoileus hemionus sitkensis*)

Figure 3. Gray wolf that escaped from a killing snare and was found alive days after in Denali National Park and Preserve. The snare was deeply embedded in the neck of the animal (Photo: Denali National Park and Preserve).

Table 1. Specimens submitted to the Canadian Wildlife Health Cooperative from 1990-2014 that either were injured or died as a consequence of capture by killing neck snares. Canids had escaped from killing neck snares. All other specimens were by-catches.

Species		**Number of cases**		
Common name	**Latin Name**	**Injured by snare**	**Killing by snare**	**Total snared**
Mammals				
Target species				
Coyote	*Canis latrans*	2	0	2
Gray wolf	*Canis lupus*	4	0	4
Red Fox	*Vulpes vulpes*	1	0	1
Non-target species				
American black bear[a]	*Ursus americanus*	1	0	1
Bobcat[b]	*Lynx rufus*	0	1	1
Canada lynx[c]	*Lynx canadensis*	0	8	8
Fisher	*Pekania pennanti*	0	2	2
Mountain lion	*Puma concolor*	0	4	4
Snowshoe hare	*Lepus americanus*	0	1	1
White-tailed deer	*Odocoileus virginianus*	0	4	4
Wolverine[b]	*Gulo gulo*	0	1	1
Total		**8**	**21**	**29**
Birds				
Bald eagle	*Haliaeetus leucocephalus*	4	75	79
Barred owl	*Strix varia*	0	2	2
Common raven	*Corvus corax*	0	2	2
Golden eagle	*Aquila chrysaetos*	2	25	27
Goshawk	*Accipiter gentilis*	0	3	3
Great horned owl	*Bubo virginianus*	2	2	4
Red-tailed hawk	*Buteo jamaicensis*	1	10	11
Rough-legged hawk	*Buteo lagopus*	0	7	7
Total		**9**	**126**	**135**
Total specimens		**17**	**147**	**164**

are often caught in killing neck snares set for gray wolves (Gardner 2007). Cougars (*Puma concolor*) are susceptible to killing neck snares placed near carrion bait to harvest gray wolves. Knopff *et al.* (2010) reported that 11% of a cougar population in west-central Alberta was removed annually as a result of incidental snaring. Guthery and Beasom (1978) reported that a population of collared peccaries (*Pecari tacaju*) was largely extirpated due to coyote snaring. In February 2011, near Rocky Mountain House, Alberta, Rodtka (unpublished data) noticed that a trapper had set 8 wolf killing neck snares around a draw bait on a registered trapline. In 1 month the trapper captured 1 white-tailed deer (*Odocoileus virginianus*), 1 cougar, and 2 wolves. In August 2011, Rodtka also noted that a trapper had set 10-15 killing neck snares to capture wolves that had depredated livestock. Within 1 week, 1 white-tailed deer (*Odocoileus virginianus*), 1 black bear (*Ursus americanus*), and 1 grizzly bear (*Ursus arctos horribilis*), a threatened species in Alberta, were snared. The Canadian Wildlife Health Cooperative received 157 submissions of non-target snare captures between 1990 and 2014, representing 8 species of mammals and 8 species of birds (Table 1). Again, this probably represents a small proportion of the snared animals that die and go undetected or unreported by people. Non-target captures included a wolverine (*Gulo gulo*) and a Canada lynx (*Lynx canadensis*), which are designated species at risk in Quebec (Fortin *et al.* 2005) and Nova Scotia (Nova Scotia Lynx Recovery Team 2006), respectively.

DISCUSSION

Currently available manual and power killing neck snares do not meet the AIHTS' humaneness standards (although these standards do not apply to snares), or Proulx and Barrett's (1994) standard. The work conducted by FPCHT (1981) and Proulx and Barrett (1990) confirmed the original concerns of some wildlife biologists (e.g., Guthery and Beasom 1978) about the cruelty of killing neck snares, and it gives credibility to the recurrent reports of moribund, snared wild and domestic animals rescued by the public (e.g., Perkel 2004; McShane 2014). Neck killing snares with one-way locking tabs were made illegal in the United Kingdom in 1981 (Wildlife and Countryside Act 1981). Killing snares are not used to catch any of the 11 AIHTS species found in the European Union (Talling and Inglis 2009). They are, however, still being used in some US states (Association of Fish and Wildlife Agencies Furbearer Conservation Technical Work Group 2009) and Russia (Talling and Inglis 2009).

The poor performance of manual and power killing neck snares at killing canids was demonstrated in scientific studies where state-of-the-art equipment and set procedures were employed. On traplines, however, many trappers see little or no value in improved locks and swivels (Figure 4) because their snares catch the target animals anyway, albeit in an inhumane manner. Also, trappers are not legally required to update their equipment. In some provinces, e.g., Saskatchewan, killing snares must be visited within a certain period of time, i.e., 48-72 h depending on the proximity from urban areas. In British Columbia, killing snares must be checked at least once every 14 days. In Alberta, there are no mandated checking times for snares. Consequently, snared animals can die slowly from their injuries, but also from exposure, exhaustion, dehydration, or starvation.

The ISO standards are the result of compromises between participating governments and agencies, and they may not be stringent due to a lack of will among some participants to either pursue further technological development or implement state-of-the-art technology (G. Proulx, personal observations at ISO meetings in Brussels, Belgium). Nonetheless, killing neck snares impact significantly on the welfare of captured animals, in a manner similar to that of steel leghold traps, which have been judged unacceptable at the international level (Proulx and Barrett 1989). It is therefore difficult to understand how killing neck snares became an exception in AIHTS's standards,

Figure 4. Basic manual killing neck snare set on a canid trail in northwestern Saskatchewan, February 2009. Note the absence of all possible improvements (e.g., locking tab, lock with compression spring, and swivel) (Photos: Gilbert Proulx).

particularly because alternative restraining devices are available for capturing canids such as modified foothold traps and foot snares (Proulx *et al.* 2012) and cable restraints (Garvey and Patterson 2014.) These alternative trapping devices were found to be humane for capturing canids without compromising capture efficiency (Linhart and Dasch 1992; Pruss *et al.* 2002; Garvey and Patterson 2014). Even these restraining devices should, of course, be monitored within a 24-h period to minimize pain and discomfort. Reducing the time animals spend in restraining devices greatly reduces injuries (Proulx *et al.* 1994; Garvey and Patterson 2014).

The snaring of non-target species can be minimized with the use of an additional wire (diverter) placed at a height that allows ungulates taller than the set height of a wolf snare to contact and push the snare away prior to contact (Gardner 2010). Snares may be equipped with a ferrule to stop the noose from closing below a specific size (Guthery and Beasom 1978), or a breakaway system that releases larger animals such as adult ungulates, though they may still capture fawns (Phillips 1996). Snaring may become more selective through better selection of trap sites, lures, and loop diameters (Knopff *et al.* 2010; FTGQ 2014). In spite of all this, however, non-target species will continue to be snared because concealed snares are set on trails or close to baits that attract an array of species and have the potential to capture any individual entering the loop.

In light of the scientific evidence regarding the lack of humaneness and the non-selectivity of snares for capturing canids, we recommend that the relevant authorities in the international community:

- Modify AIHTS to accept only killing (commercial and non-commercial) neck snares that quickly render canids irreversibly unconscious, insofar as the state of the science or the art will allow; and
- In the absence of killing neck snares that kill quickly, phase-out all snares for which efficient and more humane alternatives exist.

If wildlife managers believe that killing neck snares must remain available to trappers, then intensive research must be conducted to develop reliable and selective sets to consistently snare canids by the neck (Proulx and Barrett 1990) and to minimize non-target capture, and a thorough research program with strict assessment criteria must be implemented (Proulx *et al.* 2012).

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LITERATURE CITED

Andeweg, J. 1996. The anatomy of collateral venous flow from the brain and its value in aetiological interpretation of intracranial pathology. Neuroradiology 38: 621-628.

Association of Fish and Wildlife Agencies Furbearer Conservation Technical Advisory Group. 2009. Modern snares for capturing mammals: definitions, mechanical attributes and use considerations. Available at: http://files.dnr.state.mn.us/recreation/hunting/trapping/modern_snares.pdf. Accessed 7 December 2014.

Barrett, K. E., S. M. Barman, S. Boitano, and H. L. Brooks. 2009. Ganong's review of medical physiology, 24th edition. McGraw-Hill Medical, New York, New York, USA.

Clendenin, M. A., and M. C. Conrad. 1979a. Collateral vessel development, following unilateral chronic carotid occlusion in the dog. American Journal Veterinary Research 40: 84-88.

Clendenin, M. A., and M. C. Conrad. 1979b. Collateral vessel development after chronic bilateral common carotid artery occlusion in the dog. 40: 124-1248.

Coleridge, H. M., and G. C. J. Coleridge 1994. Pulmonary reflexes: neural mechanisms of pulmonary defense. Annual Review of Physiology 56: 69-91.

Daoust, P.-Y., and P. H. Nicholson. 2004. Severe chronic injury caused by a snare in a coyote, *Canis latrans*. Canadian Field-Naturalist 118: 243-246.

Federal Provincial Committee for Humane Trapping (FPCHT). 1981. Report of the Federal Provincial Committee for Humane Trapping. Federal-Provincial Wildlife Conference, Canadian Wildlife Service, Ottawa, Ontario, Canada.

Fédération des Trappeurs Gestionnaires du Québec 2014. Meilleures pratiques de piégeage. Available at : http://www.ftgq.qc.ca/fr/publications/images/fiches_piegeage_francais2014.pdf. Accessed August 7, 2014.

Fortin, C., V. Banci, J. Brazil, M. Crête, J. Huot, M. Huot, R. Lafond, P. Paré, J. Shaefer, and D. Vandal. 2005. National recovery plan for the wolverine (*Gulo gulo*) (Eastern Population). National Recovery Plan No. 26. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, Ontario, Canada.

Gardner, C. L. 2010. Reducing non-target moose capture in Wolf snares. Alces 46: 167-182.

Garvey, M. E., and B. R. Patterson. 2014. Evaluation of cable restraints to live-capture coyotes (*Canis latrans*) in southern Ontario, Canada. Canadian Wildlife Biology & Management 3: 22-29.

Guntheroth, W. G., and I. K. Kawabori. 1975. Hypoxic apnea and gasping. The Journal of Clinical Investigation 56: 1371-1377.

Guthery, F. S., and S. L. Beasom. 1978. Effectiveness and selectivity of neck snares in predator control. Journal of Wildlife Management 42: 457-459.

Haber, G. C. 1996. Biological, conservation, and ethical implications of exploiting and controlling wolves. Conservation Biology 10: 1068-1081.

Halford's. 2014. Mail order webstore, Edmonton, Alberta, Canada. Available at: https://www.halfordsmailorder.com/eSource/ecom/eSource/default/default.aspx. Accessed August 7, 2014.

International Organization for Standardization (ISO). 1999a. TC191. Animal (mammal) traps. Part 4: methods for testing killing trap systems used on land or underwater. International Standard ISO/DIS 10990-4. Geneva, Switzerland.

International Organization for Standardization (ISO) . 1999b. TC191. Animal (mammal) traps. Part 5: methods for testing restraining traps. International Standard ISO/DIS 10990-5. Geneva, Switzerland.

Klassen, G. 2014. Upgrading a prehistoric tool. Alberta Outdoorsmen 16 (7): 72-73.

Knopff, K. H., A. A. Knopff, and M. S. Boyce. 2010. Scavenging makes cougars susceptible to snaring at wolf bait stations. Journal of Wildlife Management 74: 644-653.

Linhart, S. B., and G. J. Dasch. 1992. Improved performance of padded jaw traps for capturing coyotes. Wildlife Society Bulletin 20: 63-66.

Loofbourrow, G. N.., W. B. Wood, and I. L. Baird. 1957. Tracheal constriction in the dog. American Journal of Physiology 191: 411- 415.

McShane, K. 2014. No cruelty investigation for injured wolf caught in a snare. Almaguin News, 13 February, 2014.

Moss, G. 1974. The adequacy of the cerebral collateral circulation: tolerance of awake, experimental animals to acute bilateral common carotid artery occlusion. Journal Surgery Research 16: 337-338.

Nova Scotia Lynx Recovery Team. 2006. Provincial recovery plan for the Canada lynx (*Lynx canadensis*), Nova Scotia. Nova Scotia Department of Natural Resources, Nova Scotia, Canada.

Official Journal of the European Communities. 1998. Agreement on international humane trapping standards between the European Community, Canada and the Russian Federation. Available at: http://ec.europa.eu/world/agreements/downloadFile.do?fullText=yes&treatyTransId=1428. Accessed 7 August 2014.

Perkel, C. 2004. Group wants wire snares outlawed. The London Free Press News, 23 January, 2004.

Phillips, R. L. 1996. Evaluation of 3 types of snares for capturing coyotes. Wildlife Society Bulletin 24: 107-110.

Powell, R. A., and G. Proulx. 2003. Trapping and marking terrestrial mammals for research: integrating ethics, standards, techniques, and common sense. Institute of Laboratory Animal Research Journal (ILAR) 44: 259-276.

Proulx, G. 1999. Review of current mammal trap technology in North America. Pages 1-46 *in* G. Proulx, editor, Mammal trapping, Alpha Wildlife Publications, Sherwood Park, Alberta, Canada.

Proulx, G., and M. W. Barrett. 1989. Animal welfare concerns and wildlife trapping: ethics, standards and commitments. Transactions of the Western Section of the Wildlife Society 25: 1-6.

Proulx, G., and M. W. Barrett. 1990. Assessment of power snares to effectively kill red fox. Wildlife Society Bulletin 18: 27-30.

Proulx, G., and M. W. Barrett. 1994. Ethical considerations in the selection of traps to harvest martens and fishers. Pages 192-196 *in* S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors, Martens, sables, and fishers: biology and conservation. Cornell University Press, Ithaca, New York, USA.

Proulx, G., M. R. L. Cattet, and R. A. Powell. 2012. Humane and efficient capture and handling methods for carnivores. Pages 70-129 *in* L. Boitani and R. A. Powell, editors. Carnivore ecology and conservation: a handbook of techniques, Oxford University Press, London, UK.

Proulx, G., I. M. Pawlina, D. K. Onderka, M. J. Badry, and K. Seidel. 1994. Field evaluation of the No. 1-1/2 steel-jawed leghold and the Sauvageau 2001-8 traps to humanely capture arctic fox. Wildlife Society Bulletin 22: 179-183.

Proulx, G., and M. Santos-Reis. 2012. A century of change in *Martes* research and management. Pages 471-489 *in* K. Aubry, B. Zielinski, M. Raphael, G. Proulx, and S. Buskirk, editors. Biology and conservation of martens, sables, and fishers: a new synthesis. Cornell University, Press, Ithaca, New York, USA.

Pruss, S. D., N. L. Cool, R. J. Hudson, and A. R. Gaboury. 2002. Evaluation of a modified neck snare to live-capture coyotes. Wildlife Society Bulletin 30: 508-516.

Ram Power Snare Systems. 2014. "Ram" connection. Available at: http://ramconnection.com/ram-power-snares. Accessed August 7, 2014.

Repanshek, K. 2008. Vet removes snare from neck of wolf in Denali National Park and Preserve. http://www.nationalparkstraveler.com/2008/05/vet-removes-snare-neck-Wolf-denali-national-park-and-preserve. Accessed 15 August 2014.

Rowsell, H. C. 1981. Research for development of comprehensive humane trapping systems snare study, Part I. University of Ottawa report submitted to the Federal Provincial Committee for Humane Trapping, Ottawa, Ontario, Canada.

Sinnema, J. 2014. A country built on fur. Edmonton Journal, 1

March: B1, B3-B5.

Talling, J. C., and I. R. Inglis. 2009. Improvements to trapping standards. DG Env, http://ec.europa.eu/environment/biodiversity/animal_welfare/hts/pdf/final_report.pdf. Accessed 7 December 2014.

Trapper Gord. 2014. Trapper Gord homestead and survival. Available at: http://trappergord.com/trapper-gord/. Accessed 7 August, 2014.

Wildlife and Countryside Act. 1986. Wildlife and countryside act 1981, Chapter 69. Available at: http://www.legislation.gov.uk/ukpga/1981/69. Accessed 7 December 2014.

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Gilbert Proulx is Director of Science at Alpha Wildlife Research & Management, Editor-in Chief of the Canadian Wildlife Biology & Management journal, and Chair of the *Martes* Working Group. Gilbert has 39 years of field experience as a wildlife biologist. He has published more than 120 scientific articles, 5 textbooks, and 8 field guides (species at risk). Since 1985, Gilbert has been involved in the evaluation and development of humane trapping devices, and published extensively on techniques to capture and handle mammals. His main research interest focuses on mammals, particularly in forest and agriculture ecosystems, and on technology development, mainly on mammal trapping and detection methods.

Dwight Rodtka – I was raised in the bush and on the trapline with my grandfather as soon as I could walk, with some rest breaks in his back pack fairly often. Then, all too soon, we moved out of the bush to a small farm and school. I was an Agricultural Fieldman for the Alberta Department of Agriculture for 39 years. My responsibilities were primarily to assist producers with predator problems both directly and through extension. The coyotes taste for sheep kept us busy using and teaching others about management, toxicants, and snares to reduce loss. During this time, we updated the snaring policy to reduce non-target catches and increase humaneness somewhat. I also began making all the snares used in the province, which were under Agricultural control. When jurisdiction for game farming and aquaculture transferred from Fish and Wildlife to Agriculture, I became a licensing inspector for both, in addition to my regular responsibilities. Today, my wife Glenda and I still live in the "bush", on a small farm a few kilometres southwest of Rocky Mountain House, Alberta.

Morley W. Barrett worked as a wildlife biologist for the province of Alberta for 32 years and subsequently worked for Ducks Unlimited Canada for 5 years. He has held management, research and executive positions during his career. His professional focus has included extensive work on pronghorns (*Antilocapra americana*), humane trapping and wildlife diseases. Dr. Barrett is currently retired and lives in the Rocky Mountain House area of Alberta.

Marc Cattet is a senior research scientist and a wildlife veterinarian with the Canadian Wildlife Health Cooperative at the Western College of Veterinary Medicine, University of Saskatchewan. He provides technical expertise in the areas of wildlife capture and handling to government wildlife agencies in Canada, and serves as project veterinarian for the Foothills Research Institute Grizzly Bear Research Program. His research is focused toward detecting, understanding, and reducing the effects of a range of human activities on the health of wild species.

Dick Dekker is an independent wildlife ecologist with a PhD from Wageningen University, The Netherlands. From 1964 to the present, he has recorded long-term wolf-ungulate dynamics in Jasper National Park, and detailed predator-prey interactions of falcons and waterbirds in central Alberta and along the Pacific west coast of British

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Erin Moffatt received both BSc and MSc through the University of Saskatchewan, Departments of Biology and Veterinary Pathology, respectively. She has spent much of her career studying populations of mule deer (*Odocoileus hemionus*) in southern Saskatchewan. These populations were the focus of her graduate research, which looked at movement patterns and social dynamics in relation to chronic wasting disease spread. Erin is currently employed as a Data and Communications Technologist for the Canadian Wildlife Health Cooperative, where her interests in data quality and scientific communication are put to good use.

Roger A. Powell - Over the past 40 years, my research has emphasized how limiting resources affect animals. I have studied energy budgets, sexual dimorphism, population stability, coexistence of competitors, and territoriality of fishers, weasels, black bears and pine voles (*Microtus pinetorum*). My field research has emphasized animals' home ranges and spacing. I now envision animals living in a fitness landscape where the habitat value at each place is the potential contribution of that place to an animal's fitness. I still do not know what a home range is but am convinced that animals give us critical clues. Studying my own home ranges has provided me with important insights. As a kid, I read field guides with a flashlight under the covers after my parents told me to put out the lights. Did that destine me to become a field biologist or was I just a crazy kid? Since then I have held a frightened fisher by the tail, had a weasel urinate on my head, watched a mother black bear nurse her cubs in their den, and have spent too many hours in front of a computer monitor. In the end, I still don't know what I shall be when I grow up. Shall I be a biologist who builds wood/canvas canoes, does photography, runs, trains dogs and loves to camp, or shall I be a canoe builder who is also a biologist who does photography, runs and trains dogs, or shall I be a photographer who . . .

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Trapping furbearers: an overview of the biological and social issues surrounding a public policy controversy

William F. Andelt, Robert L. Phillips, Robert H. Schmidt, and R. Bruce Gill

The foothold trap is an important and traditional wildlife management tool (Boggess et al. 1990). Foothold traps comprised about 61% of the traps owned by trappers in the United States during 1992 (International Association of Fish and Wildlife Agencies Fur Resources Committee 1993). An estimated 300,000 licensed trappers harvested $121 million of fur in the United States during 1987 (International Association of Fish and Wildlife Agencies Fur Resources Committee 1993), which resulted in a total economic impact of $810.8 million (Southwick Associates, Arlington, Va., unpublished report, 1993). In Canada, about 51,000 trappers (N. Jotham, Canadian Wildlife Service, Ottawa, Ont., personal communication) harvested $26 million of fur (Statistics Canada 1996) during 1994–95. Many trappers, especially aboriginals in Canada, use furbearers for food (Todd and Boggess 1987). Of 61 North American jurisdictions, 80% referred nuisance furbearer complaints to trappers (Williams and McKegg 1987), and about 63% of trappers have been contacted to trap problem animals (International Association of Fish and Wildlife Agencies Fur Resources Committee 1993). Foothold traps have been used extensively by the U.S. Department of Agriculture's Wildlife Services program, accounting for 9% of 89,213 coyotes (*Canis latrans*) taken in the United States during 1995 (M. Mendoza, U. S. Department of Agriculture, APHIS, Wildlife Services, Riverdale, Md., personal communication), usually to resolve livestock depredation complaints. Foothold traps also have been used to remove coyotes, red foxes (*Vulpes vulpes*), and other predators to enhance survival of endangered San Joaquin kit foxes (*V. macrotis*; Cypher and Scrivner 1992), California least terns (*Sterna antillarum*; Butchko 1990), and waterfowl (Anthony et al. 1991, Lokemoen and Woodward 1993), as well as to capture endangered species such as gray wolves (*C. lupus*) and red wolves (*C. rufus*) for research and relocation. Additionally, foothold traps are a valuable method for capturing furbearers for research purposes.

Despite these apparent wildlife management benefits, trapping has been controversial at times during this century (Feldman 1996). Numerous attempts, at the local, state, and national levels, have been made to ban trapping; however, most have failed (Gentile 1987). Recent ballot initiatives to ban or limit trapping in Arizona (1994), Colorado (1996), Massachusetts

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Key words: animal welfare, *Canis latrans*, Colorado, coyote, foothold traps, furbearers, human dimensions, humaneness, injury, selectivity, wildlife damage

Table 1. Frequency of foot injuries to coyotes captured in 8 types of restraining devices during Denver Wildlife Research Center studies.

Injury	Points scored[f]	Sterling MJ600®[a] (n=68)[d] %	No. 3 North woods laminated[a] (n=59) %	Victor 3NM®[b] (n=33) %	Heim-brook Special[b] (n=30) %	Soft Catch® standard[c] (n=53) %	Soft Catch modified[c] (n=60) %	No. 31/2 E-Z Grip®[a] (n=65) %	Belisle foot snare[b] (n=30) %
Edematous swelling or hemorrhage[g]	5-15	94	95	100	100	96	95	97	100
Cutaneous laceration <2 cm	5	45	58	45	63	60	62	20	17
Cutaneous laceration >2 cm	10	47	25	45	33	23	12	11	7
Minor periosteal abrasion	10	70	78	48	53	23	25	3	7
Minor subcutaneous soft tissue maceration or erosion	10	26	54	0	47	6	2	2	0
Minor tendon or ligament severance	25	63	46	52	70	13	17	6	0
Amputation of 1 digit	25	1	0	0	0	0	0	2	3
Major subcutaneous soft tissue maceration or erosion	30	9	8	0	6	0	0	3	0
Joint luxation below carpus or tarsus	30	19	13	39	17	24	7	6	0
Major periosteal abrasion	30	26	39	12	13	0	2	2	10
Major laceration on foot pads	30	6	0	0	10	6	2	8	3
Simple fracture at or below (distal to) carpus or tarsus	50	1	0	0	0	0	2	0	0
Amputation of 2 digits	50	0	0	0	0	2	0	0	0
Amputation of 3 or more digits	100	1	0	0	0	0	0	0	0
Amputation above digits	100	1	0	0	0	0	0	0	0
Joint luxation above carpus or tarsus	100	0	0	0	0	2	0	2	0
Major tendon or ligament severance	100	0	0	0	0	2	0	0	0
Compound or simple comminuted fracture above carpus or tarsus	100	0	2	0	0	0	0	2	0
Compound or comminuted fracture at or below carpus or tarsus	100	9	2	0	3	2	0	2	0

[a] From Phillips et al. (1996).

[b] From R. L. Phillips (Unpublished data).

[c] From Gruver et al. (1996). No. 3 Soft Catch® standard=No. 3 Soft Catch® trap with standard factory coil springs and a clamping force of 2.1 kg/cm^2. No. 3 Soft Catch® modified=No. 3 Soft Catch® trap with 4 coil springs and a clamping force of 3.6 kg/cm^2.

[d] Sample size for injury calculations.

[e] Each injury category was considered separately and a coyote may be represented in more than 1 row. Total percent exceeds 100.

[f] Injury points were added to obtain mean and median injury scores in Table 2.

[g] Mild=5 points, moderate=10 points, and major=15 points.

(1996), and California (1998); recent state surveys in Arizona (Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993), Colorado (Fulton et al. 1995), and Illinois (Duda and Young 1994); and national surveys (Arthur 1981, Kellert 1981, Reiter et al. 1995) indicate that most citizens do not support trapping.

In 1991, the European Council passed Regulation Number 3254/91, which prohibited use of foothold traps in the 12 countries (currently 15 countries) of the European Union as of January 1995. This regulation also prohibited importation of pelts and manufactured goods from 13 furbearer species originating in countries where harvesting with foothold traps was allowed or using trapping methods not meeting "internationally agreed humane trapping standards." Agreement was not reached on an international trap standard; thus the regulation was scheduled to ban importation of fur products from the United States and other countries using foothold traps starting in December 1997. Canada, Russia, and the European Community signed an "Agreement on International Humane Trapping Standards between Canada, the European Community and the Russian Federation" in 1997 and 1998. On 18 December 1997 the United States and the European Community signed an "Agreed Minute," a non-binding understanding to be implemented through trapping-related Best Management Practices. Both agreements are intended to improve the welfare of captured animals, thus allowing the continued importation of fur products into Europe.

We review the biological and social issues surrounding the furbearer trapping controversy and present recommendations to manage those issues. We focus on foothold traps because most public concern has been directed at foothold traps. We also focus on coyotes because most foothold trap research has been conducted on that species, and, at least in the western United States, coyotes have been at the center of controversy over predator management.

The issues

The trapping controversy has been evolving since at least the turn of the century (Gentile 1987). Biological and social developments have contributed to this evolution.

Injuries and animal welfare concerns

Several professional wildlife biologists have emphasized the need to minimize injury and pain inflicted on animals by trapping (Payne 1980, Schmidt and Bruner 1981, Proulx and Barrett 1989). When wildlife agencies and professional wildlife managers allow animals to endure unnecessary injury and pain, they lend credence and strength to charges by animal welfare and animal rights advocates that wildlife management professionals are insensitive and unresponsive to animal welfare issues (Schmidt and Bruner 1981, Decker and Brown 1987).

Humane yet effective traps are available for capture of some carnivores. Standard steel-jawed foothold traps cause significant measurable injuries to captured coyotes (Olsen et al. 1986, 1988; Onderka et al. 1990; Phillips et al. 1992) and other species (Olsen et al. 1986, 1988). Padded-jaw foothold traps, such as the Soft Catch® (Woodstream Corporation, Lititz, Pa.) and E-Z Grip® (Livestock Protection Company, Alpine, Tex.) (mention of commercial products does not constitute endorsement by the authors or the federal government), compared to standard and thick-jaw (laminated) steel traps, significantly reduce foot injuries to captured coyotes (Tables 1, 2; Olsen et al. 1986, 1988; Onderka et al. 1990; Linhart and Dasch 1992; Phillips et al. 1992, 1996) and other species (Olsen et al. 1986, 1988; Kreeger et al. 1990; Kern et al. 1994). Kreeger et al. (1990) found that padded traps caused less trauma than unpadded traps to red foxes. Padded traps have been available since 1984; however, they comprised only 3% of foothold traps owned by trappers in the United States during 1992 (International Association of Fish and Wildlife Agencies Fur Resources Committee 1993). The slow adoption of Soft Catch traps probably was influenced by low capture efficiency of early models (Linscombe and Wright 1988). Also, raccoons (*Procyon lotor*) sustained significantly fewer injuries when captured in the EGG® trap compared to the Number 1 Victor® coil spring trap (Hubert et al. 1996).

Figure 1. Number 3 Soft Catch® trap modified with additional springs and Paws-I-Trip™ pan tension device (M-Y Enterprises, Homer City, Pa.) decreases injuries to coyotes compared to unpadded steel-jaw foothold traps (Gruver et al. 1996) and excludes most small non-target animals that step on the pans of traps (Phillips and Gruver 1996).

The most common foot injury to coyotes and red foxes captured in padded foothold traps is edema (Table 1), and these animals, if released, recover within a few days (Saunders and Rowsell 1984). Freezing may occur less frequently in limbs of coyotes caught in padded traps (47% of 21 limbs) than those caught in unpadded traps (72% of 22 limbs; Onderka et al. 1990).

We believe reduced foot injuries sustained by coyotes and other animals captured in padded, compared to unpadded, traps is attributable to the padded jaws rather than the weaker springs on an earlier version of Soft Catch traps. Coyotes captured in Number 3 Soft Catch® traps, modified with stronger or additional coil springs (Figure 1) or in the larger Number 31/2 E-Z Grip® trap, sustained significantly fewer or similar foot injuries compared to coyotes captured in Soft Catch traps with standard and weaker coil springs (Tables 1, 2; Linhart et al. 1988, Gruver et al. 1996, Phillips et al. 1996). However, many animal welfare and animal rights organizations oppose padded traps (Stevens 1992) because foot, leg, and tooth injuries are not completely eliminated and even padded traps may be painful.

Trap check intervals and injuries

Opponents of trapping express concerns about lack of food and water and the stress endured by animals in traps. Boggess and Henderson (1981) and the Fur Institute of Canada (1989) recommended that all live-holding devices set on land should be checked daily. Using smaller traps (Novak 1987, Saunders et al. 1988, Warburton 1992) and daily or almost daily (1.4 days), early-morning trap checks (Novak 1987, Saunders et al. 1988, Proulx et al. 1994) have reduced injuries to trapped animals. In the United States during 1995, 33 states required that land-set traps must be checked every 24 hours or daily, but trap-check intervals were unlimited in 4 states (International Association of Fish and Wildlife Agencies Fur Resources Technical Subcommittee 1995).

Humaneness and capture efficiency

Foothold traps and trapping techniques developed to be more humane or selective should be comparable in capture efficiency (i.e., number of animals caught/unit of effort) to standard traps if they are to be acceptable to trappers (Novak 1987, Naylor and Novak 1994). However, even if more humane traps are not as efficient, trappers may have to use them to satisfy public concerns about the humane treatment of animals (Proulx and Barrett 1989). An early model of the Soft Catch trap had lower rates of capturing coyotes (Linhart et al. 1986, 1988; Linscombe and Wright 1988), bobcats (*Lynx rufus*), and red foxes (Linscombe and Wright 1988) than standard traps, but capture rates for red foxes were similar in another study (Tullar 1984). Newer and improved Number 3 Victor Soft-Catch® traps, when properly set, were as efficient as unpadded traps in capturing coyotes (Table 2; Skinner and Todd 1990, Linhart and Dasch 1992, Phillips et al. 1992, Phillips and Mullis 1996).

During wet conditions, Soft Catch traps may be less efficient than steel foothold traps for capturing red foxes (Kern et al. 1994), but Phillips and Mullis (1996) reported that the Number 3 Soft Catch® trap was as effective as unpadded traps for capturing coyotes under a variety of operational trapping conditions. The latest version of Soft Catch traps recently (1997) has been manufactured with stronger springs (C. E. Tully, Woodstream Corporation, Lititz, Pa., personal communication), which may increase capture efficiency during wet conditions (Houben et al. 1993); additional springs also may increase efficiency (Gruver et al. 1996). Efficiency of padded traps improved as trappers gained experience in using them (Skinner and Todd 1990).

Capture selectivity

Trap selectivity depends not only on the mechanical attributes of a trap but also on where and how

Table 2. Mean and median injury scores and capture rates for 8 coyote restraining devices during Denver Wildlife Research Center studies.

Trap type	Test states[a]	n[a]	Injury Score		Capture rate (%)
			Mean	Median	
Sterling MJ600®[b]	Calif., Tex., Id.	68	103.3	80.0	94
No. 3 Northwoods® laminated[b]	Calif., Tex., Id.	59	79.3	80.0	95
Victor 3NM®[c]	Tex.	33	66.3	60.0	95
Heimbrock Special[c]	Calif., Tex.	30	80.5	80.0	94
No. 3 Soft Catch® standard[d]	Calif.	53	43.5	15.0	95
No. 3 Soft Catch® modified[d]	Calif.	60	26.2	15.0	97
No. 31/2 E-Z Grip®[b]	Calif., Tex., Colo.	65	29.0	10.0	88
Belisle foot snare[c]	Tex.	30	19.7	10.0	64

[a] Test states, test dates, and sample sizes for data on injury scores.

[b] From Phillips et al. (1996), and R. L. Phillips (Unpublished data).

[c] From R. L. Phillips (Unpublished data).

[d] From Gruver et al. (1996), and R. L. Phillips (Unpublished data). No. 3 Soft Catch® standard=No. 3 Soft Catch® trap with standard factory coil springs and a clamping force of 2.1 kg/cm². No. 3 Soft Catch® modified=No. 3 Soft Catch® trap with 4 coil springs and a clamping force of 3.6 kg/cm².

the trap is set, factors influenced by the knowledge and skill of a trapper. Properly set traps can effectively capture specific depredating animals (Gipson 1975, Andelt and Gipson 1979) and permit release of non-target animals.

Novak (1987) summarized >25 studies reporting 0 to >2 non-target animals captured/target animal. Trap selectivity for large species, such as coyotes, can be increased significantly by attaching a pan tension device (Figure 1), which increases the weight (generally 1.4–1.8 kg for coyote traps) required to fire the trap, thus excluding small animals (Turkowski et al. 1984, Butchko 1990, Phillips et al. 1992, Phillips and Gruver 1996). Traps modified with pan tension devices excluded 92–100% (Turkowski et al. 1984) and 97% of 826 (Phillips and Gruver 1996) small non-target animals, whereas unmodified traps excluded only 6% (Turkowski et al. 1984). Other methods that may reduce capture rates of non-target animals include setting traps >8 m from carcasses (Hein and Andelt 1994), using appropriate and selective baits and lures (Andelt and Woolley 1996), covering baits in dirt-hole sets, setting traps away from residences and hiking trails, and not setting traps when the probability of capturing non-targets is high. Disadvantages of padded traps and pan-tension devices include higher purchase prices, the cost of replacing standard traps, the possible costs of modifying some new padded traps by attaching pan tension devices, the occasional need to replace worn or chewed rubber pads, and the additional training required to use these new traps effectively.

Public opinion and trapping

The public-at-large has limited knowledge of trapping (Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993; Duda and Young 1994). Only 22-42% of survey respondents indicated they supported trapping (Missouri Department of Conservation 1992; Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993; Duda and Young 1994; Fulton et al. 1995). This lack of support is underscored by a 1994 ballot initiative in Arizona that banned use of most traps for most purposes on public lands by a margin of 59 to 41%; a 1996 ballot initiative in Colorado that banned foothold traps, body-gripping traps, and snares (with a few exceptions) by a margin of 52 to 48%; and 1996 and 1998 ballot initiatives in Massachusetts and California that banned most traps for most purposes by margins of 64 to 36%, and 57.5 to 42.5%, respectively.

The public seems concerned primarily about humane treatment of animals (avoidance of pain and suffering), secondarily about specificity (extent to which only target animals are captured), and least concerned about the cost of control (and presumably trapping) methods (Arthur 1981). Trapping is perceived to cause more pain and suffering than other methods and is judged one of the least acceptable methods to control coyotes (Arthur 1981). In general, the public has negative attitudes toward traps and considers them inhumane (Kellert 1981; Galloway Vigil and Associates 1986; Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993; Reiter et al. 1995).

Public approval of trapping also depends on the reason for trapping. In 2 surveys—one in 1995 in Colorado (Fulton et al. 1995) and one in 1994 in Illinois (Duda and Young 1994)—only 9 and 15% of respondents, respectively, approved of trapping for recreation, whereas 13 and 27%, respectively, approved of trapping to obtain money. However, 69% of respondents in Colorado and 71% in Illinois approved of trapping to protect livestock and property, and 87% of the Colorado respondents supported trapping to prevent the spread of disease.

More than 80% of Colorado adults surveyed indicated that wildlife and trapping laws should be rewritten to ensure that pain and suffering to wildlife were minimized (Fulton et al. 1995). Those respondents (33%) who opposed trapping in Illinois indicated that they would be more likely to find trapping acceptable if daily trap checks and limited trap sizes were legal requirements (they are, in fact, in Illinois), and if certain types of traps were prohibited to ensure that trapping was conducted as humanely as possible given current technology (Duda and Young 1994). Thirty-one percent of the respondents indicated that knowing that seasons were structured in the fall and winter to avoid capture or abandonment of young would make them more inclined to find trapping acceptable. Given these results, we believe the public would be more likely to support padded-jaw traps and other improvements to traps which reduce injuries.

Ballot initiatives are frequently used by small groups exploiting mass media to affect voting and to usurp agency or legislative decisions on wildlife management issues (Minnis 1998). In 1996, the public voted on wildlife policy issues in Alaska, California, Colorado, Idaho, Massachusetts, Michigan, Oregon, and Washington. These policy issues were debated in forums rich in propaganda but often lacking informed debate. For example, proponents of the referendum in Massachusetts showed television footage of 6 or 7 different animals that were captured in traps or sets already prohibited by wildlife regulations (T. A. Decker, Agency of Natural Resources, St. Johnsberry, Vt., personal communication). Decisions in these ballot initiatives were arrived at largely by appeal to emotions, beliefs, and values, not through reasoned analyses. Thus, each time the public overturns existing wildlife policy by popular referendum, the wildlife management environment becomes ever more polarized, intractable, and unpredictable.

Progress in improving trapping systems

Despite, or perhaps because of, hostility in the political environment surrounding the trapping controversy, steady progress is being made to improve the humaneness and effectiveness of trapping devices, methods, and practices.

Canada

Since the 1950s, Canada has worked aggressively to improve the humaneness of trapping systems by supporting trap-testing research on numerous furbearers (Barrett et al. 1988). A trap-testing facility is maintained near Vegreville, Alberta, where 10 more-humane killing traps and 1 more-humane restraining device have been developed (L. D. Roy, Alberta Environmental Center, Vegreville, Alta., personal communication). Canada was instrumental in attempting to establish international trap standards through the International Organization for Standardization (ISO), in Geneva, Switzerland (Proulx and Barrett 1989). The Canadian General Standards Board's Committee on Development of Humane Trapping Standards approved a national standard for killing traps in 1984 (Canadian General Standards Board 1984) and in 1996 (Canadian General Standards Board 1996) and is working on standards for restraining and submersion trapping, which are expected to be completed before the end of 1999 (L. D. Roy, Alberta Environmental Center, Vegreville, Alta., personal communication). During 1997 and 1998, Canada, Russia, and the European Community signed an agreement on international humane trapping standards.

United States

Most trap research conducted in the United States has evaluated restraining traps for coyotes (Linhart et al. 1986, 1988; Linscombe and Wright 1988, Olsen et al. 1988, Phillips et al. 1992, 1996; Hubert et al. 1997), red foxes (Tullar 1984, Kreeger et al. 1990, Kern et al. 1994), and raccoons (Tullar 1984, Olsen et al. 1988, Hubert et al. 1996). The United States and the European Community signed an Agreed Minute in 1997 that is intended to identify and incorporate the use of more-humane traps and trapping methods, and recognizes that authority to regulate trapping resides primarily in state and tribal authorities. The Fur Resources Technical Subcommittee of the International Association of Fish and Wildlife Agencies (IAFWA), which represents state fish and wildlife agencies, participated in the ISO process to develop standards for trapping, helped negotiate the Agreed Minute, has compiled data on trap research, has identified priority species and trapping systems for additional work, is coordinating a trap-testing program throughout the United States, and is compiling Best Management Practices for trapping (International Association of Fish and Wildlife Agencies Fur Resources Technical Subcommittee 1997).

New Zealand

Research has been conducted in New Zealand to determine efficiency and degree of injuries sustained by Australian brushtail possums (*Trichosurus vulpecula*) in various foothold traps and killing effectiveness of body-gripping traps (Warburton 1982, 1992). New Zealand recently has used these findings and ISO draft trap standards to develop a "code of practice" for trapping possums that is intended to be incorporated into its animal-welfare legislation (N. Jotham, Canadian Wildlife Service, Ottawa, Ont., personal communication).

International Organization for Standardization

In 1986, the ISO established Technical Committee 191 with a mandate to develop international standards for humane mammal traps. Approximately 10

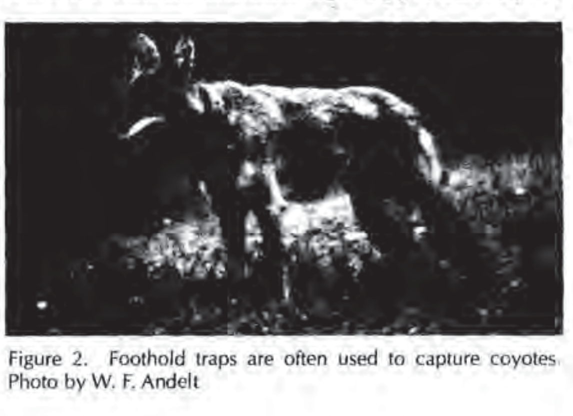

Figure 2. Foothold traps are often used to capture coyotes. Photo by W. F. Andelt

years later, participating countries could not agree on performance requirements for a trap standard. However, ISO Technical Committee 191 developed an international standard for trap testing (ISO TC191 1998) that was to have received final vote in 1998. This standard, as well as a standard scoring system for injuries, is needed to compare research results.

Future challenges

Adopting research findings

Numerous scientific publications indicate padded foothold traps reduce foot injuries to several furbearer species, yet padded traps were required by law in only 7 states (Ariz., Calif., Colo., Ill., La., Mass., Tenn.) for some species and under some conditions during 1995 (International Association of Fish and Wildlife Agencies Fur Resources Technical Subcommittee 1995, T. A. Decker, Agency of Natural Resources, St. Johnsberry, Vt. and G. F. Hubert, Illinois Department of Natural Resources, Hinckley, Ill., personal communication). The National Trappers Association has taken an active role in the ISO process, in developing Best Management Practices and sponsoring Best Management Practices workshops. Wildlife managers should consider incentives such as reduced license fees, trap "buy-back" programs, and expanded opportunities for trappers that incorporate the latest devices and techniques. Ultimately, new devices and techniques promoting humane and selective capture of animals should be incorporated in Best Management Practices, or in national or international standards, and in regulatory changes that indicate to the public that real changes have been made and will continue to be made. Without adopting new research-based findings, we believe that trappers and wildlife managers will be confronted with increased critical public scrutiny.

Best Management Practices

The Fur Resources Technical Subcommittee of the IAFWA, in cooperation with the National Trappers Association, is developing Best Management Practices, which will be a set of regional recommendations for use by individual state wildlife agencies and trapper organizations to improve the welfare of several species of captured furbearers by selecting traps and trapping methodologies that cause the fewest injuries under various trapping conditions and are selective, efficient, practical, and safe for the user (International Association of Fish and Wildlife Agencies Fur Resources Technical Subcommittee 1997). We encourage all state wildlife agencies and trapper organizations to adopt these forthcoming practices and incorporate them into trapper education and furbearer management programs to indicate to the public that they are serious about improving the welfare of trapped animals. Adopting these practices may circumvent engaging in lengthy development of a state's own standards when attempting to resolve conflicts between trappers and other interests.

Trapping regulations and public desires

States generally manage wildlife within their borders, with wildlife held in trust for their citizens (Musgrave and Stein 1993). We believe it is essential for states and other jurisdictions to adopt trapping regulations that meet the expectations of the majority of citizens, with those expectations tempered by professional judgment. While wildlife management should not be subjected to a popularity contest, neither should it be conducted outside the consent of interested and affected citizens. Otherwise, agencies will lose credibility in managing wildlife and we will likely see a continued proliferation of ballot initiatives in which voters make uninformed wildlife management decisions independently from wildlife professionals.

The public appears more supportive of trapping when it is limited and regulated (Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993). Most Missourians (71%) approved of trapping when it was defined as regulated (Missouri Department of Conservation 1996), but only 42% approved when it was not so defined (Missouri Department of Conservation 1992).

Research needs

Research on foothold traps has concentrated on reducing injuries to the restrained feet of animals and improving the selectivity and efficiency of traps. Although this research has focused primarily on coyotes, and secondarily on raccoons and red foxes, additional research is needed on other furbearer species. Todd (1987) described a method of prioritizing furbearer species for research and development of humane capture methods based upon "stress" of capture methods, size of the harvest, human preference for the species, and other factors. During 1998 the Fur Resources Technical Subcommittee of the IAFWA was to have conducted 8 studies in 17 states, using 8 species and 28 types of traps, to determine the effect of various improvements and modifications to traps on efficiency, selectivity, and injuries (D.A. Hamilton, Missouri Department of Conservation, Columbia, Mo., personal communication). Where traps are used to capture animals that cause damage, research should focus on how to selectively capture specific target animals.

Foot snares have been used to capture black bears (*Ursus americanus*) (Johnson and Pelton 1980, Beck 1991), mountain lions (*Puma concolor*; Lindzey 1987), coyotes, and other furbearers by the foot or leg. Foot injuries to coyotes captured in Belisle foot snares (Edouard Belisle, 3269 Chemin Lac Klamika, Ste-Veronque, PQ, Canada JOW 1X0) have been similar to those captured in Number 3 Victor Soft Catch traps (Tables 1, 2), but foot snares have had lower capture rates than foothold traps (Table 2; Skinner and Todd 1990, Mowat et al. 1994). We believe foot snares such as the Belisle, E-Z Lee, Fremont, Godwin, and Nelson have potential to humanely capture and restrain coyotes and other furbearers, but additional research and development are needed to improve their utility, practicality, and capture efficiency (Table 2).

Cage traps have been used to capture pine marten (*Martes americana*; deVos and Guenther 1952), muskrats (*Ondatra zibethicus*; Proulx and Gilbert 1983), mountain lions (Neighbor et al. 1991), black bears (T.D.I. Beck, Colorado Division of Wildlife, Dolores, Colo., personal communication), and wolverines (*Gulo gulo*; Copeland et al. 1995) with few injuries, but these traps rarely capture coyotes. Additional research is needed to determine practicality, capture efficiency, and public acceptance of cage traps.

Needs of individual states and provinces

Trapping standards may need to vary among states. For example, in cold northern areas, foot snares might be preferable to padded foothold traps because foot snares appear to have less potential for freezing the feet of lynx (*Lynx lynx*; Mowat et al. 1994) and possibly other species. In some northern areas where furbearer densities are low and frequent trap-check intervals are not practical, it may be necessary to use killing-type traps instead of foot-holding devices (Proulx et al. 1994).

Need for trapper training

Several authors have emphasized the need for trapper education courses to enhance adoption of more-humane and selective trapping devices (Payne 1980, Proulx and Barrett 1989, Boggess et al. 1990, Siemer et al. 1994). Most Arizona residents (76%) (Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993), trappers across the United States (72%) (Kellert 1981), and trappers responding to a survey (56%) in *Trapper Magazine* (Boddicker 1981) indicated that trappers should complete a trapper education course. These programs are needed to ensure proper use of existing devices and incorporation and acceptance of new devices and techniques. The delay in adopting padded traps suggests that considerable educational efforts are needed before trappers will adopt padded traps and other trapping improvements. To enhance adoption of padded traps, we suggest educational programs that incorporate: (1) the assistance of respected trappers who have successfully used padded traps, (2) discussions of public expectations for humane capture of furbearers, (3) discussions of the public image of trappers who adopt the most humane capture devices and techniques compared to those who do not, and (4) possibly field demonstrations and videos that show the proper use and capture effectiveness of padded traps. States will be incorporating the forthcoming Best Management Practices into their trapper education programs.

Public education

The public tends to be poorly informed about trapping issues (Boggess et al. 1990, Proulx and Barrett 1991, Duda and Young 1994, Fulton et al. 1995). In Arizona, 8% of residents indicated that they were strong supporters of trapping and 54% were firm opposers, whereas 38% indicated that their attitudes toward trapping were not strongly fixed and were open to change (Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993). Thus, additional information may change the opinion of only a minority of the public. However, opposition to trapping decreased with increased knowledge of trapping issues (Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993; Duda and Young 1994). Education that provides objective and accurate information is needed so that the public can make informed decisions (Boggess et al. 1990). The Fur Resources Technical Subcommittee of the IAFWA is initiating a public education program as part of the Best Management Practices on trapping (International Association of Fish and Wildlife Agencies Fur Resources Technical Subcommittee 1997).

Public acceptance of trapping likely will be highest if wildlife managers provide educational information that emphasizes current regulations that minimize injuries and trauma in animals, promote selective capture, avoid seasons when females have dependent young, emphasize that it is illegal to trap threatened and endangered species, and emphasize publicly acceptable reasons for trapping, such as minimizing economic damage (see also Behavior Research Center, Inc., Phoenix, Ariz., unpublished report, 1993; Duda and Young 1994; Fulton et al. 1995). A public communication program that clearly explained trapping policies and their rationale would be helpful (Fulton et al. 1995). The overall goal of a public education program should be to obtain informed consent for trapping, not to convince the public that animals feel good in traps.

Public beliefs and attitudes toward trapping appear rooted in values about wildlife welfare, wildlife rights, and wildlife uses (Fulton et al. 1995). People's basic value and belief structures are far more intractable than most wildlife professionals want to believe (Fulton et al. 1996). The most promising way to educate a limited portion of the public about the complexities of public policy issues appears to be through public involvement processes that assign significant power to the participants (Stout et al. 1996). When members of the public directly engage one another in the resolution of public issues of mutual concern, knowledge of issues, tolerance for competing values and viewpoints, flexibility, adaptability, and creative problem solving are all enhanced (Barber 1984, Dryzek 1990, Yankelovich 1991, Manning 1993).

Economic factors

The IAFWA Fur Resources Committee (1993) reported that trappers across the United States spent an average of $1,126 each for traps, lures, travel expenses, other trap-related equipment, and major equipment purchases in the 1991-92 season. Number 1 1/2 and Number 3 Soft Catch traps cost about $110 and $150/dozen, respectively, approximately 50% more than standard steel foothold traps. Costs might be reduced by manufacturing padded jaws that could be used to retrofit existing standard traps and by phasing in padded traps over a period of time.

Managing the controversy

Wildlife managers are entrusted by the public to be stewards of publicly owned wildlife resources (Kania and Conover 1991). Regardless of funding sources, professional wildlife managers dealing with public resources should understand and represent many of the myriad values of the public or at least conduct activities that are within the public's informed consent. Traditionally, wildlife managers have focused on biological aspects of wildlife management, but now they are paying closer attention to the sociological and political aspects. Peterson and Manfredo (1993) contend that social science must be elevated to a higher level of emphasis within wildlife management to meet the challenges of the 21st century and beyond. Wildlife managers must establish and maintain impeccable professional standards to treat the people's wildlife humanely and ethically to avoid the loss of public credibility and trust (Schmidt 1992).

Wildlife managers should continue to endorse traps and trapping as a wildlife management activity. In doing so, they should be concerned with: (1) developing, scientifically evaluating, manufacturing, and implementing more humane and selective traps; (2) adopting minimum trap-check intervals that reduce animal injuries; (3) setting harvest seasons to avoid periods when females have dependent young; and (4) focusing on the need to trap where public tolerance and acceptance are high, such as instances of safeguarding public health and safety, managing wildlife damage, and protecting endangered wildlife species and habitats. We need to develop and implement standards nationally and internationally to demonstrate dramatically and publicly the commitment of the wildlife profession to ethical and humane practices consistent with widespread public wildlife values. Lastly, we need better forums for concerned members of the public, the trapping community, and wildlife managers to debate and resolve concerns over trapping.

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Literature cited

ANDELT, W. F., AND P. S. GIPSON. 1979. Domestic turkey losses to radio-tagged coyotes. Journal of Wildlife Management 43:673-679.

ANDELT, W. F., AND T. P. WOOLLEY. 1996. Responses of urban mammals to odor attractants and a bait-dispensing device. Wildlife Society Bulletin 24:111-118.

ANTHONY, R. M., P. L. FLINT, AND J. S. SEDINGER. 1991. Arctic fox removal improves nest success of black brant. Wildlife Society Bulletin 19:176-184.

ARTHUR, L. M. 1981. Coyote control: the public response. Journal of Range Management 34:14-15.

BARBER, B. R. 1984. Strong democracy: participatory politics for a new age. University of California Press, Berkeley.

Barrett, M. W., G. Proulx, and N. Jotham. 1988. Wild fur industry under challenge: the Canadian response. Transactions of the North American Wildlife and Natural Resources Conference 53:180-190.

Beck, T. D. I. 1991. Black bears of west-central Colorado. Colorado Division of Wildlife Technical Publication Number 39, Denver, Colorado.

Boddicker, M. L. 1981. Profiles of American trappers and trapping. Proceedings of the Worldwide Furbearer Conference 3:1919-1949.

Boggess, E. K., G. R. Batcheller, R. G. Linscombe, J. W. Greer, M. Novak, S. B. Linhart, D. W. Erickson, A. W. Todd, D. C. Juve, and D. A. Wade. 1990. Traps, trapping, and furbearer management. Wildlife Society Tech Review 90-1.

Boggess, E. K., and F. R. Henderson. 1981. Trapper/hunter education and implications for furbearer management. Proceedings of the Worldwide Furbearer Conference 3:1950-1970.

Butchko, P. H. 1990. Predator control for the protection of endangered species in California. Proceedings of the Vertebrate Pest Conference 14:237-240.

Canadian General Standards Board. 1984. Animal traps—humane, mechanically powered, trigger activated. Canadian General Standards Board Report CAN2-144.1-M84, Ottawa, Ontario, Canada.

Canadian General Standards Board. 1996. Animal (mammal) traps—mechanically powered, trigger-activated killing traps for use on land. Canadian General Standards Board Report CAN/CGSB-144.1-96, Ottawa, Ontario, Canada.

Copeland, J. P., E. Cesar, J. M. Peek, C. E. Harris, C. D. Long, and D. L. Hunter. 1995. A live trap for wolverine and other forest carnivores. Wildlife Society Bulletin 23:535-538.

Cypher, B. L., and J. H. Scrivner. 1992. Coyote control to protect endangered San Joaquin kit foxes at the Naval Petroleum Reserves, California. Proceedings of the Vertebrate Pest Conference 15:42-47.

Decker, D. J., and T. L. Brown. 1987. How animal rightists view the "wildlife management-hunting" system. Wildlife Society Bulletin 15:599-602.

deVos, A., and S. E. Guenther. 1952. Preliminary live-trapping studies of marten. Journal of Wildlife Management 16:207-214.

Dryzek, J. S. 1990. Discursive democracy: politics, policy, and political science. Cambridge University Press, Cambridge, Massachusetts.

Duda, M. D, and K. C. Young. 1994. Illinois residents' opinions and attitudes regarding trapping, fur hunting, and furbearer management. Mark Damian Duda and Associates, Harrisonburg, Virginia.

Feldman, J. W. 1996. The politics of predator control, 1964-1985. Thesis, Utah State University, Logan.

Fulton, D. C., M. J. Manfredo, and J. Lipscomb. 1996. Wildlife value orientations: a conceptual and measurement approach. Human Dimensions Wildlife 1(2):24-47.

Fulton, D. C., J. Pate, and M. J. Manfredo. 1995. Colorado residents' attitudes toward trapping in Colorado. Colorado Division of Wildlife Project Report Number 23, Fort Collins, Colorado.

Fur Institute of Canada. 1989. Recommended regulations. Page 190 *in* R. Lafond, editor. Proceedings of the Northeast Fur Resources Technical Committee. Ministere Loisir Chasse et Peche du Quebec, Quebec, Canada.

Galloway Vigil and Associates. 1986. Market research project for the Colorado Division of Wildlife. Galloway Vigil and Associates and Market Analysis Professionals, Denver, Colorado.

Gentile, J. R. 1987. The evolution of anti-trapping sentiment in the United States: a review and commentary. Wildlife Society Bulletin 15:490-503.

Gipson, P. S. 1975. Efficiency of trapping in capturing offending coyotes. Journal of Wildlife Management 39:45-47.

Gruver, K. S., R. L. Phillips, and E. S. Williams. 1996. Leg injuries to coyotes captured in standard and modified Soft Catch traps. Proceedings of the Vertebrate Pest Conference 17:91-93.

Hein, E. W., and W. F. Andelt. 1994. Evaluation of coyote attractants and an oral bait delivery device. Wildlife Society Bulletin 22:651-655.

Houben, J. M., M. Holland, S. W. Jack, and C. R. Boyle. 1993. An evaluation of laminated offset traps for reducing injuries to coyotes. Proceedings of the Great Plains Wildlife Damage Control Workshop 11:148-155.

Hubert, G. F., Jr., L. L. Hungerford, and R. D. Bluett. 1997. Injuries to coyotes captured in modified foothold traps. Wildlife Society Bulletin 25:858-863.

Hubert, G. F., Jr., L. L. Hungerford, G. Proulx, R. D. Bluett, and L. Bowman. 1996. Evaluation of two restraining traps to capture raccoons. Wildlife Society Bulletin 24:699-708.

International Association of Fish and Wildlife Agencies Fur Resources Committee. 1993. Ownership and use of traps by trappers in the United States in 1992. Fur Resources Committee of the International Association of Fish and Wildlife Agencies and The Gallup Organization, Washington, D. C.

International Association of Fish and Wildlife Agencies Fur Resources Technical Subcommittee. 1995. Summary of trapping regulations for fur harvesting in the United States and Canada. Fur Resources Technical Subcommittee of the International Association of Fish and Wildlife Agencies, Washington, D. C.

International Association of Fish and Wildlife Agencies Fur Resources Technical Subcommittee. 1997. Improving animal welfare in U.S. trapping programs: process recommendations and summaries of existing data. Fur Resources Technical Subcommittee of the International Association of Fish and Wildlife Agencies, Washington, D. C.

International Organization for Standardization TC191. 1998. Animal (mammal) traps-part 5: methods for testing restraining traps. ISO/DIS 10990-5.2:1998(E). International Organization for Standardization, Geneva, Switzerland.

Johnson, K. G., and M. R. Pelton. 1980. Prebaiting and snaring techniques for black bears. Wildlife Society Bulletin 8:46-54.

Kania, G. S., and M. R. Conover. 1991. How governmental wildlife agencies should respond to local governments that pass antihunting legislation—a response. Wildlife Society Bulletin 19:224-225.

Kellert, S. R. 1981. Trappers and trapping in American society. Proceedings of the Worldwide Furbearer Conference 3:1971-2003.

Kern, J. W., L. L. McDonald, M. D. Strickland, and E. Williams. 1994. Field evaluation and comparison of four foothold traps for terrestrial furbearers in Wyoming. Western EcoSystems Technology, Cheyenne, Wyoming.

Kreeger, T. J., P. J. White, U. S. Seal, and J. R. Tester. 1990. Pathological responses of red foxes to foothold traps. Journal of Wildlife Management 54:147-160.

Lindzey, F. G. 1987. Mountain lion. Pages 656-668 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources and Ontario Trappers Association, Toronto, Ontario, Canada.

Linhart, S. B., F. S. Blom, G. J. Dasch, R. M. Engeman, and G. H. Olsen.

1988. Field evaluation of padded jaw coyote traps: effectiveness and foot injury. Proceedings of the Vertebrate Pest Conference 13:226–229.

Linhart, S. B., and G. J. Dasch. 1992. Improved performance of padded jaw traps for capturing coyotes. Wildlife Society Bulletin 20:63–66.

Linhart, S. B., G. J. Dasch, C. B. Male, and R. M. Engeman. 1986. Efficiency of unpadded and padded steel foothold traps for capturing coyotes. Wildlife Society Bulletin 14:212–218.

Linscombe, R. G., and V. L. Wright. 1988. Efficiency of padded foothold traps for capturing terrestrial furbearers. Wildlife Society Bulletin 16:307–309.

Lokemoen, J. T., and R. O. Woodward. 1993. An assessment of predator barriers and predator control to enhance duck nest success on peninsulas. Wildlife Society Bulletin 21:275–282.

Manning, N. J. 1993. Reconciling science and politics in the Forest Service decision making: new tools for public administrators. American Review of Public Administration 23:343–369.

Minnis, D. L. 1998. Wildlife policy-making by the electorate: an overview of citizen-sponsored ballot measures on hunting and trapping. Wildlife Society Bulletin 21:75–83.

Missouri Department of Conservation. 1992. Missourians' interests in fish, forests, and wildlife: results of a statewide citizen survey, 1989-1990. Missouri Department of Conservation Public Profile 3-92, Jefferson City, Missouri.

Missouri Department of Conservation. 1996. Missouri—annual "conservation monitor" 1994-1996: three years of Gallup Polls of Missourians' conservation interests and opinions. Missouri Department of Conservation Public Profile 2-96, Jefferson City, Missouri.

Mowat, G., B. G. Slough, and R. Rivard. 1994. A comparison of three live capturing devices for lynx: capture efficiency and injuries. Wildlife Society Bulletin 22:644–650.

Musgrave, R. S., and M. A. Stein. 1993. State wildlife laws handbook. Government Institutes, Rockville, Maryland.

Naylor, B. J., and M. Novak. 1994. Catch efficiency and selectivity of various traps and sets used for capturing American marten. Wildlife Society Bulletin 22:489–496.

Neighbor, D. S., T. K. Ruth, J. R. Skiles, Jr., and B. P. McKinney, Jr. 1991. Live trapping mountain lion. Page 25 *in* C. E. Braun, editor. Mountain lion-human interaction symposium and workshop. Colorado Division of Wildlife, Denver, Colorado.

Novak, M. 1987. Traps and trap research. Pages 941–969 *in* M. Novak, J.A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources and Ontario Trappers Association, Toronto, Ontario, Canada.

Olsen, G. H., S. B. Linhart, R. A. Holmes, G. J. Dasch, and C. B. Male. 1986. Injuries to coyotes caught in padded and unpadded steel foothold traps. Wildlife Society Bulletin 14:219–223.

Olsen, G. H., R. G. Linscombe, V. L. Wright, and R. A. Holmes. 1988. Reducing injuries to terrestrial furbearers by using padded foothold traps. Wildlife Society Bulletin 16:303–307.

Onderka, D. K., D. L. Skinner, and A. W. Todd. 1990. Injuries to coyotes and other species caused by four models of footholding devices. Wildlife Society Bulletin 18:175–182.

Payne, N. F. 1980. Furbearer management and trapping. Wildlife Society Bulletin 8:345–348.

Peterson, M. R., and M. J. Manfredo. 1993. Social science and the evolving conservation philosophy. Pages 292–303 *in* S. K. Majumdar, E. W. Miller, D. E. Baker, E. K. Brown, J. R. Pratt, and R. F. Smalz, editors. Conservation and resource management. The Pennsylvania Academy of Science, Easton, Pennsylvania.

Phillips, R. L., F. S. Blom, G. J. Dasch, and J. W. Guthrie. 1992. Field evaluation of three types of coyote traps. Proceedings of the Vertebrate Pest Conference 15:393–395.

Phillips, R. L., and K. S. Gruver. 1996. Performance of the Paws-I-Trip$^{\text{TM}}$ pan tension device on 3 types of traps. Wildlife Society Bulletin 24:119–122.

Phillips, R. L., K. S. Gruver, and E. S. Williams. 1996. Leg injuries to coyotes captured in three types of foothold traps. Wildlife Society Bulletin 24:260–263.

Phillips, R. L., and C. Mullis. 1996. Expanded field testing of the No. 3 Victor Soft Catch® trap. Wildlife Society Bulletin 24:128–131

Proulx, G., and M. W. Barrett. 1989. Animal welfare concerns and wildlife trapping: ethics, standards and commitments. Transactions of the Western Section of the Wildlife Society 25:1-6.

Proulx, G., and M. W. Barrett. 1991. Ideological conflict between animal rightists and wildlife professionals over trapping wild furbearers. Transactions of the North American Wildlife and Natural Resources Conference 56:387–399.

Proulx, G., and F. F. Gilbert. 1983. The ecology of the muskrat, ***Ondatra zibethicus*** at Luther Marsh, Ontario. Canadian Field-Naturalist 97:377–390.

Proulx, G., I. M. Pawlina, D. K. Onderka, M. J. Badry, and K. Siedel. 1994. Field evaluation of the number 1 1/2 steel-jawed leghold and the Sauvageau 2001-8 traps to humanely capture arctic fox. Wildlife Society Bulletin 22:179–183.

Reiter, D., M. W. Brunson, and R. H. Schmidt. 1995. Public attitudes toward predators in Texas. Pages 85–86 *in* D. Rollins, C. Richardson, T. Blankenship, K. Canon, and S. Henke, editors. Coyotes in the Southwest: a compendium of our knowledge. Texas Parks and Wildlife Department, Austin, Texas.

Saunders, B. P., and H. C. Rowsell. 1984. Padded trap testing in British Columbia. Proceedings of the Western Association of Fish and Wildlife Agencies. 64:136–142.

Saunders, B. P., H. C. Rowsell, and I. W. Hatter. 1988. A better trap, the search continues. Canadian Trapper. Winter.

Schmidt, R. H. 1992. Why bad things happen to good animals. Proceedings of the Vertebrate Pest Conference 15:25–28.

Schmidt, R. H., and J. G. Brunner. 1981. A professional attitude toward humaneness. Wildlife Society Bulletin 9:289–291.

Siemer, W. F., G. R. Batcheller, R. J. Glass, and T. L. Brown. 1994. Characteristics of trappers and trapping participation in New York. Wildlife Society Bulletin 22:100–111.

Skinner, D. L., and A. W. Todd. 1990. Evaluating efficiency of footholding devices for coyote capture. Wildlife Society Bulletin 18:166–175.

Statistics Canada. 1996. Livestock Statistics. Agricultural Division, Statistics Canada, Ottawa, Ontario, Canada.

Stevens, C. 1992. The "padded" trap is not the answer. The Probe 119:1–2.

Stout, R. J., D. J. Decker, B. A. Knuth, J. C. Proud, and D. H. Nelson. 1996. Comparison of three public-involvement approaches for stakeholder input into deer management decisions: a case study. Wildlife Society Bulletin 24:312–317.

Todd, A. W. 1987. A method of prioritizing furbearer species for research and development in humane capture methods as applied in Canada. Wildlife Society Bulletin 15:372–380.

Todd, A. W., and E. K. Boggess. 1987. Characteristics, activities, lifestyles, and attitudes of trappers in North America. Pages 59–76 *in* M. Novak, J.A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources and Ontario Trappers Association, Toronto, Ontario, Canada.

Tullar, B. F., Jr. 1984. Evaluation of a padded leg-hold trap for capturing foxes and raccoons. New York Fish and Game Journal 31:97–103.

Turkowski, F. J., A. R. Armistead, and S. B. Linhart. 1984. Selectivity and effectiveness of pan tension devices for coyote foothold traps. Journal of Wildlife Management 48:700–708.

Warburton, B. 1982. Evaluation of seven trap models as humane and catch-efficient possum traps. New Zealand Journal of Zoology 9:409–418.

Warburton, B. 1992. Victor foot-hold traps for catching Australian brushtail possums in New Zealand: capture efficiency and injuries. Wildlife Society Bulletin 20:67–73.

Williams, O., and J. McKegg. 1987. Nuisance furbearer management programs for urban areas. Pages 156–163 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources and Ontario Trappers Association, Toronto, Ontario, Canada.

Yankelovich, D. 1991. Coming to public judgement: making democracy work in a complex world. Syracuse University Press, Syracuse, New York.

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Chapter 30
Animal Welfare Issues Pertaining to the Trapping of Otters for Research, Conservation, and Fur

Thomas L. Serfass, Lesley Wright, Kelly Pearce, and Nicole Duplaix

30.1 Introduction

Legal trapping of otters is conducted for research (e.g., to equip individual animals with radio transmitters) and applied conservation (e.g., to obtain individuals for reintroduction projects) and for utilitarian purposes (i.e., the fur industry for some species). Until relatively recently, standards defining the most appropriate traps in relation to animal welfare for wildlife caught for utilitarian purposes (wildlife species killed for fur have become generically referred to as furbearers, a term that will be used hereafter) were poorly established. Trapping was usually subject to regulations imposed by individual wildlife management jurisdictions [e.g., state and provincial wildlife agencies in the United States of America (USA) and Canada, respectively]. Canada, Russia, the European Union (EU), and USA are involved in collaborative, ongoing efforts to develop and implement standards for what ostensibly constitutes "humane trapping." The motivation for developing trapping standards seems largely a response by Canada, Russia, and the USA (the three top wild fur-producing countries; Animal Legal and Historical Center 2010) to overcome

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legislation passed by the European Union in 1991 (Regulation 3254/91). This legislation bans the import of wild fur from countries allowing the use of leghold traps [now often referred to as "foothold trap," a semantical adjustment presumably adopted to depict trapping less harshly (i.e., more humanely) than "leghold trap." Leghold traps are banned in at least 80 countries (Fox 2004)].

Two agreements ratified by the EU council in 1998 [the first with Canada and Russia—"Agreement on International Humane Trapping Standards" (AIHTS)] and the other as a separate agreement with the USA [incorporating comparable standards as AIHTS, but in the form of "Best Management Practices for Trapping" (BMPs); Association of Fish and Wildlife Agencies (AFWA) 2006] through an agreed "Minute," which is nonbinding—i.e., apparently there are no penalties or enforcement to ensure standards are met) resulted in an exemption for Canada, Russia, and the USA. This enabled continued export of fur from wild-caught furbearers and use of leghold traps during an undefined evaluation period to assess humane issues pertaining to leghold and other traps (United States Department of Commerce 1997; Iossa et al. 2007; Proulx et al. 2012). These agreements brought about the first attempt to establish international standards [i.e., through the International Organization for Standardization (ISO)] to define what constitutes "humane" for traps within certain general trap-type categories (Harrop 2000; Princen 2004). Unanimity was not achieved on what constitutes key thresholds for traps regarding the extent of injuries caused by traps intended to restrain, but not kill, an animal and the time required for an animal to become unconscious when caught in traps designed for killing. However, a process was established to define performance of a trap (safety for the trapper and efficiency in capturing target species), to assess trauma related to physical injuries caused to animals caught in traps designed for restraint, and killing efficiency for traps designed to kill. Stress-induced trauma endured by a trapped animal currently is not a part of ISO welfare standards for trapping (Iossa et al. 2007). Fundamental to these agreements is that mandatory testing be conducted to determine if traps conform to standards established under AIHTS and BMPs for a particular species (i.e., become certified as acceptable under the agreement). Through the agreements, traps failing to meet agreed standards are expected to be phased from use. However, traps not meeting standards are permitted to remain in use if there are no alternative traps certified for the target species. This presumes that trap research continues with the intent of identifying a trap or traps that meet certification requirements. Trap standards are at various stages of completion (depending on species) (e.g., Fur Institute of Canada 2015), but design of trap testing protocols and evaluation of trap performance appear in some cases to be largely at the discretion of authorities responsible for managing furbearer trapping, with minimal external review. Specific details for outcomes of trap performance assessments are not readily available in the USA and have not been subjected to meaningful, external peer review. In contrast, Canada has published a variety of outcomes from trap testing and, along with Russia, has phased out the use of "traditional" leghold traps (Proulx 1999; AIHTS 2012).

The North American river otter (*Lontra canadensis*; hereafter river otter) serves particularly well for discussing traps and trapping systems in relation to animal welfare issues pertaining to otters in general for both research, and conservation and fur trapping—particularly in reference to populations in the USA. The river otter has received considerable conservation/research attention [predominantly in the USA where reintroduction projects involving live-trapping (i.e., the intention is for the trapped animal to be alive post-trapping event) and translocations of individuals from areas with viable populations have taken place in 22 states to restore extirpated populations]. The USA and Canada both kill substantial numbers of river otters each year for the fur trade, but Canadian populations did not suffer declines to the extent of those in the USA and have thus received less research/conservation attention based on live-trapping. The Eurasian otter (*Lutra lutra*) has received extensive research attention (see Kruuk 2006 for a review), but relatively few studies have been based on live-trapping (Fernandez-Moran et al. 2002; Ó Néill et al. 2007). Other species of otters generally have received little research attention or, as with the Eurasian otter, live-trapping has not been part of most studies. Paucity of live-trapping studies for otters outside of North America (NA) likely is related to greater concern for animal welfare regarding trapping and restrictions on the use of leghold traps. Hence, the following review of animal welfare issues pertaining to live-trapping for research and conservation focuses on the river otter in the USA, using examples from other species when applicable; those pertaining to fur trapping exclusively focus on the river otter in both the USA and Canada.

30.2 Types of Traps and Animal Welfare Standards

Traps considered for AIHTS agreements are placed in two general categories: (1) restraining traps and (2) killing traps. Restraining traps are designed to restrict a captured animal's movements and include leghold traps, modified leghold traps, powered and non-powered snares, and cage-type traps.

Among killing traps, rotating-jaw traps, which have spring-powered jaws that when triggered close forcibly across the body (the neck or chest is intended) of the trapped animal, have received considerable attention regarding animal welfare considerations pertaining to trapping (Proulx 1999; Proulx et al. 2012). However, restraining traps (leghold traps, and non-powered and powered snares) are also sometimes classified and used as killing traps, typically by setting the trap in a manner that will drown the captured animal (AFWA 2006). Drowning sets are typically used to kill semiaquatic mammals, including the river otter.

30.3 Restraining Traps

30.3.1 Leghold Traps

This type of trap is manufactured in a variety of configurations and sizes (Proulx 1999). The basic design of all leghold traps is the same, being comprised of two metal jaws that are held open at 180° by a triggering mechanism when set and clamp together (to grasp the trapped animal's limb) at 90° in reference to the set position

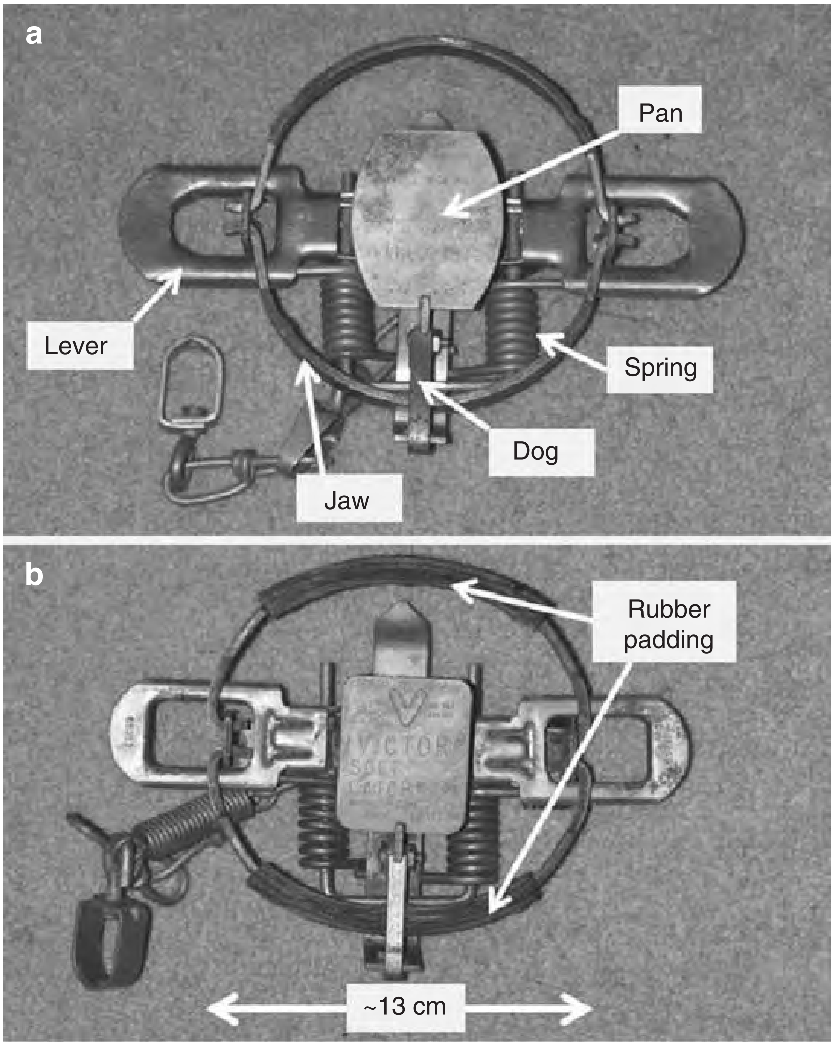

Fig. 30.1 Examples of coil spring leghold traps: (**a**) unmodified and (**b**) modified with rubber padding on inner surface of jaws ("padded jaw" or "Soft Catch™"). The traps are displayed in the "set" or "open" position. Primary components of a leghold trap are depicted on the image of the unmodified leghold trap (see AFWA 2006 for a review of the function of the trap components)

when sprung. The jaws of the trap and triggering components (the pan and dog) are comparable for all types of leghold traps (Fig. 30.1). Leghold traps are now manufactured as two types: coil spring traps (two coil springs each cause a lever to move upward, closing the trap's jaws) and longspring traps (depending on the style, either one or two longsprings close the jaws of the trap). When referring to a leghold trap, the type of trap (i.e., coil spring or longspring) is preceded with a number—usually from one to four—with smaller numbers indicating traps with smaller jaw spreads (i.e., distance between the inner sides of the jaws when the trap is set) (e.g., a No. 2 coil spring or No. 11 longspring). (Note: A No. 11 longspring trap and No. 1 longspring trap have the same jaw spread, with the No. 11 denoting the trap as having two longsprings and the No. 1 indicating the trap as having a single longspring, a convention applied to denote the use of one or two springs for all sizes of longspring traps.)

30.3.2 Modified Leghold Traps

These traps are configured and function identically to the leghold trap (see Proulx 1999), but the jaws are modified in a manner intended to increase efficiency (i.e., minimize the rate at which a captured animal pulls free of the trap) and minimize injury to the trapped appendage. Modifications to the jaws include the following: (1) laminated—an additional strip of metal is welded to the top and/or bottom of each jaw; (2) double jaws—each outer jaw (traditional jaw) is paired with a smaller, inner jaw; (3) offset jaws—the striking surface of the jaws is not in contact when closed [i.e., there is a space (offset) of 3–6 mm between the jaws of a closed trap]; and (4) padded jaws—rubber padding is inserted between the jaws (Fig. 30.1b).

30.3.3 Cage Traps

Traps constructed of wire-mesh framing with one or two doors. These traps are available in various dimensions, with the dimensions of a trap used dependent on the species intended to be trapped. Animals are captured in this trap by entering through doors and then stepping on a trigger, which causes the door(s) to close. These traps are analogous in design to *box traps*.

30.3.4 Snares

Snares are lengths of stranded steel cable configured into a loop that captures an animal by tightening over its neck, body, or limb. Tightening of the loop around the animal is accomplished either passively (i.e., non-powered snare—the loop is tightened by the movement of the animal) or actively (i.e., powered snare—tightening of the loop is initiated by a spring-powered device activated by contact with the animal). Snares used with the intent of restraining an animal by the neck should have “stops” designed to prevent excessive tightening of the cable to reduce the chance of asphyxiating captured individuals.

30.3.5 Suitcase-Type Traps

These are large traps originally designed for American beavers (*Castor canadensis*). The Hancock Live Trap (Fig. 30.2) and the Bailey Beaver Live Trap are specific types of traps within this category that have been evaluated for use in capturing river otters. Both traps have large movable metal frames covered in chain-link material that close around an animal [i.e., an animal is captured within, not between, the trap jaws—the Hancock trap has a single movable (closing) jaw, whereas both jaws of

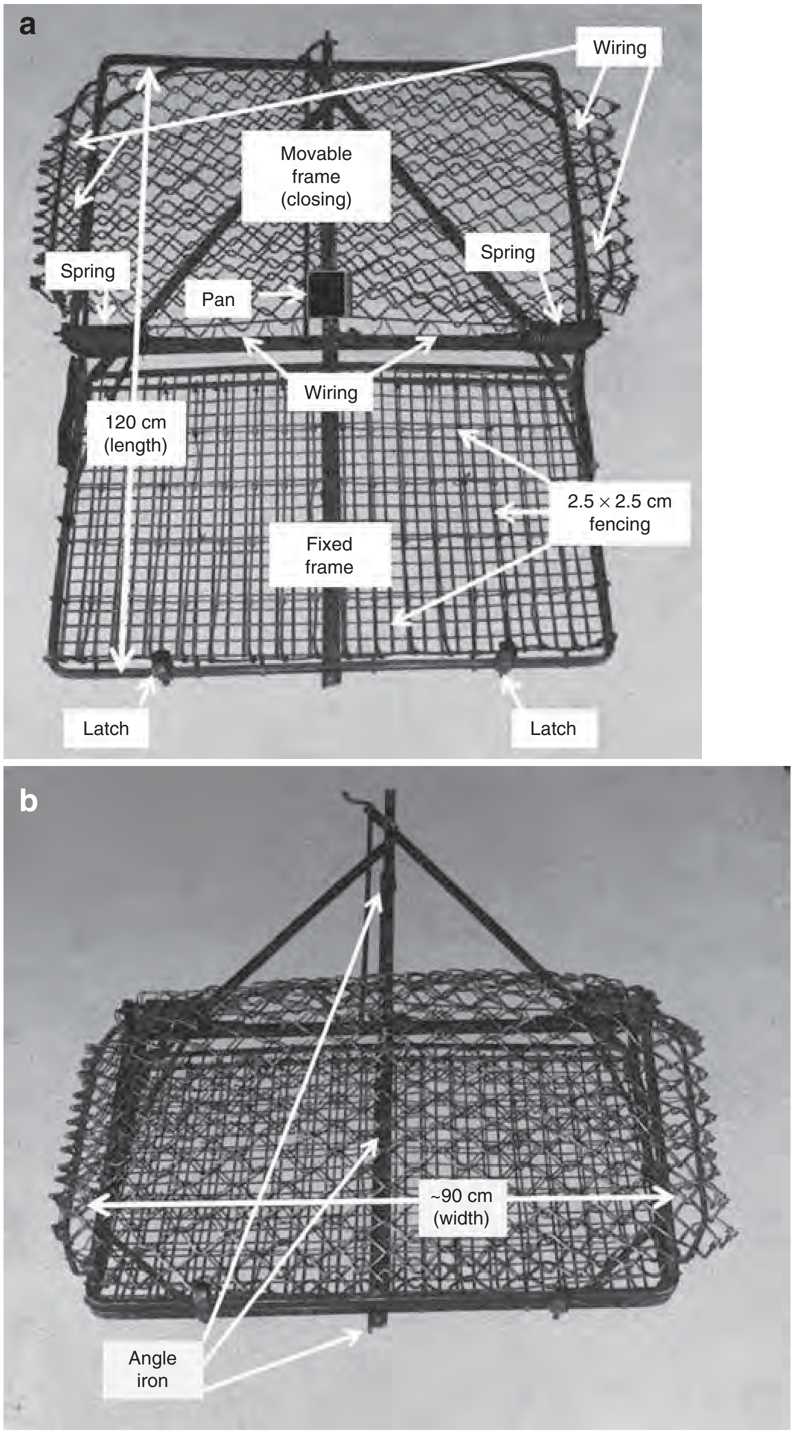

Fig. 30.2 A Hancock trap as modified by Serfass (1984) to lay flat in the "set" or "open" position (**a**) and the trap in the closed position (**b**). The trap is held flat in the open position by affixing a length of angle iron along the back of the trap [note: The movable frame (closing side) of an unmodified Hancock trap is at an angle of about 130° to the fixed frame (non-closing side) when the trap is in the set position]. To minimize chances of river otters escaping, Melquist and Hornocker (1979) recommended (1) adding springs on the inner side of "latches," which are intended to prevent a captured animal from forcing open the movable side of the opening (the springs better ensure that latches remain over the frame of the movable sides of a closed trap) and (2) using wire to close gaps along the margins of the trap frame. A further modification to prevent escape or injury of a captured river otter involves covering the 5 × 10-cm wire grid on the fixed side of the trap frame with vinyl coated 2.5 × 2.5-cm welded wire fencing (Serfass 1984)

the Bailey trap are movable and close simultaneously]. The Bailey trap has been shown to be ineffective in capturing river otters (Northcott and Slade 1976).

30.4 Killing Traps

30.4.1 Rotating-Jaw Traps

Also commonly referred to as bodygrip, bodygripping, or Conibear™-type traps, these traps have two rotating jaws powered by one or two springs (Fig. 30.3). As with leghold traps, numbering associated with these traps is a reference to the size (inner distance between jaws) of the trap, with a smaller number indicating less distance between the jaws (e.g., 110 Conibear, 220 Conibear, and 330 Conibear represent traps of progressively increasing distance between the jaws). Animals entering an open trap are intended to be killed when the jaws forcefully close and crush a vital region of the body—for the most humane death as possible, the preferred areas intended to be struck by the jaws are the neck or upper chest.

30.4.2 Killing Snares

Killing snares are configured in the same manner as snares used for restraint, and the loop likewise becomes tightened around an animal either passively or actively. However, snares designed to kill are intended to capture an animal around the neck

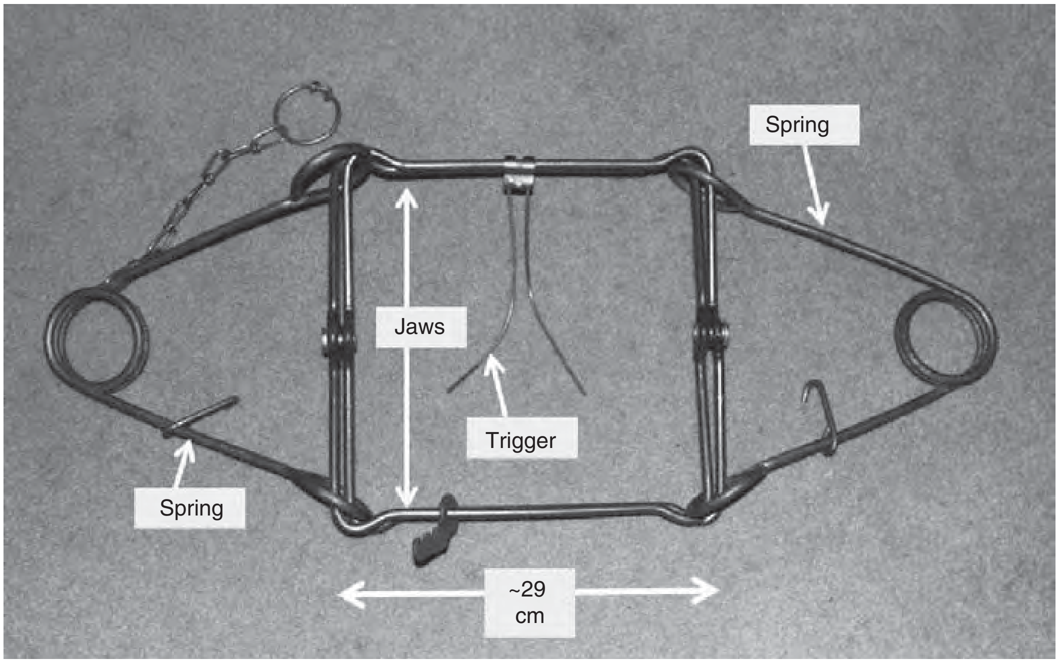

Fig. 30.3 A 330 rotating-jaw trap (also called bodygrip, bodygripping, or Conibear™-type traps) in the closed (not set) position. This type of trap is intended to quickly kill a captured animal and is frequently used by trappers to capture river otters for fur (Responsive Management 2015a)

and do not have stops to restrict tightening of the loop. Thus, the loop continues to tighten as the animal struggles until it is asphyxiated. Powered killing snares also kill by asphyxiation, but the snare tightens more quickly, ideally causing a quicker death. (Note: Stops can be used to limit closure of the loop to a circumference that minimizes capture or harm to smaller, nontarget species.)

30.4.3 Drowning (or Submersion) Traps/Sets

Leghold traps and snares can be set in a manner to drown animals captured in or near the water (AFWA 2006). Traps are either set underwater (at a depth that prevents the captured animal from reaching the surface) or along the shoreline (attached to a cable that leads the trapped animal into water deep enough to keep it from reaching the surface).

Note: Proulx (1999) and Iossa et al. (2007) provide extensive and detailed reviews of animal welfare for restraining and killing traps used to capture mammals. In BMPs for trapping in the USA (AFWA 2006), the AFWA explains trap components and trapping setting techniques for capturing furbearing animals. The information in these documents provides an important basis for developing insight necessary to inform discussion pertaining to animal welfare issues related to trapping wild mammals.

30.5 Animal Welfare and Trapping

Establishment of animal welfare standards for trapping has developed through the use of standardized scores for injuries sustained by individuals captured in restraining traps. These scores are based on the ISO trauma scale (ISO 10990-4 1999), which is categorized into four levels for each injury sustained:

Mild trauma (scores range from 2 to 10 points—injuries such as claw loss and abrasions)

Moderate trauma (scores range from 25 to 30 points—injuries such as loss of single digit and eye laceration)

Moderately severe trauma (a score of 50 points—injuries such as loss of two digits and a simple fracture below the carpus or tarsus)

Severe trauma (a score of 100 points—an injury such as loss of three or more digits to resulting in death)

A composite score of individual's injuries is used to assess if a trap meets appropriate welfare standards (see Iossa et al. 2007, for an extensive review of animal welfare standards based on scoring of trap-caused injuries following the ISO trauma scale). To achieve AIHTS, killing traps are expected to cause death in ≤5 min for 70% of trapped individuals for the species being evaluated. However, Proulx et al. (2012) and Proulx and Rodtka (2015) argue that ≤3 min should be applied as the minimum standard for time until death (irreversible unconsciousness). Time until death of animals caught in drowning sets is dependent on the onset of hypoxia, which typically will be a prolonged period (i.e., potentially much longer than the $\leq$5 min standard established for death of animals captured in killing traps) for the semiaquatic mammals typically targeted by trappers using this method of trapping (Gilbert and Gofton 1982; Iossa et al. 2007).

Animal welfare issues associated with fur trapping—especially the use of leghold traps—have been the primary motivation for the development of trapping standards. Nonetheless, projects that involve the live-trapping of wild animals for research and conservation purposes often involve the same types of traps used by fur trappers and likewise deserve scrutiny to understand, and mitigate, the effects on the animals during capture and handling. Outcomes of research and conservation projects likely will be enhanced when traps and trapping procedures are efficient and cause minimal injury to captured individuals (e.g., less time and expense associated with capturing an appropriate number of animals to fulfill project objectives and in rehabilitating injured animals). Hence, in addition to what should be direct concern based on animal welfare, project investigators are also motivated by practical issues related to ensuring the well-being of live-trapped animals in relation to intended research or conservation outcomes. In contrast, the intent of fur trappers is to kill trapped animals for the pelt or other products derived from the carcass—i.e., although there may be a humanitarian concern to reduce suffering to the trapped animal, there is no practical motivation for a fur trapper to be concerned about injuries incurred to an animal during trapping unless the injuries somehow impact the value of the fur or other products. In fact, in the absence of regulation, practical issues would dictate that fur trappers adopt the most efficient trapping methods—those yielding the highest capture rates at the least expense—in lieu of animal welfare concerns. This dichotomy in practical issues between live-trapping for research/conservation and trapping for fur serves to emphasize an important reason, in addition to the fact that live-trapping for research/conservation purposes is conducted much less frequently than trapping for fur, that establishing animal welfare standards for trapping has been focused on fur trapping.

30.6 Live-Trapping Otters for Research and Conservation

Although killing traps may be used to lethally collect specimens for research purposes, the focus of this section is directed toward the use of restraining traps to livetrap otters (animal welfare issues related to using kill traps are discussed in the ensuing Sect. 30.9 “Trapping River Otters for Fur”). A variety of restraining traps and associated trap-setting procedures have been assessed for use in live-trapping river otters, and sometimes these methods have subsequently been applied and refined to livetrap other otter species [e.g., for reintroducing the Eurasian otter into Spain (Fernandez-Moran et al. 2002) and reintroducing the Eurasian otter into the Netherlands (Koelewijn et al. 2009)]. Animal welfare concerns for live-trapping wild animals should necessarily apply not only to the traps used but to how traps are set, how procedures are used to restrain animals for removal from traps, and the immediate post-trapping handling of animals (hereafter this collective is referred to as the "trapping system"). Various leghold traps and Hancock™ traps have primarily been used for trapping river otters for research/conservation purposes, with results of the applications and outcomes (e.g., trap-setting procedures, review of injuries, and capture rates) published in various formats. In contrast, there are no peer-reviewed assessments of injury rates for other traps that could potentially be considered for use in live-trapping river otters (e.g., cage traps and snares), although cage traps have been used in studies requiring the live-capture Cape clawless otters (*Aonyx capensis*) (Van der Zee 1982; Arden-Clarke 1986) and spotted-necked otters (*Hydrictis maculicollis*) (Perrin and Carranza 1999). The following review focuses on published cases of various traps used to live-trap river otters, with respect to injuries and the trapping systems employed, but also includes mention of trap types that may theoretically be used but which have not been frequently used or evaluated for use with river otters or other otter species. This discussion of traps may have similar merits and/or liabilities for otters species other than river otters.

30.6.1 Leghold Traps

Serfass et al. (1996) compared injuries caused to teeth, feet, and legs of river otters captured using No. 1.5 coil spring traps with padded jaws (hereafter padded trap; Fig. 30.1b) with one factory spring replaced with a No. 2 spring (captured in Pennsylvania by authors and Maryland by personnel of the Maryland Department of Natural Resources; $n = 38$), No. 11 longspring traps (captured in Louisiana by a supplier licensed to capture and sell river otters; $n = 17$), and various unidentified types of leghold traps (captured in Michigan, New Hampshire, and New York by private trappers; $n = 29$) for a river otter reintroduction project. Trap-setting techniques were similar for No. 1.5 coil spring traps with padded jaws and No. 11 traps {traps were set and anchored in the water [anchor (i.e., the trap attachment)]}. Traps were attached with a segment of chain typically 1.5 m in length, enabling river otters to swim while captured (see Serfass et al. 1996, for details and precautions associated with this trap-setting technique to avoid drowning captured animals). In contrast, trap-setting procedures followed by private trappers are poorly reported, but traps were presumed to be primarily set and attached on the shoreline (i.e., not in the water as Serfass et al. 1996). Few severe injuries to limbs occurred among river otters captured in padded traps [1 (4%) had an injury requiring an amputation (a single digit) in comparison to amputations in 12 (71%; ≥1 digit) and 9 (37.5%; ≥1digit ($n = 7$), a foot, and a leg) river otters caught in No. 11 traps and by private trappers using unspecified traps/trap-setting techniques, respectively]. River otters caught in padded traps and No. 11 traps sustained fewer, and less severe, dental injuries than those obtained from private trappers. Regardless of trap type, injuries (to appendages and the teeth) sustained by juvenile river otters were much less than for adults (Serfass et al. 1996).

A study in coastal Alaska used No. 11 double-jaw longspring traps set on land (anchored with trap chains ≤70 cm in length) to live-capture 30 river otters (Blundell et al. 1999). This project used a trauma scale developed by Olsen et al. (1996) and Jotham and Phillips (1994) to score injuries to the teeth and appendages [scores for an individual could range from 0 (no injuries) to 100 (death)] but did not provide details of specific injuries contributing to scoring or the number of individuals acquiring injuries to the teeth and/or appendages. Traps were monitored a minimum of two to three times daily—a transmitter was attached to traps, and this was activated when traps were sprung. The scoring system and number of daily trap checks present a challenge for meaningful comparison with Serfass et al. (1996), who used different metrics to quantify injuries, and traps were checked once daily. More frequent trap checks may reduce frequency and extent of injuries by minimizing time an animal is restrained by a trap. Five (17%) of the river otters captured in No. 11 double-jaw traps by Blundell et al. (1999) attained serious injuries to appendages, whereas only one (3%) of those caught in padded traps by Serfass et al. (1996) would have been scored as having a serious injury. Injuries to the teeth considered serious were low in Blundell et al. (1999) and also likely to be low for Serfass et al. (1996), but actual comparison is not possible because of the different scoring systems followed by the respective projects. Melquist and Hornocker (1979) captured nine river otters in leghold traps [five captures in No. 2 coil spring traps and four captures in No. 3 jump traps (no longer manufactured to our knowledge)]. Injuries to river otters caught in No. 2 coil spring traps were described as minor (no details provided), but escape rates were reportedly high. Two of the river otters (both juveniles) caught in No. 3 jump traps sustained broken hind limbs (the bones broken were not reported).

30.6.2 Hancock Trap

The Hancock trap was originally designed for live-trapping American beavers. Northcott and Slade (1976) and Melquist and Hornocker (1979) described important modifications necessary for the trap to be suitable for river otters (i.e., to prevent escape). Two further modifications were made by Serfass (1984): the first enabled the trap to lay flat for concealment when set in shallow water (as manufactured the movable side of the trap is at an angle to the fixed side), and the second involved covering the fixed side of the trap (comprised wires spanning opposing sides of the trap frame to form a rigid 5 × 10-cm grid) with vinyl coated 2.5 × 2.5-cm welded wire fencing (Fig. 30.2a, b). When constrained, river otters often vigorously attempt to escape by scratching or biting to breach any perceived weak areas in a cage, cage-type trap, or other confinement, potentially causing injury to forepaws and teeth. The spacing of wires on the fixed side of the trap created a grid comprised of openings likely large enough to become the focus of escape efforts by river otters (the head of most river otters will fit through a 5 × 10-cm opening), which was overcome by the second modification. Also, when set flat in shallow water [made possible by the first modification suggested by Serfass (1984)], the fixed side of the trap is not exposed to a captured animal, and although exposed, the chain-link on the (closing) movable side of the trap compresses and is thus less likely to cause teeth damage if bitten (Fig. 30.2b). The chain-link of the movable side of a Hancock trap [the top of the trap when closed as configured by Serfass (1984)] can expand upward to about 30 cm from the bottom of the trap. Care must be taken to monitor changes in water levels to ensure that the top of the trap remains above the surface (i.e., to avoid drowning a trapped animal).

Melquist and Hornocker (1979) tested a variety of traps and considered a properly modified Hancock trap the most favorable for use with river otters—there was no mention of occurrence of injuries (or lack thereof) among 21 captures, which included 2 adult-sized river otters captured simultaneously. In Blundell et al.'s (1999) comparison of Hancock traps and No. 11 double-jaw leghold traps for capturing river otters (*n* = 11 for Hancock traps, and *n* = 30 for leghold traps), serious injuries to the teeth occurred much more frequently in Hancock traps, but serious injuries to appendages were higher for leghold trap (no injuries to appendages occurred in river otters caught in Hancock traps versus about 17% in those caught in leghold traps). In contrast, Serfass (1984) indicated no injuries to six river otters captured in Hancock traps modified as described by Melquist and Hornocker (1979) and Serfass (1984). Dental injuries reported by Blundell et al. (1999) may have occurred because modifications were not made to the fixed side of the Hancock trap.

In comparison to leghold traps, Hancock traps have received limited use and evaluation for live-trapping river otters, possibly fostered by the somewhat negative evaluation by Blundell et al. (1999). The much larger size, higher cost, and limited availability of the Hancock trap (in comparison to leghold traps) also present various practical limitations to its use. Another practical concern relates to the potential for larger animals (including people and pets) to accidentally trigger and be injured by being caught between the frames of the hard-closing trap. Likewise, there is potential for otters to be caught between the frames of this trap, especially if >1 otter visits the trap site. Regardless, the virtues of the Hancock trap for live-capturing river otters [e.g., no injuries when modified as reported by Serfass (1984) and good capture efficiency reported by Melquist and Hornocker (1979) and Blundell et al. (1999)] merit its further evaluation, particularly as an alternative for live-trapping river otters or other otter species in areas where use of leghold traps is limited or prohibited.

30.6.3 Other Traps

Various types of leghold traps and the Hancock trap are the only traps used with any regularity for live-capturing river otters. Other traps that have potential for use with river otters have either had limited or no evaluation. In addition to leghold and Hancock traps, Melquist and Hornocker (1979) also conducted brief evaluations of a powered foot snare and several cage-type traps (one from a trap manufacturer and three constructed specifically for the project: culvert, barrel, and floating traps) but reported little meaningful information on capture or injury rates. Cape clawless otters and spotted-necked otters have been successfully captured in what were described as "standard carnivore traps" (800 × 800 × 1400 mm cage traps with a single door) [Van der Zee (1982) and Arden-Clarke (1986)—capture of Cape class otters; Perrin and Carranza (1999)—capture of spotted-necked otters]. No information was provided on injuries or lack thereof to the captured animals. To our knowledge, body/neck snares have not been evaluated with live-capturing river otters. Severe injuries caused to wolves (*Canis lupus*) and coyotes (*Canis latrans*) caught in neck/body snares suggest that extreme caution should be used in developing protocols for evaluating the suitability of snares or any other untested traps to livetrap otters. Concerns for snaring these species have been raised by Proulx and Rodtka (2015) and Proulx et al. (2015), and general concerns for animals captured in snares were raised by Rochlitz (2010). Cage-type traps have been successfully used to capture a variety of carnivore species with minimal or no injury and deserve further research attention to determine if otters can be captured efficiently and relatively unharmed using this type of trap.

30.7 Restraint of Captured Otters for Release from Traps

Development and refinement of protocols for efficiently reducing stress and injury to captured animals being released from traps are sometimes overlooked as a component of the trapping system. Restraining an animal for release from a trap is accomplished either by physical or chemical restraint (delivery of a drug, i.e., a chemical immobilant) to enable handling of an animal. Physical restraint is any approach that confines the movement of an animal—a trap represents a physical restraint, but the term is most often applied to devices used to further restrict the movement of an animal restrained in a trap. Physical restraint should facilitate either the direct release of a trapped animal or delivery of a chemical restraint to immobilize the animal for release from the trap and to enable subsequent evaluations (e.g., physical examination, ear tagging, or transport to a captive facility). Methods to physically restrain river otters while captured in live traps will be the focus of the ensuing discussion.

30.7.1 Leghold Traps

Techniques for physically restraining river otters captured in leghold traps necessarily vary by trap-setting technique. Shirley et al. (1983) and Serfass et al. (1996) describe the use of long-handled nets to restrain river otters captured in leghold traps attached to chains (typically 0.6–1.25 m in length, but potentially longer) anchored in the water. River otters had limited access to the shoreline but were able to swim within the radius of trap chains and the captured animals were netted while in the water. The use of nets for physical restraint necessitates evaluation as to whether the structure of netting will cause the trap restraining an animal to become entangled in

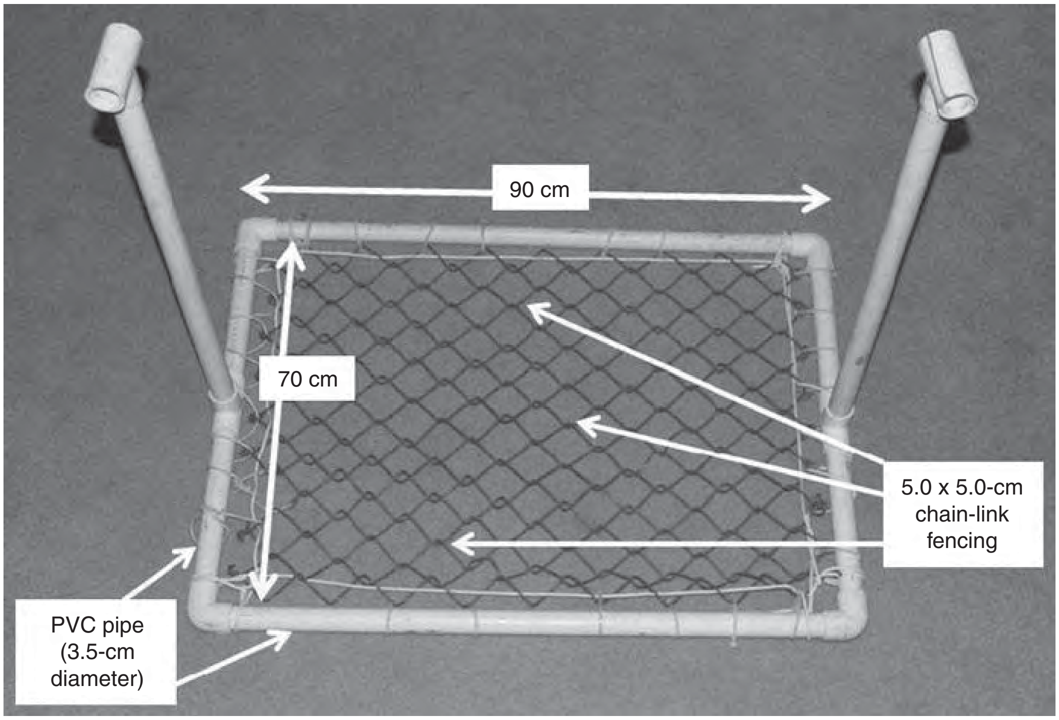

Fig. 30.4 Hold-down device used to physically restrain river otters captured in leghold traps. Trapped river otters initially are restrained in nets the netted river otter is further restrained with the hold-down device to better enable delivery of chemical restraint (see Serfass 1984; Serfass et al. 1996). The hold-down device is constructed of polyvinyl chloride (PVC) pipe (wood and metal framing also have been used) surrounding vinyl coated chain-link fencing. Handles of hold-down device detach for transport

the net. Such entanglement may result in injury and additional stress to a captured animal. The likelihood of a trapped animal becoming entangled in a net will vary based on construction of nets (e.g., fibers used, the thickness of those fibers, and mesh size—an assessment is easily accomplished by placing leghold traps inside various netting to determine if entanglement occurs). Serfass et al. (1996) describes a process for bringing the netted animal to the shoreline and application of a second form of physical restraint (use of a hold-down device; Fig. 30.4), for quick, efficient, and safe (for the animal and investigator) delivery of a chemical immobilant.

The use of capture poles (e.g., Ketch-All™ poles, San Luis Obispo, California 93401, USA) is common for restraining animals captured in leghold traps but has limited application for river otters—the circumference of a river otter's neck tends to be larger than that of the head (particularly in adults) and, unless excessively tightened, the noose of the capture pole generally will slip off the head. In lieu of physical restraint, Blundell et al. (1999) successfully delivered darts with chemical restraint through a blow gun, and Fernandez-Moran et al. (2002) also used such an approach for delivering chemical immobilants to Eurasian otters captured in No. 1.5 padded traps. Remote delivery of chemical immobilants reduces stress and potential injury that could be contributed by physical restraint, but consideration should be given for the possibility for an animal becoming free of the trap following delivery but before being restrained by the chemical immobilant. Such scenarios were not reported by either Blundell et al. (1999) or Fernandez-Moran et al. (2002), but should be considered, and would be of particular concern for otters, which if escaping the trap would likely enter the water and potentially drown after the drug takes effect.

30.7.2 Hancock Live Traps

Chemical immobilants can easily be delivered to animals captured in Hancock traps by injecting with a hand syringe (hand injection) through the chain-link mesh on the movable side of trap (Serfass 1984; Blundell et al. 1999). Movement of a trapped animal can be further restricted to better facilitate injection by compressing the chain-link comprising the movable side of the trap (i.e., the investigator will stand on the chain-link on opposing sides to the animal in a manner that confines but does not exert excessive downforce). Serfass (1984) set Hancock traps exclusively in shallow water and recommends that traps be pulled from the water prior to delivering chemical restraint to the captured animal to prevent it from ingesting water during induction.

30.8 Concluding Comments: Live Traps

Meaningful comparisons of outcomes of the relatively few reports of live-trapping river otters are a challenge. There seldom have been direct comparisons of traps where associated trapping systems have been controlled, including periods between trap checking. For example, the live-trapping study conducted by Blundell et al. (1999) occurred in an area (coastal Alaska) that enabled use of transmitters to remotely determine if traps were sprung, which facilitated monitoring each trap site at least two or three times a day. In contrast, Serfass et al. (1996) conducted their live-trapping study in northeastern Pennsylvania where trapping sites were widely distributed across the landscape, which logistically limited checking traps sites to once every 24 h. In such cases disparities in trap-check frequency may have influenced outcomes as much or more than the trap and trapping system applied. For example, longer times between the checking of traps could correlate positively with more injuries. Regional difference in environmental conditions and associated difference in trapping conditions could likewise compromise meaningful comparisons of traps and trapping systems.

Because of the large number of wild river otters captured for reintroduction projects in the USA (>4000; Bricker et al. 2016), there may be an impression that techniques for live-trapping the species are well established. However, the majority of the animals used for reintroduction projects were captured in southern Louisiana through arrangements with an individual licensed to trap and sell river otters. Hence, there were no assessments of mortality rates, injuries that prevented sale of otters for reintroduction, or, with the exceptions of Serfass et al. (1996), assessments of injuries sustained by animals that were reintroduced. Hancock traps have been used infrequently, even though a few assessments of this trap indicated its potential for use in live-trapping river otters. Clearly more rigorous studies are needed for assessing both practical and animal welfare issues for traps and trapping systems most appropriate for use in live-trapping river otters.

Outcomes of live-trapping studies conducted in the USA and the few studies conducted elsewhere (e.g., Fernandez-Moran et al. 2002; Koelewijn et al. 2009) can serve as a basis for assessing best methods to livetrap other species of otters. However, researchers should understand that physical and behavioral differences of other otter species could affect responses to being trapped and be open to investigating potentially new and more innovative approaches for live-trapping otters. Researchers investigating other species of otters also should be certain that live-trapping studies are designed in a manner that enables meaningful comparisons of the traps and trapping systems being evaluated.

The development of noninvasive techniques for otters [e.g., camera trapping (Stevens and Serfass 2008) and extraction of DNA from feces (Fike et al. 2004; Beheler et al. 2005) and hair (Depue and Ben-David 2010)] has limited the need for more invasive field techniques that may cause physical harm and stress to animals, such as live-trapping. Regardless, the use of radiotelemetry remains an important part of many studies of wild animals and provides insight about animal behaviors and movement patterns not always assessable by noninvasive techniques. Conducting radiotelemetry studies is inherently dependent on capturing and handling individual animals to attach transmitters, which argues for the continued use of live-trapping of wild animals (including otters) for some field investigations. In the case of otters, live-trapping is in need of further refinement (for species that previously have been livetrapped) and development through appropriately designed studies for species that have not been the focus of studies involving live-trapping.

30.9 Trapping River Otters for Fur

Killing otters to obtain their pelts for the fur trade is an international venture undertaken legally and illegally, depending on species and geopolitical jurisdiction. Illegal methods of killing otters will vary based on what is most expedient for perpetrators. Illegally killing of otters in some parts of the world is considered to be severely impacting populations of some species [e.g., populations of otter species inhabiting southeastern Asia are believed to be declining because of intense demand for their pelts in China (Foster-Turley and Santiapillai 1990; Gomez et al. 2016)]; but few details are available regarding the extent of the illegal trade or approaches used to kill otters. Regardless, individuals involved in the illegal killing of otters (or any wildlife) are not going to adhere to any prescribed standards of animal welfare.

Legal killing of otters presumes some standards are in place to limit depletion of populations [e.g., regulations for periods when killing can occur (closed seasons) and number of individuals that can be killed (quotas)] and to limit pain and suffering. Of the world's 13 species of otters, all are listed as Convention on International Trade in

Endangered Species of Wild Fauna and Flora (CITES) Appendix I or II because of respective concerns of endangered or threatened conservation statues, except for the river otter, which is listed under Appendix II as a "look-alike species" (*A designation for a species legally part of international trade that is of similar appearance to one or more species not legally traded. Hence, the designation serves as a precaution against inclusion of specimens or parts of a protected species from being illegally exported by being posed as those of a similar species that is legally traded.*). However, trade of Appendix II (non-look-alike) species is permissible if conditions are met demonstrating that there will be no detriment to the survival of the species in the wild.

Among the world's otter species, the river otter is the only species possessing a population status considered suitable for meeting conditions that will enable sustainable killing of individuals for the pelt trade throughout large portions of its range. As an otter species legally trapped throughout much of its range for pelts that are frequently traded internationally, the river otter is thus of predominant concern regarding the humaneness of techniques and equipment used to capture and kill individuals. Prior to European settlement, the river otter occupied aquatic habitat throughout the Continental USA and Canada (Hall 1981). By the early to mid-1900s, the species had experienced substantial population declines, or complete extirpations in some areas. These declines occurred throughout large portions of the river otter's historic range in the USA but to a lesser extent in Canada. These losses resulted from the combined detrimental effects of overkilling by trappers, disturbances to riparian habitats (e.g., deforestation), and water pollution (Bricker et al. 2016). The combination of more restrictive trapping regulations including prohibition of trapping river otters in some USA states, successful reintroduction projects in 22 states, and improvements in the conditions of riparian and aquatic habitats contributed to the recovery of river otter populations in many areas of NA (Bricker et al. 2016). Legal trapping of river otters has expanded as populations have recovered. About 171,000 river otters in the USA and about 83,000 river otters in Canada were trapped for their pelts between 2006 and 2012. River otters are a primary target species for about 9% of trappers in the USA (Responsive Management 2015a).

Trappers use a variety of devices to capture river otters. Trapping devices are selected for various reasons, including practical (e.g., cost of traps and associated equipment), social (e.g., personal preference, influence of peers, and tradition), habitat conditions, regulations imposed by a particular jurisdiction within a country, and international agreements, including the AIHTS in Canada (Fur Institute of Canada 2015) and BMPs in the USA (AFWA 2014). Growing public concern over animal welfare issues have raised specific attention to the ethics and humaneness of trapping wildlife for fur, and this has come alongside a realization that minimizing injury to a trapped animal should also be a consideration when selecting a trapping device. AIHTS and BMPs focus on physical injuries in assessing animal welfare issues regarding trapping. Iossa et al. (2007) make a compelling argument that stress and various other physiological indices should be used in such assessments. Rothschild et al. (2008) and Taylor et al. (2016) assessed stress (glucocorticoid) levels, and Kimber and Kollias (2005) evaluated biochemistry values of blood in river otters following their live-capture and placement into captivity as part of reintroduction projects. These studies demonstrated no long-term adverse stress responses and also concluded that blood values were not a good indicator of the level of physical injury. No such studies have been undertaken for river otters as part of the AIHTS and BMP trap certification processes in relation to fur trapping.

30.9.1 Restraining Traps

Leghold traps, which are the most common type of restraining trap used by trappers to capture river otters, have received extensive review through the process of developing BMPs and are thus the focus of this discussion on restraining traps. An adequate critique of leghold traps in relation to animal welfare issues requires including an assessment of various trapping systems that may be employed. For example, methods used to attach [anchor] traps at trap sites should be included in critiques. Other often overlooked factors for such critiques include trapper willingness to implement recommendations (especially when formal regulations are not in place to mandate use of a particular trap and trapping system, as with BMPs), variation in regulations for legal trap types and trapping systems imposed by wildlife management authorities (for the USA, wildlife management for most species, including river otters, is at the state-wildlife-agency level), the capabilities and effort put forth by the various management authorities to enforce regulations, and variation in response to being restrained in a trap among species and by individuals of a species.

Coil spring traps (unmodified only) with jaw spreads ≥5 in. (13 cm) and long-spring traps (either unmodified or modified to have double jaws) with jaw spreads of ≥3 7/8 × 3 7/16 in. (10 × 9 cm) meet BMP criteria for river otter (AFWA 2014). However, AFWA (2014) also states "Many currently-used trap models meet specifications." Details about testing of approved traps are not provided or description of the criteria used to establish the suitability of "many currently used trap models." Likewise, no reasons are provided for not specifically listing certain types of traps as acceptable (e.g., modified coil spring traps). These omissions may be related to a trap not yet having been tested, the trap having been tested and failed humane requirements, or having been tested and failed other BMP criteria (e.g., efficiency—a trap is not judged to be efficient if <60% of individuals for the target species remain captured after activating the trap).

30.9.1.1 Physical Injury

Other than published reports of river otters captured for research and conservation purposes (see Sect. 30.6), we were unable to find published descriptions of injuries sustained by river otters captured in leghold traps. Review of the published studies of river otters captured in leghold traps as part of conservation and/or research projects indicated considerable variation in injuries caused among various leghold traps (see Sect. 30.6.1). This contrasts with portrayals in BMP recommendations for leghold traps as being suitable for river otters. In fact, virtually all of the styles and sizes of leghold traps considered efficient in trapping river otters prior to development of BMPs are now approved as meeting BMP criteria. BMP evaluations to determine a trap as suitable appear to be based on controlling other factors related to trapping (e.g., how a trap is set and the time required to check traps). Review of the published reports on live-trapping river otters suggests that such factors (in addition to the type of trap used) are likely to influence injuries to a trapped animal. Such variations appear to be discounted in assessments for determining BMPs, where participating trappers are monitored to ensure compliance with prescribed trapping procedures. There is no evidence, for example, that the trapping procedures followed by trappers participating in BMP evaluations will become expectations (i.e., in the form of regulations) for fur trapping. Objective evaluation to determine if BMPs will be useful in enhancing welfare standards for animals caught in leghold traps is virtually impossible from published information related to the development of BMPs for river otters or other furbearers.

30.9.2 Killing Captured Animals

Methods for killing an animal captured by trappers using restraining traps are often overlooked in humane assessments of trapping. Generally, trappers are recommended to shoot the trapped animals between the eyes with a .22 caliber gun (International Association of Fish and Wildlife Agencies [IAFWA] 2005). However, trapper's magazines often recommend drowning, suffocation (standing or kneeling on the animal's chest), or hitting on the head with clubs as a way to minimize damage to the fur (i.e., avoid the blood that would get on the pelt if the animal is shot) (Fox and Papouchis 2004). The IAFWA (2005) also recommends these methods as humane forms of killing trapped animals.

30.9.3 Killing Traps: Bodygrip Traps

The published BMPs for otters list any bodygrip trap within sizes designated as 220, 280, and 330 as acceptable for use with river otters. Traps of this type are considered to meet humane standards if 70% of the animals are dead within 5 min after being captured (Iossa et al. 2007; Proulx et al. 2012; Proulx and Rodtka 2015). Such standards omit discussion of humane considerations for the 30% of animals potentially not dead after 5 min or the suffering that occurs to those that do meet the 5 min standard. Testing to assess these standards has in some cases taken place in captive settings where anesthetized animals are positioned between the jaws of a set trap and then the trap is sprung. Such an approach does not necessarily represent conditions seen in natural settings, where the trap is less likely to close on the preferred part of the body (to expedite the time until death). We were unable to find published details of testing outcomes for assessments of bodygrip traps for river otters.

30.9.4 Drowning Traps/Sets

Trappers commonly use “drowning traps/sets” when capturing semiaquatic furbearers, such as river otters. River otters reportedly have the capacity to remain underwater for up to 8 min (Smithsonian n.d.), exceeding the acceptable time established for death using bodygrip traps to meet humane requirements. However, BMPs make no mention of any evaluations conducted to assess animal welfare standards for this type of trapping of river otters, but the BMP does state that performance standards are comparable to killing devices for other aquatic furbearers (AFWA 2014). In fact, this type of trapping system is recommended for river otters, with the only BMP standard being that the trapping system must not allow the animal to reach the surface after being submerged.

30.9.5 Killing Snares

Trappers legally use snares to capture river otters in some USA states and Canadian provinces. However, there are no published evaluations of the humaneness of capturing river otters in snares nor are these devices considered in AIHTS or BMP evaluations of trap performance criteria. Proulx et al. (2015) reviewed issues pertaining to the use of snares to kill canids [gray wolves (*Canis lupus*), coyotes (*C. latrans*), and red foxes (*Vulpes vulpes*)] in Canada, concluding that death to the animals was prolonged or some animals remained alive (i.e., did not meet humane standards for death applied to other killing traps), injuries were sometimes severe (e.g., deep lacerations where the snare tightened around the neck), and killing snares are nonselective—often capturing a variety of nontarget animals. From these outcomes, Proulx et al. (2015) recommended that use of killing snares be disallowed unless modifications can be achieved that improve the humaneness of this trapping system. In contrast, use of snares is being promoted in the USA (e.g., Vantassel et al. 2010). Given a well-developed musculature in the neck, river otters, like canids, are unlikely to be killed quickly or at all when caught in a snare. Snares, incorporated into drowning sets, would eventually cause death by asphyxiation. In the absence of contrary evidence, the evaluation of killing snares by Proulx et al. (2015) for canids establishes an important basis for regarding this trapping system as likely to be inhumane (by any standards) for capturing river otters.

30.9.6 Unintended Captures

River otters are sometimes caught accidentally by trappers intending to catch other semiaquatic furbearers or those that frequent riparian habitats. Responsive Management (2015a) conducted an extensive survey of trapping in the USA, which included assessment of species captured, types of traps used for a particular species, and furbearing species captured unintentionally (i.e., not the primary target of the trapper). Unintentional capture of river otters was reported by 29.5% of trappers targeting American beavers. Large bodygrip traps, various leghold traps, and snares are used for beavers, with the No. 330 bodygrip trap predominating (about 78% of beaver trappers reported using that trap). Traps and trap sets used for beavers are in some ways comparable to what would be expected for use with river otters and, thus, represent similar issues pertaining to a humane death—time to death caused by closure and/or drowning in bodygrip traps, time until drowning in drowning sets, and potential injuries from snares. River otters also were reported to be unintentionally caught by trappers primarily pursuing American mink (*Neovison vison*), muskrat (*Ondatra zibethicus*), and raccoon (*Procyon lotor*), but less frequently than by beaver trappers (<6% for each of these species). However, trappers trapping American mink and muskrat in leghold traps often may not anchor the trap sufficiently (either by using stakes or weight) to retain a trapped river otter at the capture site (i.e., the river otter escapes with the trap attached to its leg), contributing to both humane concerns and potential for underrepresenting the extent of unintentional captures. Also, many trappers included in the Responsive Management (2015a) survey undoubtedly were not trapping in areas occupied by river otters. Expected rates of unintentional captures would thus be higher if not diluted by inclusion of trappers trapping in areas unoccupied by river otters. Realistic insight on expectations for the extent of unintentional captures is needed and could be gained by focusing only on the subset of trappers trapping in areas occupied by river otters.

30.10 Concluding Thoughts: Trapping for Fur

Trapping river otters for pelts appears to be “maintainable” (i.e., local populations appear to be able to withstand the numeric impacts) at the landscape-level scale in NA—although local, trapping-induced extirpations likely occur in marginal habitats and reintroduction projects may have been unnecessary in some areas of the USA if trapping had not limited expansion of natural populations. We note, for example, that there has been rapid post-release expansion of reintroduced populations, which initially were legally protected from trapping [see Bricker et al. 2016) for a detailed review of trapping and reintroductions of river otters], whereas native populations remained stationary or expanded slowly where trapping was permitted. Regardless, debate over trapping river otters is largely based on opposing values pertaining to what is appropriate and “ethical use of wildlife” and specific animal welfare concerns pertaining to the capture of animals in traps. However, those involved in supporting trapping in NA comprise a large, integrated wildlife management system that includes governmental wildlife agencies (and associated wildlife professionals), nongovernmental organizations representing these agencies [e.g., AFWA (http://www.fishwildlife.org/)], some university wildlife researchers, manufacturers of hunting and trapping-related equipment, and supporting political entities—a set of interactions referred to by Gill (2004) as an “Iron Triangle,” whereby those not within the "Iron Triangle" have a limited voice in wildlife policy decision-making. These relationships constitute a "conservation-industrial complex," which collectively offers considerable financial, political, and organizational resources to promote a value system based on sustainably killing wild animals.

The so-called North American Model of Wildlife Conservation [NAM; first articulated by Geist et al. (2001)] demonstrates the promotional capabilities of the wildlife management system in NA. The NAM is comprised of seven primary elements (Geist et al. 2001; Organ et al. 2012), each repeatedly depicted by various media in a manner that supports and justifies consumptive use of wildlife, managed by public, state-level conservation agencies, as the "cornerstone" of wildlife conservation in NA. Two of the primary elements of NAM: wildlife products should not be commercialized (i.e., sold as part of a market-based system) and the Public Trust Doctrine (PTD) are particularly relevant to discussions of trapping and the management of furbearing animals in the USA. Trapping for fur is a large, international, commercial enterprise of which trade in furbearers captured in the USA is a prominent part, an obvious contradiction to the primary element of NAM opposing commercialization of wildlife. The PTD is based on the concept that certain natural resources, including wildlife, cannot be owned by individuals but are instead to be conserved by the government in a manner that benefits current and future generations of citizens. An implicit assumption of the PTD is that the values and interests of all citizens be considered in approaches used to conserve and manage PTD-based natural resources (Treves et al. 2015). However, the values and interests of those engaged in hunting and trapping have been disproportionately favored in wildlife management decision-making at the state-agency level.

Over about the last 15 years, NAM has been widely portrayed as both a historical account of how wildlife were conserved in NA in the past and a prescriptive model for how wildlife should be conserved in the future (Peterson and Nelson 2016). Without question progenitors of NAM clearly endorse recreational, regulated killing of wildlife (the focus is on hunting, but trapping also has been established within the framework) of certain species of wildlife (i.e., those defined as game species, which includes "furbearing" animals such as the river otter) as the fundamental aspect of wildlife conservation. The repetitiveness by which NAM has been portrayed in numerous and varied forums (e.g., Mahoney 2004; Prukop and Regan 2005; Geist 2006; Mahoney et al. 2008; Organ et al. 2010, 2012) has aspects suggesting a marketing effort to promote fundamental concepts of NAM to both conservation professionals and the general public, an approach seemingly designed to homogenize acceptance of consumptive use as fundamental to properly managing wildlife. Foundations for such marketing efforts are anchored in social-science surveys conducted by private organizations that conduct public opinion surveys for state wildlife agencies about hunting and trapping and include investigations providing outcomes such as "How to Talk to the Public About Hunting: Research-Based Communication Strategies" (Responsive Management 2015b).

As with the seemingly overarching purpose of NAM, furbearer trapping also has been promoted to gain acceptance among wildlife professionals and the public. Muth et al. (2006) provided evidence that the majority of conservation professionals supported outlawing the use of the leghold trap and expressed concern that new recruits into the wildlife profession with "…non-traditional wildlife management backgrounds, such as women, ethnic minorities, non-hunters and non-trappers, and urban residents may possess a different value system regarding consumptive use of wildlife than their older counterparts." One mechanism that evolved concurrently with NAM is "Conservation Leaders for Tomorrow"—a program designed to instill NAM's principles by instructing both nonhunting/trapping university students (enrolled in wildlife-related degree programs) and natural resource professionals about the virtues of hunting and trapping in conservation (Conservation Leaders for Tomorrow 2015).

Likewise, seminars at various conferences sponsored by AFWA and The Wildlife Society (TWS) promote the importance of fur trapping in modern wildlife management to students interested in careers in wildlife conservation as well as practicing wildlife professionals [e.g., Trapping Matters Workshop 2016; AFWA Trapping Matters Workshop 2015) and an IAFWA-produced video (see IAFWA 2015)]. The AFWA provides "quick tips" for supporters of trapping on how best to communicate the role and benefits of regulated trapping in wildlife management. These "quick tips" encourage discussions to promote trapping by focusing on the following themes (AFWA 2015):

1. Regulated trapping does not cause wildlife to become threatened or endangered.
2. Trapping is managed through scientifically based regulations enforced by conservation officers.
3. State wildlife agencies continue to refine approaches to trapping methods that include issues pertaining to animal welfare [e.g., Best Management Practices (BMPs)].
4. Regulated trapping provides many benefits to the public (e.g., reducing wildlife damage to crops and minimizing threats to human health and safety).
5. Trapped animals are used for clothing and food.

These themes are mimicked with more elaboration in various publications authored by individuals actively engaged in promoting support for trapping and BMPs—e.g., "Trapping and furbearer management in North American wildlife conservation" appearing in various editions as a standalone publication of the Northeast (USA) Furbearer Technical Committee (Organ et al. 2015) and under the same title but different text as part of a special issue of the *International Journal of Environmental Studies* featuring NAM (White et al. 2015). Recommendations of strategies to gain public acceptance of specific aspects of trapping occur unabashedly in scientific publications of TWS (e.g., use of snares: *"In states where cable-traps are currently prohibited, a drastic regulatory change would likely result in immediate protest from anti-trapping organizations. For example, focusing on regulatory liberalization of snaring in water where beavers are causing damage would likely be more successful than an immediate regulatory change that allowed all forms of cable-trapping."*; Vantassel et al. (2010)). These and other examples raise ethical questions about public employees (many of whom are involved in the articulation of NAM and BMPs) promoting personal values to the public being represented, the role of science versus personal values in formulating wildlife management policy, and, most importantly for this discussion, whether BMPs are focused on improving the welfare of trapped animals or as an opportunity to promote trapping, both in the USA and internationally.

Science is referred to as the basis for developing and implementing furbearer management policy in the USA. However, the process of developing BMPs and promoting the process of fur trapping also includes considerable emphasis on the economic and cultural values of trapping furbearers to some local communities (e.g., Organ et al. 2015; White et al. 2015); topics having practical and emotional relevance but little to do with science in addressing concerns about animal welfare. Traps recommended under the BMP for river otters include virtually all of those used prior to BMPs, and no traps are recommended as inappropriate for the species. Although the BMP for river otters has been recently updated and available on the AFWA web site, no specific details of trap testing outcomes are provided on the site or are readily available for critique. Review and interpretation of outcomes used to establish BMPs are thus seemingly conducted primarily by those involved with the BMP initiative, implying that the public should accept unquestioningly the process and outcomes (a "good faith" approach) associated with selecting traps that adequately meet humane expectations for the public's furbearers. Organ et al. (2014) seemingly support the PTD (as applied in NAM) as being in congruence with this "good faith" management scheme by citing the following statement from Scott (1999): *"Additionally, if a trustee has special skills or expertise (e.g., wildlife professional), they have a duty to use these heightened capacities to enhance the conservation of resources under their management in the interests of trust beneficiaries."* Such a statement seemingly implies that wildlife professionals employed by state wildlife agencies will act in an unbiased manner and objectively represent the interests of all stakeholders in decision-making related to trapping wildlife for fur, a process that is not in evidence when considering promotional efforts to gain public acceptance of fur trapping nor by the system of wildlife conservation championed by proponents of NAM. Treves et al. (2015) effectively identify and review concerns pertinent to the application of public trust responsibilities by state wildlife agencies—specifically pertaining to the conservation of predators. Preeminent among these concerns is the narrow and preferential focus on consumptive use of wildlife embedded in the version of PTD portrayed by proponents of NAM (Batcheller et al. 2010). In contrast, Sax (1970) interpreted proper application of PTD as incorporating interests from a broad constituent base, advocating preserving public, environmental assets for future generations and defending society from undemocratic allocations of environmental assets (modified from Treves et al. 2015). Treves et al. (2015) define undemocratic allocation in part as those that "… reflect tyranny of minority or majority,…," a situation indicative of the wildlife conservation system advocated by NAM whereby consumptive users (who represent a fraction of the overall population in NA) have the predominate voice in decision-making pertaining to wildlife policy. Although humane issues have not received specific attention in discussions of PTD, application of PTD in the narrow sense promoted by Batcheller et al. (2010) and Organ et al. (2012) may nonetheless diminish attention and action in addressing humane concerns pertaining to trapping (or other consumptive uses of wildlife), especially if such concerns collide with entrenched values systems and interests associated with the NA system of wildlife conservation.

The number of states allowing legal trapping of river otters has expanded in recent years (Bricker et al. 2016). Prior to initiation of trapping seasons, strikingly similar negative media portrayals of river otters occurred in several states (Serfass et al. 2014), characteristically beginning with praise for implementation of progressive wildlife conservation policies by state wildlife agencies (i.e., implementing successful river otter reintroduction projects) and ending by proposing that a trapping season may be necessary to alleviate conflict associated with rapidly growing numbers of river otters. Conflict was portrayed as river otters predating on fish in private ponds, and being harmful to gamefish populations, thus causing complaints by anglers (Serfass et al. 2014). However, the extent of these conflicts was seldom quantified by state wildlife agencies or exaggerated in states portrayed as having public resentment toward river otters (Bricker et al. 2016). These negative portrayals appeared to have the intent of lessening public opposition for proposed plans to initiate river otter trapping seasons. State wildlife agencies appear to have allied with some media in the negative messaging. Fostering an acrimonious situation to achieve a wildlife management outcome (i.e., a trapping season on river otters) to benefit a particular constituency (i.e., trappers) would breach PTD obligations of state wildlife agencies to conserve wildlife in a manner that considers the interest of all citizens, not to manipulate public opinion through a marketing effort to achieve a management outcome. Further, labelling an animal as a pest or problem lessens public concern for its welfare (Rochlitz 2010). The marketing approaches seemingly being followed to promote support for fur trapping in general and river otters specifically cast doubt on the objectivity of decision-makers involved in the development of BMPs in placing animal welfare at a level equivalent to traditional wildlife management practices in the USA.

Trapping wild animals for fur is a contentious issue in the USA and elsewhere and will not be accepted by most animal welfare groups, regardless of approaches used to enhance the humaneness of a trap or trapping system. Nonetheless, opposition to fur trapping (especially when using leghold traps) from animal welfare groups in Europe and NA provided the primary impetus for developing universally standardized approaches in defining animal welfare standards for trapping animals with restraining and killing traps (i.e., standards established by the ISO). Establishment of ISO criteria provides a basis for evaluating the humanness of restraining and killing traps used for both research and fur trapping. Although this appeared to be a positive step in recognizing the need to address welfare concerns for trapped animals, the process of trap testing to define traps meeting ISO standards and, more importantly, the actual humaneness of the traps and associated trapping systems and the evaluative process are in need of further scrutiny, particularly in the USA.

References

AFWA Trapping Matters Workshop (2015) Southeast Association of Fish and Wildlife Agencies-pdf. http://www.seafwa.org/Documents%20and%20Settings/46/Site%20Documents/Conferences/2015/2015%20Conference/2015%20Conference/TrappingMattersWorkshop_SEAFWA.pdf. Accessed 9 April 2017

Agreement on International Humane Trapping Standards (AIHTS) (2012) Joint management committee meeting http://www.fishwildlife.org/files/AIHTS_JMC2012report.pdf. Accessed 8 May 2016

Animal Legal and Historical Center (2010) Detailed discussions of fur animals and fur productions. Michigan State University College of Law. https://www.animallaw.info/article/detailed-discussion-fur-animals-and-fur-production. Accessed 1 July 2016

Arden-Clarke CHG (1986) Population density, home range size and spatial organization of the cape clawless otter, *Aonyx capensis*, in a marine habitat. J Zool Soc Lond 209:201–211

Association of Fish and Wildlife Agencies (AFWA) (2006) Best management practices for trapping in the United States. http://www.fishwildlife.org/files/Introduction_BMPs.pdf. Accessed 8 July 2016

Association of Fish and Wildlife Agencies (AFWA) (2014) Best management practices for trapping river otter in the United States. http://www.fishwildlife.org/files/Otter_BMP_2014_F.pdf Accessed 8 July 2016

Association of Fish and Wildlife Agencies (AFWA) (2015) Key messages on trapping. http://wwwfishwildlifeorg/files/AFWA-Furbearer_KeyMessages_2015pdf. Accessed 8 July 2016

Batcheller G R, Bambery MC, Bies L, Decker T., Dyke S, Guynn D, McEnroe M, O'Brien M, Organ J F, Riley S J, Roehm, G (2010) The public trust doctrine: implications for wildlife management and conservation in the United States and Canada. Technical Review 10–01.The Wildlife Society, the Association of Fish and Wildlife Agencies, the Western association of fish and wildlife agencies, and the Wildlife Management Institute, Bethesda, MD, USA

Beheler AS, Fike JA, Dharmarajan G, Rhodes OE Jr, Serfass TL (2005) Ten new polymorphic microsatellite loci for North American river otters (*Lontra canadensis*) and their utility in related mustleids. Mol Ecol Notes 5:602–604

Blundell GM, Kern JW, Bowyer RT, Duffy LK (1999) Capturing river otters: a comparison of Hancock and leg-hold traps. Wildl Soc Bull 27:184–192

Bricker EA, Serfass TL, Ammer FK, Hanley ZL, Pearce KJ, Stevens SS (2016) Conservation status of the North American otter in the United States and Canada: assessing management practices and public perceptions of the species. In: Linh San ED, Somers MJ (eds) Small carnivores: evolution, ecology, behaviour and conservation. Wiley-Blackwell, Oxford

Conservation Leaders for Tomorrow (CLfT) (2015) The history of CLfT. http://clftorg/history. Accessed 9 July 2016

Depue JE, Ben-David M (2010) Hair sampling techniques for river otters. J Wildl Manag 71:671–674

Fernandez-Moran J, Saavedra D, Mantexa-Vilanova X (2002) Reintroduction of the Eurasian otter (*Lutra lutra*) in northeastern Spain: trapping, handling, and medical management. J Zoo Wildl Med 33:222–227

Fike JA, Serfass TL, Beheler AS, Rhodes OE Jr (2004) Genotyping error rates associated with alternative sources of DNA for the Northern American River Otter IUCN Otter Spec Group Bull 21A

Foster-Turley P, Santiapillai C (1990) Action plan for Asian otters. In: Foster-Turley P, Macdonald SM, Mason CF (eds) Otters: an action plan for their conservation. IUCN, Gland, Switzerland

Fox CH (2004) Trapping in North America: a historical overview. In: Fox CH, Papouchis CM (eds) Cull of the wild. A contemporary analysis of wildlife trapping in the United States. Bang Publishing, Brainerd, Minnesota, pp 1–22

Fox CH, Papouchis CM (2004) Refuting the myths. In: Fox CH, Papouchis CM (eds) Cull of the wild. A contemporary analysis of wildlife trapping in the United States. Bang Publishing, Brainerd, Minnesota, pp 23–29

Fur Institute of Canada (2015) AIHTS—humane trapping standards and animal welfare. http://furca/fur-trapping/humane-trapping-standards-and-animal-welfare/. Accessed 8 May 2016

Geist V (2006) The North American model of wildlife conservation: a means of creating wealth and protecting public health while generating biodiversity. In: Gaining ground: in pursuit of ecological sustainability. International Fund for Animal Welfare; University of Limerick, Limerick, Ireland; Guelph, Canada, pp 285–293

Geist V, Mahoney SP, Organ JF (2001) Why hunting has defined the North American model of wildlife conservation. Trans N Am Wildl Nat Resour Conf 66:175–185

Gilbert FF, Gofton N (1982) Terminal dives in mink, muskrat, and beaver. Physiol Behav 8:835–840

Gill RB (2004) Challenges of change: natural resource management professionals engage their future. In: Manfredo MJ, Vaske JJ, Bruyere BL, Field DR, Brown PJ (eds) Society and natural resources: a summary of knowledge. Modern Litho, Jefferson City, MO, pp 35–46

Gomez L, Leupen BTC, Theng M, Fernandez K, Savage M (2016) Illegal otter trade: an analysis of seizures in selected Asian countries (1980–2015). TRAFFIC, Petaling Jaya, Selangor, Malaysia

Hall ER (1981) The mammals of North America, 2nd edn. Wiley, New York

Harrop SR (2000) The international regulation of animal welfare and conservation issues through standards dealing with the trapping of wildlife animals. J Environ Law 12:333–360

International Association of Fish and Wildlife Agencies (IAFWA) (2005) Trapper education manual: a guide for trappers in the United States. http://www.fishwildlife.org/files/Trapping_Student_Manual_2005.pdf. Accessed 21 June 2016

International Association of Fish and Wildlife Agencies (IAFWA) (2015) Trapping matters [video]. https://www.youtube.com/watch?v=2R61brsbSy8. Accessed 9 April 2017

Iossa G, Soulsbury CD, Harris S (2007) Mammal trapping: a review of animal welfare standards of killing and restraining traps. Anim Welf 16:335–352

ISO 10090-4 (1999) International standards for animal (mammal traps): methods for testing restraining traps. https://www.iso.org/obp/ui/#iso:std:iso:10990:-5:en. Accessed 21 June 2016

Jotham N, Phillips RL (1994) Developing international trap standards: a progress report. Proc Vertebr Pest Conf 16:308–310

Kimber K, Kollias GV (2005) Evaluation of injury severity and hematologic and plasma biochemistry values for recently captured North American river otters (*Lontra canadensis*). J Zoo Wildl Med 36:371–384

Koelewijn HP, Perez-Haro M, Jansman HAH, Boerwinkel MC, Bovenschen J, Lammertsma DR, Niewold FJJ, Kuiters AT (2009) The reintroduction of the Eurasian otter (*Lutra lutra*) into the Netherlands: hidden life revealed by noninvasive genetic monitoring. Conserv Genet 11:601–614

Kruuk H (2006) Otters: ecology, behavior, and conservation. Oxford University Press, New York

Mahoney SP (2004) The seven sisters: pillars of the North American wildlife conservation model. Bugle 21:141–144

Mahoney SP, Geist V, Organ J, Regan R, Batcheller GR, Sparrowe RD, McDonald JE, Bambery C, Dart J, Kennamer JE, Keck R, Hobbs D, Fielder D, De Gayner G, Frampton J (2008) The North American model of wildlife conservation: enduring achievement and legacy. In: J Nobile, MD Duda (eds). Strengthening America's hunting heritage and wildlife conservation in the 21st century: challenges and opportunities, pp 7–24. White house conference on North American wildlife policy. Sporting conservation council. Retrieved from http://www.fws.gov/whhcc/doc/2009-29110-16517_Report_2009-10-13-17-19-00.pdf. Accessed 1 Dec 2016

Melquist WE, Hornocker MG (1979) Methods and techniques for studying and censoring river otter populations. Univ Idaho for Wildlife and Range Esp Stri Tech Rep 8:17

Muth RM, Zwick RR, Mather ME, Organ JF, Daigle JJ, Jonker SA (2006) Unnecessary source of pain and suffering or necessary management tool: attitudes of conservation professionals toward outlawing leghold traps. Wildl Soc Bull 34:706–715

Northcott TH, Slade D (1976) A live-trapping technique for river otters. J Wildl Manag 40:163–164

Ó Néill L, De Jongh AD, Ozolinš J, De Jong T, Rochford J (2007) Minimizing leg-hold trapping trauma for otters using mobile phone technology. J Wildl Manag 71:2776–2780

Olsen GH, Linscombe RG, Wright VL, Holmes RA (1996) Reducing injuries to terrestrial furbearers by using padded foothold traps. Wildl Soc Bull 16:303–307

Organ JF, Decker, T, Langlois S, Mirick PG (2015) Trapping and Furbearer Management in North American Wildlife Conservation. http://www.fishwildlife.org/files/Trap-Fur-Mgmt_final.pdf. Accessed 9 April 2017

Organ JF, Decker DJ, Stevens SS, Lama TM, Doyle-Capitman C (2014) Public trust principles and trust administration functions in the North American model of wildlife conservation: contributions of research. Hum Dimens Wildl 16:407–416

Organ JF, Geist V, Mahoney SP, Williams S, Krausman PR, Batcheller GR, Decker TA, Carmichael R, Nanjappa P, Regan R, Medellin RA, Cantu R, McCabe RE, Craven S, Vecellio GM, Decker DJ (2012) The North American model of wildlife conservation. Technical review 12-04. The Wildlife Society, Bethesda, MD

Organ JR, Mahoney S, Geist V (2010) Born in the hands of hunters: the North American model of wildlife conservation. Wildl Prof 4:22–27

Perrin MR, Carranza ID (1999) Capture, immobilization and measurements of the spotted-necked otter in Natal Drakensberg, South Africa. S Afr J Wildl Res 29:52–52

Peterson NM, Nelson MP (2016) Why the North American model of wildlife conservation is problematic for modern wildlife management. Hum Dimens Wildl. doi:10.1080/10871209.2016.1234009

Princen SBM (2004) Exporting regulatory standards: the cases of trapping and data protection. In: Knodt MD, Princen SBM (eds) Understanding the EU's external relations. Routledge, London, pp 142–157

Proulx G (1999) Review of current mammal trap technology in North America. In: Proulx G (ed) Mammal trapping. Alpha Wildlife Publications, Alberta, Canada

Proulx G, Cattet MRL, Powell RA (2012) Humane and efficient capture and handling methods for carnivores. In: Boitani L, Powell RA (eds) Carnivore ecology and conservation: a handbook of techniques. Oxford University Press, London, pp 70–129

Proulx G, Rodtka D, Barrett MW, Cattet M, Dekker D, Moffatt E, Powell RA (2015) Humaneness and selectivity of killing neck snares used to capture canids in Canada: a review. Can Wildl Biol Manag 4:55–65

Proulx G, Rodtka D (2015) Predator bounties in western Canada cause animal suffering and compromise wildlife conservation efforts. Animals 5:1034–1046

Prukop J, Regan RJ (2005) In my opinion: the value of the North American model of wildlife conservation—an International Association of Fish and Wildlife Agencies position. Wildl Soc Bull 33:374–377

Responsive Management (2015a) Trap use, furbearers trapped, and trapper characteristics in the United States in 2015. Harrisonburg, Virginia

Responsive Management (2015b) How to talk to the public about hunting: research based communication strategies. Harrisonburg, Virginia

Rochlitz, I (2010) The impact of snares on animal welfare. Cambridge University Animal Welfare Information Service, Cambridge, United Kingdom. http://onekind.org/uploads/publications/onekind_report_on_snaring_chapter_1.pdf. Accessed 1 Dec 2016

Rothschild DM, Serfass TL, Seddon WL, Hegde L, Fritz RS (2008) Using fecal glucocorticoids to assess stress levels in captive river otters. J Wildl Manag 72:138–142

Sax JL (1970) The public trust doctrine in natural resource law: effective judicial intervention. Michigan Law Review 68:471–566

Scott A (1999) Trust law, sustainability, and responsible action. Ecol Econ 31:139–154

Serfass TL (1984) Ecology and feeding relationships of river otters in north eastern Pennsylvania. MS thesis, East Stroudsburg University, East Stroudsburg, Pennsylvania, USA

Serfass TL, Brooks RP, Swimley TJ, Rymon LM, Hayden AH, Serfass TL, Brooks RP, Swimley TJ, Rymon LM, Hayden AH (1996) Considerations for capturing, handling, and translocating river otters. Wildl Soc Bull 24:25–31

Serfass TL, Bohrman JA, Stevens SS, Bruskotter JT (2014) Otters and anglers can share the stream! The role of social science in dissuading negative messaging about reintroduced predators. Hum Dimens Wildl 19:532–544

Shirley MG, Linscombe RG, Sevin LR (1983) A live trapping and handling technique for river otter. Proc Annu Conf Southeast Assoc Fish Wildl Agencies 37:182–189

Smithsonian (n.d.) North American river otter (*Lontra canadensis*). http://naturalhistory.si.edu/mna/image_info.cfm?species_id=142. Accessed 9 Aug 2016

Stevens SS, Serfass TL (2008) Visitation patterns and behaviors or neartic river otters (*Lontra canadensis*) at latrines. Northeast Nat 15:1–12

Trapping Matters Workshop (2016) Oregon Chapter of The Wildlife Society homepage. https://ortws.wordpress.com/2016/05/31/trapping-matters-workshop/. Accessed 11 April 2017

Taylor R, Serfass T, Wong J (2016) Stress levels in captured river otters (*Lontra canadensis*) decreased after transportation to reintroduction sites. J Zoo Wildl Med 47:1057–1060

Treves A, Chaprom G, López-Bao JV, Shoemaker C, Goeckner AR, Bruskotter JT (2015) Predators and the public trust. Biol Rev. doi:10.1111/brv.12227

United States Department of Commerce (1997) European Union Humane trapping standards agreement. http://tcc.export.gov/Trade_Agreements/All_Trade_Agreements/exp_002820.asp. Accessed 21 June 2016

White BH, Decker T, O'Brien MJ, Organ JF, Roberts NM (2015) Trapping and furbearer management in North American wildlife conservation. J Environ Stud 72:756–769

Van Der Zee D (1982) Density of cape clawless otters *Aonyx capensis* (Shinz, 1821) in the Tsitsikamma coastal National Park. S Afr J Wildl Res 12:8–13

Vantassel S, Hiller TL, Powell KDJ, Hygnstrom SE (2010) Using advancements in cable-trapping to overcome barriers to furbearer management in the United States. J Wildl Manag 74:934–939

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AN EVALUATION OF LONG-TERM CAPTURE EFFECTS IN URSIDS: IMPLICATIONS FOR WILDLIFE WELFARE AND RESEARCH

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The need to capture wild animals for conservation, research, and management is well justified, but long-term effects of capture and handling remain unclear. We analyzed standard types of data collected from 127 grizzly bears (*Ursus arctos*) captured 239 times in western Alberta, Canada, 1999–2005, and 213 American black bears (*U. americanus*) captured 363 times in southwestern North Carolina, 1981–2002, to determine if we could detect long-term effects of capture and handling, that is, effects persisting $\geq$1 month. We measured blood serum levels of aspartate aminotransferase (AST), creatine kinase (CK), and myoglobin to assess muscle injury in association with different methods of capture. Serum concentrations of AST and CK were above normal in a higher proportion of captures by leghold snare (64% of 119 grizzly bear captures and 66% of 165 black bear captures) than capture by helicopter darting (18% of 87 grizzly bear captures) or by barrel trap (14% of 7 grizzly bear captures and 29% of 7 black bear captures). Extreme AST values ($>$5 times upper reference limit) in 7 (6%) grizzly bears and 29 (18%) black bears captured by leghold snare were consistent with the occurrence of exertional (capture) myopathy. We calculated daily movement rates for 91 radiocollared grizzly bears and 128 radiocollared black bears to determine if our activities affected their mobility during a 100-day period after capture. In both species, movement rates decreased below mean normal rate immediately after capture (grizzly bears: $\bar{X} = 57\%$ of normal, 95% confidence interval = 45–74%; black bears: 77%, 64–88%) and then returned to normal in 3–6 weeks (grizzly bears: 28 days, 20–37 days; black bears: 36 days, 19–53 days). We examined the effect of repeated captures on age-related changes in body condition of 127 grizzly bears and 207 black bears and found in both species that age-specific body condition of bears captured $\geq$2 times (42 grizzly bears and 98 black bears) tended to be poorer than that of bears captured once only (85 grizzly bears and 109 black bears), with the magnitude of effect directly proportional to number of times captured and the effect more evident with age. Importantly, the condition of bears did not affect their probability of capture or recapture. These findings challenge persons engaged in wildlife capture to examine their capture procedures and research results carefully. Significant capture-related effects may go undetected, providing a false sense of the welfare of released animals. Further, failure to recognize and account for long-term effects of capture and handling on research results can potentially lead to erroneous interpretations.

Key words: American black bear, body condition, exertional myopathy, grizzly bear, long-term capture effects, movement rates, muscle injury, ursids, *Ursus americanus*, *Ursus arctos*

Information gathered from wild animals is required for wildlife research, conservation, and management. Although much can be learned by indirect techniques, such as collecting fecal samples to determine hormone status (Foley et al. 2001; Millspaugh et al. 2001) or collecting hair for DNA analysis (Beier et al. 2005; Boulanger et al. 2004), some information is collected only by capturing animals, for example, age determination, morphometric measurements, or serum biochemistry (Garshelis 2006; Powell and Proulx 2003). Capture of wild animals has potential to cause injury and to change

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normal behavior and physiology (Kreeger et al. 1990; Proulx 1999). Consequently, researchers are challenged to design research and use methods that have minimal impact on study animals and remain safe for field personnel. Procedures that affect study animals adversely not only raise important ethical and animal welfare issues but also are likely to influence the animals' behavior or physiology in ways that affect research results (Powell and Proulx 2003).

A major obstacle to gathering information on effects of capture and handling, especially those occurring over periods of weeks or months, is that these effects can be difficult to detect. Mortality rates are sometimes used to evaluate capture procedures (Arnemo et al. 2006; DelGiudice et al. 2005; Haulton et al. 2001). Observed mortality rates, however, may not provide accurate estimates of true mortality rates unless survival of all released animals is confirmed for an adequate period after capture (Lebreton et al. 1992; Schaub and Pradel 2004). Mortality may go undetected because, for example, scavengers or predators consume carcasses, animals die in concealed places, carcasses decompose quickly, radiotransmitters malfunction, or animals fitted with radiotransmitters emigrate from the study area (Bunck et al. 1995; Vyas 1999; Wobeser and Wobeser 1992). More importantly, mortality rates provide no information on how many animals might be negatively affected by capture short of death.

The full impact of capture and handling procedures cannot be determined without evaluating physical, behavioral, and physiological effects on captured animals at the time of capture and in the days and weeks that follow. Perhaps because assessment of all potential effects over different timescales is difficult to carry out, comprehensive reports covering capture effects over wide timescales are few (an exception is the series of publications by Kock et al. [1987a, 1978b, 1987c]). Researchers more often report only the short- or intermediate-term effects of capture and handling, such as physical injury (e.g., Peterson et al. 2003; Shivik et al. 2005) or significant changes in blood and other physiological values (e.g., Golden et al. 2002; Marco et al. 1997; Storms et al. 2005) that persist from minutes to days. Although documentation of long-term effects is sparse, several recent publications conclude that capture and handling may have significant consequences not only for specific wild populations (Alibhai et al. 2001; Côté et al. 1998) but also for the accuracy and interpretation of research results (Clinchy et al. 2001). However, other studies have not found convincing evidence for long-term adverse effects (Creel et al. 1997; Laurenson and Caro 1994; Lunn et al. 2004).

Herein, we report on an evaluation of long-term ($\geq$1-month) effects of capture and handling in 2 ursid species, grizzly bears (*Ursus arctos*) and American black bears (*U. americanus*). Our data originate from 2 independent studies, the Foothills Model Forest Grizzly Bear Research Project and the Pisgah Bear Sanctuary Black Bear Research Project, conducted by different teams of researchers in geographically distinct areas. Prompted by findings from previous studies (Cattet et al. 2003b; Powell 2005), we resolved to evaluate whether long-term effects of capture and handling were detectable and, if so, to determine what possible implications this could have for the welfare of released animals and the interpretation of research results. Our analysis was entirely retrospective and, unless stated otherwise, we use the phrase "capture and handling" in the broadest sense to include the combination of all procedures, that is, pursuit or restraint, anesthesia, tooth extraction, application of radiotelemetry equipment, and so on. Our primary objectives were to document occurrence and severity of capture-related muscle injury, to evaluate the mobility of bears in the weeks after capture, and to determine if body condition of bears was affected by repeated captures.

MATERIALS AND METHODS

Foothills Model Forest Grizzly Bear Research Project.—We captured 127 grizzly bears 239 times between April 1999 and August 2005 (research goals are summarized by Stenhouse and Graham [2005]) within a 150,000-km^2 area of western Alberta, Canada (49°00′–55°50′N, 113°50′–120°00′W). Captured bears were composed of 61 females (1–21 years old at 1st capture) and 66 males (1–19 years old at 1st capture). Females included 25 juvenile ($<$5 years old) and 36 adult bears ($\geq$5 years old), whereas males included 32 juveniles and 34 adults.

We used Aldrich leghold snares (Aldrich Snare Co., Clallam Bay, Washington) for 130 captures, remote drug delivery from helicopter (helicopter darting) for 99 captures, and barrel traps for 10 captures (Cattet et al. 2003b). All bears were anesthetized by remote drug delivery (Pneu-Dart Inc., Williamsport, Pennsylvania, and Paxarms NZ Ltd., Timaru, New Zealand) using a combination of xylazine and zolazepam–tiletamine administered intramuscularly as xylazine (Cervizine 300; Wildlife Pharmaceuticals, Inc., Fort Collins, Colorado) at 2 mg/kg and Telazol (Fort Dodge Laboratories, Inc., Fort Dodge, Iowa) at 3 mg/kg estimated body weight (Cattet et al. 2003a). We administered atipamezole (Antisedan; Novartis Animal Health Canada Inc., Mississauga, Ontario, Canada) at 0.15–0.20 mg/kg, half-volume intramuscularly and half-volume intravenously, to reverse the effects of xylazine.

We recorded pulse and respiratory rates, rectal temperature, and hemoglobin oxygen saturation (Nellcor NPB-40 pulse oximeter; Nellcor, Pleasanton, California) for all bears at onset of handling and every 15 min thereafter during a $\leq$75-min handling period. We extracted a premolar tooth to estimate age by counting cementum annuli (Stoneberg and Jonkel 1966). We weighed bears in a sling suspended beneath a load scale (MSI-7200 Dynalink; Precision Giant Systems Inc., Edmonton, Alberta, Canada) and measured body length as dorsal straight-line distance from tip of nose to end of last tail vertebra.

We collected blood from the femoral vein into sterile tubes for biochemical analysis, and into an ethylenediaminetetraacetic acid tube for measurement of complete blood count. We centrifuged blood samples within 8 h of collection, and extracted and froze (−20°C) serum for biochemistry analysis using an Abbott Spectrum Series II biochemistry analyzer (Abbott Laboratories Diagnostic Division, Abbott Park, Illinois), and for myoglobin analysis using an ADVIA Centaur immunoassay system (Bayer Healthcare, Tarrytown, New York). We chilled blood samples in ethylenediaminetetraacetic acid for determination of complete blood cell counts within 24 h of collection using an Abbott Cell-Dynn 3200 hematology analyzer (Abbott Laboratories Diagnostic Division). For purposes of this study, we extracted data describing serum concentrations of creatine kinase (CK), aspartate aminotransferase (AST), and myoglobin because these constituents are normally concentrated in muscle, but leak into blood circulation for some time after muscle damage; their level in blood provides a rough indication of the extent of muscle fiber destruction (Cardinet 1997; Hulland 1993). This well-established relationship is the basis for wide usage of these serum constituents as diagnostic markers of muscle injury in human and veterinary medicine (Kiessling et al. 1981; Krefetz and McMillin 2005; Latimer et al. 2003). We characterized muscle injury as significant if serum enzyme levels exceeded reference values (Teare 2002) for captive grizzly bears (18–142 U/liter for AST [$n = 139$] and 0–387 U/liter for CK [$n = 50$]).

We fitted bears with either a Televilt Simplex Global Positioning System (GPS) radiocollar (Televilt; TVP Positioning AB, Lindesberg, Sweden) or an Advanced Telemetry Systems GPS radiocollar (Advanced Telemetry Systems, Inc., Isanti, Minnesota). We programmed the majority of radiocollars to acquire 3-dimensional locations at 4-h time intervals; however, some collars were programmed for shorter intervals ranging from 1 to 3 h. Our research protocol was reviewed and approved by the University of Saskatchewan's Committee on Animal Care and Supply, and was in accordance with guidelines provided by the American Society of Mammalogists' Animal Care and Use Committee (Gannon et al. 2007) and the Canadian Council on Animal Care (2003) for the safe handling of wildlife.

Pisgah Bear Sanctuary Black Bear Research Project.—We captured 213 American black bears 363 times between May 1981 and August 2002 (research goals are summarized by Powell et al. [1997]) in the 220-km^2 Pisgah Bear Sanctuary, located on the Pisgah National Forest approximately 35 km southwest of Asheville, North Carolina (35°28′N, 82°40′W) in the southern Blue Ridge Mountains of the Southern Appalachians. Captured bears were composed of 80 females (1–11 years old at 1st capture) with 50 juvenile bears (<3 years old) and 30 adults (≥ 3 years old) and 133 males (1–15 years old at 1st capture) with 98 juveniles and 35 adults.

We used Aldrich-type leghold snares for 351 captures and barrel traps for 12 captures (Powell 2005). The leghold snares were modified with automobile hood springs to provide cushioning for trapped bears (Johnson and Pelton 1980). Bears were anesthetized by pole syringe or blowpipe using a 2:1 mixture of ketamine hydrochoride (Fort Dodge Animal Health, Overland Park, Kansas) and xylazine hydrochloride (Phoenix Pharmaceutical Inc., St. Joseph, Missouri), with approximately 200 mg ketamine and 100 mg xylazine per milliliter, administered intramuscularly at a combined dosage of 12 mg/kg estimated body weight. We monitored vital signs (body temperature, pulse rate, and respiration rate) continuously during the first 20–30 min of handling and every 5–10 min thereafter. We gave all bears ear tags and tattoos and recorded standard measurements. We weighed bears slung beneath a load scale and measured body length as distance from tip of nose to end of last tail vertebra following the curvature of the back. We extracted a premolar tooth to estimate age by counting cementum annuli (Stoneberg and Jonkel 1966) and drew blood from the femoral vein into sterile tubes for biochemical analysis and into an ethylenediaminetetraacetic acid tube for determination of the complete blood count. Blood samples were placed on ice immediately after collection and delivered to Mission Memorial Hospital in Asheville, North Carolina, within 1.5 h for laboratory analyses using standard hospital protocols. For this study, we extracted data describing serum concentrations of CK and AST. Serum myoglobin was not measured in blood samples collected from black bears. We characterized muscle injury as significant if serum enzyme levels exceeded reference values (Teare 2002) for captive black bears (0–205 U/liter for AST [$n = 135$] and 0–421 U/liter for CK [$n = 90$]).

We fitted 154 bears with very-high-frequency (VHF) radiocollars (made by multiple manufacturers over the course of >20 years), according to research goals at the time of capture. By driving the Blue Ridge Parkway, which bisected the study area, we could estimate locations of up to 12 bears in 2 h. We estimated locations of bears as the arithmetic mean of azimuths recorded within 15 min, unless a bear was inactive, in which case we sometimes extended the time limit. We located bears in blocks of four, six, or twelve 2-h periods, depending on objectives for our research in a given year, while attempting to reduce temporal autocorrelation among blocks (location estimates exhibited independence after 28–33 h—Swihart and Slade 1985). Using this schedule, we could obtain nearly 400 location estimates for bears followed during an entire active season. The bears' collars indicated activity or inactivity. Angle error was leptokurtotic around 0° and median error for location estimates was approximately 250 m (Zimmerman and Powell 1995). Our protocol for handling bears was approved by the Institutional Animal Care and Use Committees of North Carolina State University and Auburn University; was in accordance with the principles and guidelines of the of the American Society of Mammalogists' Animal Care and Use Committee (Gannon et al. 2007), with the Animal Behavior Society (2003), and with the Canadian Council on Animal Care (2003); and met the criteria for animal welfare of livetrapped mammals set by Powell and Proulx (Powell 2005; Powell and Proulx 2003).

Statistical analyses.—We performed statistical analyses under 3 broad themes: capture and muscle injury; effect of capture on mobility; and effect of repeated captures on body condition. Sample sizes varied between analyses depending on completeness of records or constraints imposed on the analysis. Details for specific analyses including sample sizes are as follows.

Muscle injury and survival.—We used program MARK (White and Burnham 1999) to estimate sex-specific survival rates in grizzly bears and American black bears and to determine if high AST concentration at capture was associated with lower individual survival. We selected AST as a covariate instead of myoglobin because it was measured in both species.

Although CK also was measured in both species, determination of serum kinetics in humans (Krefetz and McMillin 2005) and domestic mammals (Latimer et al. 2003) show that AST remains elevated in blood for a longer duration than CK after muscle injury, that is, 5–7 days versus 1–2 days. Thus, we assumed AST levels in bears would better reflect severity of injury, especially in bears captured by leghold snare or barrel trap where time lapsed between capture and blood collection could be prolonged, that is, as long as 16 h.

We created encounter histories based on 1-month intervals for 56 grizzly bears (30 females and 26 males) captured during 1999–2003 and on 1-year intervals for 103 black bears (42 females and 61 males) captured during 1981–2002. We used the Barker model, a generalization of the joint live and dead encounters model (Burnham 1993), that allows live resightings (either visually or by radiotelemetry) and deaths to be reported at any time during the open period between capture and recapture (Barker 1997). This model parameterizes capture–recapture and tag mortality jointly by estimating both survival (S), which is the probability that an animal survives between 2 sampling occasions, and the probability of recapture (p). In addition, this model estimates the probabilities that a tag will be reported given that the individual was found dead (r), a resighting will occur within the study period (R), an animal will be resighted and then die within the study period (R'), an animal will remain in the study area (F), and an animal will temporarily emigrate from the study area (F'). We used a logit link in the analyses of both species, and we excluded from the analyses any data collected during the winter (denning) months.

For the analysis of grizzly bears, we reduced the available sample to 56 bears that were captured in a central portion of the study area between 1999 and 2003 to ensure that all bears had a defined area of initial capture during the time period of the survival analysis. All of these bears had been fitted at capture with either a GPS radiocollar, a VHF ear radiotransmitter (Advanced Telemetry Systems, Inc.), or both devices. We captured bears in the central study area continuously throughout the study period, so all bears had the potential to be recaptured by helicopter darting or by leghold snare, or to be "resighted" by GPS locations or by VHF signals received during telemetry flights. Recoveries of dead bears were based on investigation of potential mortalities during monthly flights for GPS collar uploads and tracking of VHF ear radiotransmitters as well as any incidental finding of dead bears. Bears of unknown fate included bears that removed their radiotransmitter devices or emigrated from the central study area, as well as bears with radiotransmitter devices that malfunctioned or were destroyed, for example, by poachers. Monthly sampling intervals were used because this time interval corresponded best with the occurrence of radiotelemetry flights and captures.

To develop models, we 1st reduced the number of parameters by fixing the movement parameters, F and F', to create simpler movement models including permanent emigration ($F' = 0$) and random emigration ($F' = F = 1$), as well as a more complex Markov emigration model (Barker and White 2001). We added to these base models by including sex and mean age of bear during the study as covariates. This was justified because other studies of bears have shown that these biological factors can influence survival rates and capture probabilities (Hovey and McLellan 1996). Although we held the parameters in most models constant over time, we also included a model that allowed recapture rate to be higher during spring than during fall, which was consistent with our capture efforts. We then used the model most supported by the data to test the effect of AST on bear survival.

For the analysis of black bears, we used a sample of 103 radiocollared bears for which serum AST results were available. Resightings for the Barker model were composed of VHF signals received during summers 1981–2002. The recovery of dead bears was based on mortality information from the North Carolina Wildlife Resources Commission and from field observations. Annual sampling intervals were used because this time interval corresponded best with telemetry and trapping schedules.

Similar to the analyses of grizzly bears, we initially determined the most-supported Barker movement model. We used a base model in which survival varied by sex and capture probability varied by age. Because juvenile black bears were less likely to be collared than were adult bears, we varied the resighting parameters by age. After the best-supported movement model was determined, we expanded our analyses by including AST as an individual covariate to survival. We did not consider time variation in any parameters given the restriction of model complexity based upon our relatively small sample size of marked bears. For both species, we used sample-size–adjusted Akaike Information Criterion (AIC_C) model selection (Burnham and Anderson 1998) to determine which models were most supported by the data, that is, $\Delta\text{AIC}_\text{C}$ values ≤ 2. We evaluated AIC_C weights for each model, which provided strength of evidence for model selection. We did not test goodness-of-fit because no reliable means of testing model fit currently exist for models developed using Barker's parameterization (R. Barker, pers. comm.).

Mobility after capture.—For this analysis, we tested the hypothesis that capture and handling of bears causes a measurable decrease in daily movement rates in the days after capture. We calculated movement rates (m/h) for grizzly bears as straight-line distance (m) between consecutive locations, recorded every 1–4 h with dilution of precision values ≤ 5, divided by time interval (h). We calculated movement rates (m/h) for American black bears as straight-line distance between consecutive locations, recorded $\leq$33 h apart, divided by time interval. For both species, we calculated daily movement rates as the average of all movement rates ($\leq$12 rates per day) recorded on a given day for an individual bear. We justified averaging of movement rates within a day because large variation in movement rates caused by daily activity patterns (e.g., diurnal and nocturnal activity patterns) was irrelevant to this analysis. For grizzly bears, we limited captures to those occurring between 1 April and 31 July because this was when $\geq$85% of captures occurred. We also limited calculation of movement rates to $\leq$100 days after capture for individual bears so, in effect, analyses of movement rates covered the period from April to October. For black bears, we further limited movement rates to bears tracked for ≥ 10 days after capture. Finally, we log-transformed movement rates to help meet the assumption of equal variances of response values across the range of predictor variables.

We used a random coefficient mixed-model analysis of covariance to test for decreased movement rates among grizzly bears and black bears recently captured and radiocollared (Milliken and Johnson 2002). We fitted polynomial (quadratic and cubic) curves to daily movement rates as a function of days after capture (≤ 100) for each bear on the assumption that, if capture affected movement rates for an individual bear, its daily movement rate would increase for a time after capture before reaching a plateau. We also investigated the fit provided by linear terms, which would suggest that movement rates increase indefinitely after capture. Conceptually, the sample space for the analysis was the ''population'' of bear response curves after capture. We nested response curves of individual bears to allow variance estimation with bears as the sample unit and to avoid pseudoreplication and repeated-measure issues with pooling locations from individual bears (Littell et al. 1996; Verbeke and Molenberghs 2000). In constructing models for each species, we considered effects of other factors and covariates, as well as interactions between factors, on daily movement rate (Stenhouse et al. 2005) including day and month of capture, sex and reproductive class (male, female, or female with dependent offspring), method of capture, the number of times a bear was captured in a given year, and duration between location fixes. We modeled seasonal changes in movement rate by estimating month-specific and month × day of month interaction terms to account for potential differences in movement rate patterns of bears with home ranges at different elevations, for example, alpine versus agricultural areas.

We used AIC_C model selection (Burnham and Anderson 1998) and considered models with $\Delta\text{AIC}_\text{C}$ values ≤ 2 most supported by the data. The effective sample size of AIC_C calculations was the number of unique bears in the analysis. We primarily used AIC_C methods to select appropriate models rather than hypothesis tests of individual parameters to avoid statistical issues when combining 2 methods of model selection (Lukacs et al. 2007). Strength of relationships was evaluated by plotting topical covariates and associated confidence intervals (Burnham and Anderson 1998).

After finding the most-supported model, we added AST (for both species) and myoglobin (for grizzly bears) levels to the model to see if these indicators of muscle injury were significant covariates. Because AST and myoglobin values were not available for all captures of bears, sample sizes for these analyses were smaller than for the movement rate analyses. Therefore, we recalculated AIC_C parameters for the most-supported models ($\Delta\text{AIC}_\text{C} \leq 2$) using reduced data sets to compare with models that included AST or myoglobin as covariates.

Body condition and repeated captures.—For this analysis, we tested the hypothesis that age-related changes in the body condition of bears are affected negatively by the number of times a bear is captured. In other words, if the general trend is for body condition to increase with age when controlling for other potentially confounding factors (e.g., year of capture), the rate of increase will be less for bears captured repeatedly than for bears captured 1 time only. To quantify body condition, we calculated a body condition index (BCI) for grizzly bears and American black bears using a model of the form:

$$\text{BCI} = \frac{\text{M} - 3.21\text{L} + 11.64}{0.29 + 0.017\text{L}},$$

where M is the natural log of body mass (kg) and L is the natural log of body length (cm—Cattet et al. 2002). This model predicts the standardized residual from the regression of body mass against body length, an index of body condition strongly correlated with true body condition in black bears ($R^2 = 0.93$, $P < 0.001$, $n = 33$), defined as the combined mass of fat and skeletal muscle relative to body size.

We used a mixed-model repeated-measures analysis of covariance to determine if changes in BCI values differed as a function of number of times a bear was captured (Milliken and Johnson 2002). We assumed that body condition of a bear also might change with age, reproductive status, and environmental conditions. So, in constructing models for each species, we considered effects of other factors and covariates on BCI values including age, sex and reproductive class, year of capture, as well as the interaction between number of times captured and year of capture. The interaction term allowed changes in BCI to differ as a function of the number of times a bear was captured. We tested models with year of capture as both a linear term (YR) and a quadratic term (YR^2) to determine if number of times captured affected slope of the age–body condition relationship (i.e., a linear effect), or shape of the curve (i.e., a quadratic effect), or both. For bears inadvertently captured more than once within a single year, we considered BCI values recorded at 1st capture of the year only. In addition, because the interval between subsequent captures for bears captured more than once was variable, we only considered models with covariance structures that allow unequal intervals between observations, for example, spatial, unstructured, and compound symmetry models (Milliken and Johnson 2002). We used AIC_C model selection and considered only models with $\Delta\text{AIC}_\text{C}$ values ≤ 2 to be most supported by the data. The effective sample size was the number of unique bears in the analysis.

An implicit assumption in this analysis was that bears captured repeatedly were a random sample of the population such that the probability of being captured was not affected by their body condition. However, should bears in poor condition be more likely to be lured to snare sites or barrel traps by the presence of bait and consequently captured than bears in good condition, this assumption would be incorrect and our hypothesis would fall. To test this assumption, we removed helicopter capture records from the grizzly bear data set, and used the Burnham (1993) joint live-and-dead encounter model in program MARK (White and Burnham 1999) to explore effects of body condition on grizzly bear and black bear recapture rates. The Burnham model estimates the same parameters as the Barker model with exception of sighting probabilities (R and R'). Radiotelemetry sightings were not used with the Burnham model and therefore sighting probabilities are not relevant. In addition, the Burnham model estimates a single fidelity parameter (F). The most-supported biological model for each species from the Barker analysis described above in the "*Muscle injury and survival*" section was used as a base model for this analysis. The mean BCI value of bears was entered as a covariate to recapture rate and slope (β) estimates of the BCI-covariate term were then used to evaluate for a potential relationship between recapture rate and BCI.

RESULTS

Capture-related muscle injury.—We had serum chemistry results available from 213 grizzly bear and 172 American black bear captures. Serum concentrations of aspartate AST, CK, and myoglobin were greater in grizzly bears captured by leghold snare than in bears captured by helicopter darting (Fig. 1a; mean, median, and range, respectively: AST—288 U/liter, 198 U/liter, and 41–1,665 U/liter versus 128 U/liter, 96 U/liter, and 34–702 U/liter; CK—3,197 U/liter, 807 U/liter, and 31–37,280 U/liter versus 213 U/liter, 117 U/liter, and 31–3,838 U/liter; myoglobin—497 μg/liter, 231 μg/liter, and 24–7,184 μg/liter versus 65 μg/liter, 40 μg/liter, and 15–341 μg/liter) or by barrel trap (AST—115 U/liter, 113 U/liter, and 69–166 U/liter; CK—283 U/liter, 104 U/liter, and 43–1,399 U/liter). Values for AST exceeded the upper limit of the reference interval for captive grizzly bears (142 U/liter) in 70% of samples collected from 119 leghold-snare captures, 18% of samples from 87 helicopter-darting captures, and 14% of samples from 7 barrel-trap captures. Values for CK exceeded the upper limit of the reference interval for captive grizzly bears (387 U/liter) in 64% of samples collected from leghold-snare captures, 14% of samples from helicopter-darting captures, and 14% of samples from barrel-trap captures. A reference interval for serum myoglobin has not been established for grizzly bears.

Serum concentrations of AST and CK were greater in American black bears captured by leghold snare than in bears captured by barrel trap (Fig. 1b; AST—575 U/liter, 247 U/liter, and 39–5,340 U/liter versus 132 U/liter, 91 U/liter, and 44–331 U/liter; CK—10,297 U/liter, 2,242 U/liter, and 39–109,780 U/liter versus 1,708 U/liter, 235 U/liter, and 89–6,540 U/liter).

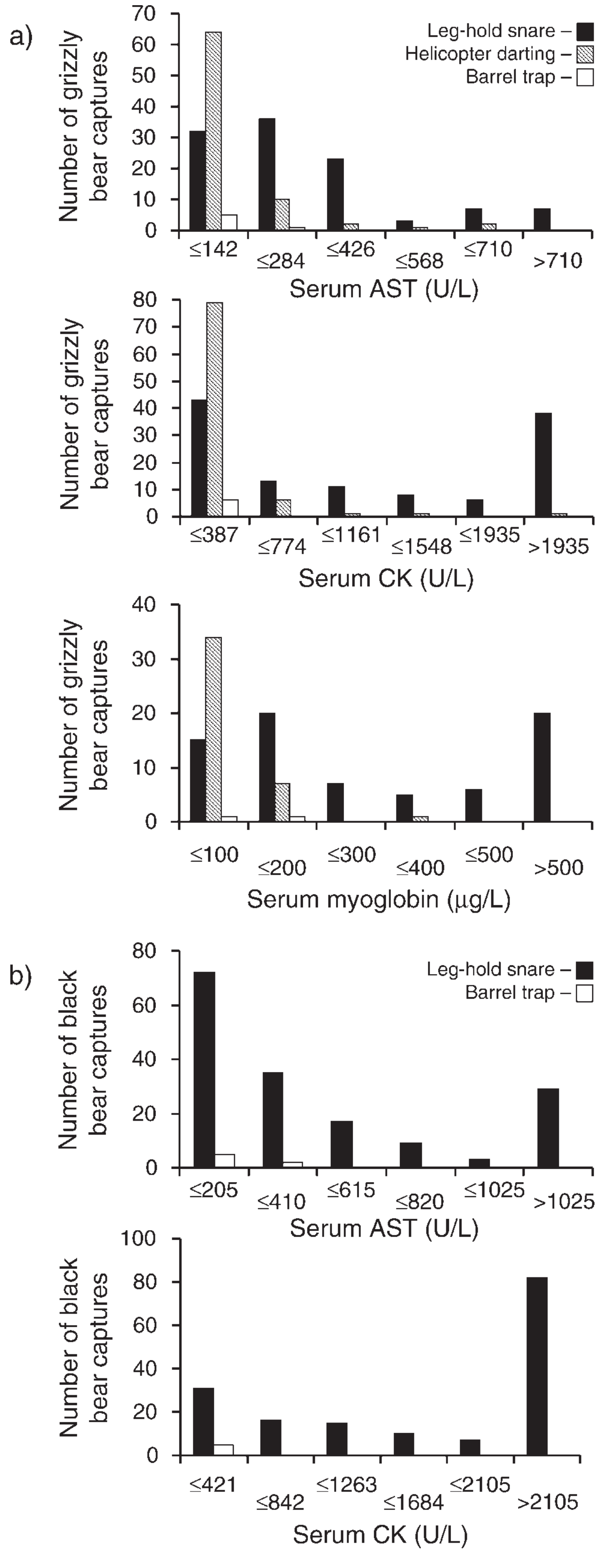

FIG. 1.—a) Serum concentrations of aspartate aminotransferase (AST), creatine kinase (CK), and myoglobin recorded at 213 grizzly bear captures for the Foothills Model Forest Grizzly Bear Project in western Alberta, Canada (1999–2005). Values were recorded for bears captured by leghold snare ($n = 119$), helicopter darting ($n = 87$), and barrel trap ($n = 7$). Cut points for intervals represent multiples of the upper limit of the reference interval for captive grizzly bears for AST (142 U/liter) and CK (387 U/liter—Teare 2002). A reference interval for serum myoglobin has not been established for grizzly bears. b). Serum concentrations of AST and CK recorded at 172 black bears captures for the Pisgah Bear Sanctuary Black Bear Research Project in North Carolina (1981–2002). Values were recorded for bears captured by leghold snare ($n = 165$) and barrel trap ($n = 7$). Cut points for intervals represent multiples of the upper limit of the reference interval for captive black bears for AST (205 U/liter) and CK (421 U/liter—Teare 2002). Serum myoglobin was not measured for black bears.

Table 1.—Models selected using sample-size–adjusted Akaike Information Criterion (AIC_C) to test the hypothesis that the serum aspartate aminotransferase (AST) concentration of a) grizzly bears captured for the Foothills Model Forest Grizzly Bear Research Project in western Alberta, Canada (1999–2005), and b) American black bears captured for the Pisgah Bear Sanctuary Black Bear Research Project in North Carolina (1981–2002) at the time of capture affected survival. The analyses are based on the capture records and resight data (by visual or radiolocation) for 57 grizzly bears and 103 black bears.

No.	Model[a,b]	AIC_C	$\Delta\text{AIC}_\text{C}$	w_i[c]	K[d]
a) Grizzly bears					
1	$S(\text{SEX} + \text{AST})\ p(\text{SEX})\ r(\text{AGE})\ R(.)\ R'(.)\ F = F' = 1$	2,072.6	0.00	0.46	9
2	$S(\text{SEX} \times \text{AST})\ p(\text{SEX})\ r(\text{AGE})\ R(.)\ R'(.)\ F = F' = 1$	2,073.8	1.21	0.25	10
3	$S(\text{SEX})\ p(\text{SEX})\ r(\text{AGE})\ R(.)\ R'(.)\ F = F' = 1$	2,074.0	1.35	0.24	8
4	$S(\text{SEX} + \text{AGE})\ p(\text{SEX} + \text{AGE})\ r(\text{AGE})\ R(.)\ R'(.)\ F = F' = 1$	2,078.0	5.34	0.03	10
5	$S(\text{SEX})\ p(\text{SEX})\ r(.)\ R(.)\ R'(.)\ F = F' = 1$	2,079.1	6.50	0.02	7
6	$S(\text{SEX} \times \text{AGE})\ p(\text{SEX} \times \text{AGE})\ r(\text{AGE})\ R(.)\ R'(.)\ F = F' = 1$	2,080.6	7.97	0.01	12
7	$S(\text{AGE})\ p(\text{AGE})\ r(\text{AGE})\ R(.)\ R'(.)\ F = F' = 1$	2,080.6	8.00	0.01	8
8	$S(\text{SEX})\ p(\text{SEX})\ r(.)\ R(.)\ R'(.)\ F(.)\ F'(0)$	2,081.2	8.55	0.01	8
9	$S(.)\ p(.)\ r(.)\ R(.)\ R'\ (.)\ F = F' = 1$	2,082.1	9.44	0.00	5
10	$S(\text{SEX})\ p(\text{SEX})\ r(.)\ R(.)\ R'(.)\ F(.)\ F'\ (.)$	2,083.2	10.62	0.00	9
11	$S(\text{SEX})\ p(\text{SEX})\ r(\text{AGE})\ R(.) = R'(.)\ F = F' = 1$	2,084.3	11.69	0.00	6
b) American black bears					
1	$S(\text{SEX})\ p(\text{AGE})\ r(.)\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(.)$	1,200.6	0.00	0.25	11
2	$S(\text{SEX} \times \text{AST})\ p(\text{AGE})\ r(\text{AGE})\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(.)$	1,201.0	0.46	0.20	14
3	$S(\text{SEX} + \text{AST})\ p(\text{AGE})\ r(\text{AGE})\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(.)$	1,201.7	1.17	0.14	13
4	$S(\text{SEX} \times \text{AST})\ p(\text{AGE})\ r(.)\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(.)$	1,201.8	1.20	0.14	13
5	$S(\text{AST})\ p(\text{AGE})\ r(\text{AGE})\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(.)$	1,202.6	2.07	0.09	12
6	$S(\text{SEX})\ p(\text{SEX})\ r(.)\ R(\text{SEX})\ R'(\text{SEX})\ F(.)\ F'(.)$	1,203.3	2.71	0.06	11
7	$S(\text{SEX})\ p(\text{SEX})\ r(.)\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(.)$	1,203.9	3.36	0.05	11
8	$S(\text{SEX} \times \text{AST})\ p(\text{SEX} + \text{AGE})\ r(.)\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(.)$	1,204.4	3.78	0.04	15
9	$S(\text{SEX})\ p(\text{AGE})\ r(.)\ R(\text{AGE})\ R'(\text{AGE})\ F = F' = 1$	1,205.6	4.98	0.02	11
10	$S(\text{SEX})\ p(\text{AGE})\ r(.)\ R(\text{AGE})\ R'(\text{AGE})\ F(.)\ F'(0)$	1,207.7	7.17	0.01	11
11	$S(.)\ p(.)\ r(.)\ R(.)\ R'(.)\ F(.)\ F'(.)$	1,210.3	9.76	0.00	7

[a] Model parameters are S = survival, p = capture probability, r = the recovery or reporting rate of dead bears, and R and R' = the probability of resighting a bear, either visually or by radiolocation. The movement parameters F and F' indicate permanent emigration when $F' = 0$, random emigration when $F' = F = 1$, and Markov emigration when $F(.)\ F'(.)$.

[b] Variables are SEX = sex and AGE = mean age of bear during study; (.) is a parameter-specific constant; + and × denote additive and interactive effects, respectively.

[c] AIC weight.

[d] Number of estimable parameters in model.

Values for AST exceeded the upper limit of the reference interval for captive black bears (205 U/liter) in 66% of samples collected from 165 leghold-snare captures and 29% of samples from 7 barrel-trap captures. Values for CK exceeded the upper limit of the reference interval for captive black bears (421 U/liter) in 81% of samples collected from leghold-snare captures and 29% of samples from barrel-trap captures. Serum myoglobin was not measured in samples collected from black bears.

Serum enzymes and myoglobin were positively correlated in grizzly bears (Pearson correlation: AST versus CK—$R = 0.80$, $P \leq 0.001$, $n = 193$; AST versus myoglobin—$R = 0.69$, $P \leq 0.001$, $n = 116$; CK versus myoglobin—$R = 0.57$, $P \leq 0.001$, $n = 117$). Similarly, AST and CK were positively correlated in black bears ($R = 0.82$, $P \leq 0.001$, $n = 172$). For captures by leghold snare, serum concentrations of CK or AST did not correlate with body mass for grizzly bears (Pearson correlation: $P \geq 0.13$, $n = 73$) or black bears (Pearson correlation: $P \geq 0.62$, $n = 163$).

Muscle injury and survival.—Of 56 grizzly bears used in the analysis, 29 were captured by remote drug delivery (28 from a helicopter and 1 from the ground), 25 by leghold snare, and 2 by barrel trap. The sample was composed of 30 females (mean ± *SD*, range, respectively; age = 8.1 ± 5.9 years, 1.9–21.7 years) and 26 males (5.9 ± 4.2 years, 1.0–17.1 years). Mean AST concentration was 249 U/liter (*SD* = 253.6 U/liter, range = 38–1,248 U/liter) with 55% of values > 142 U/liter, the upper limit of the reference interval for captive grizzly bears (Teare 2002).

We developed age-specific survival models in a progressive manner that began with 1st determining which model described movement pattern of grizzly bears best, that is, permanent, random, or Markov emigration (Table 1a). Support was stronger for a random emigration model ($F = F' = 1$, model 5) than for permanent emigration ($F' = 0$, model 8) or Markov emigration models (model 10). We determined next if a random emigration model was affected by the biological covariates sex and mean age of bear during the study. Support was stronger for model 3, a model in which survival and capture probability varied by sex and reporting rate varied by age, than for model 9, a model that does not include biological covariates. The final step was to determine if a biologically appropriate random emigration model was affected by the muscle-injury covariate AST. For bears captured more than once, this was the AST value recorded at last capture. Overall, support was strongest for model 1, in which AST had an additive effect on survival. A

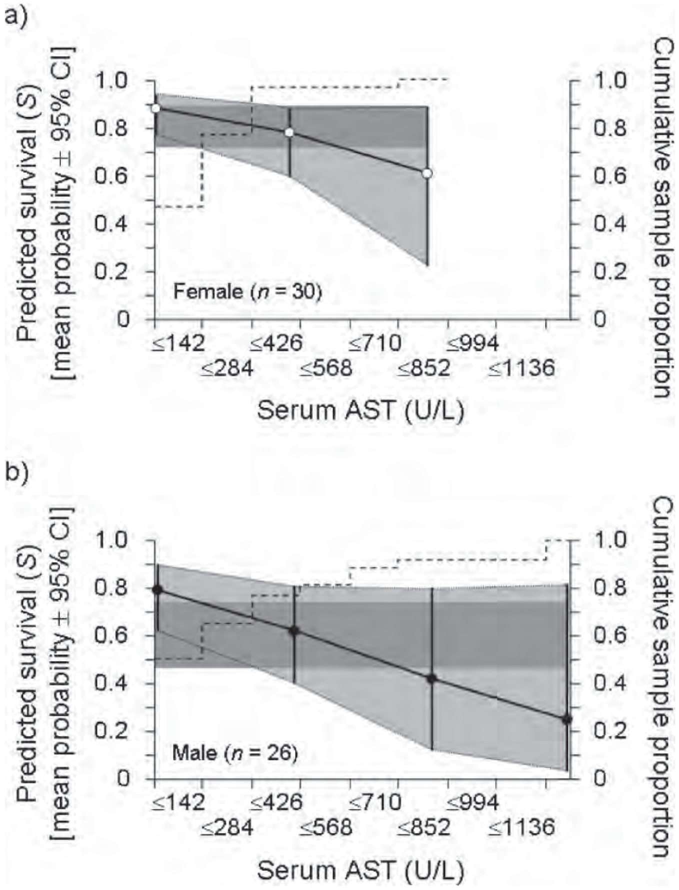

Fig. 2.—Probability of survival for grizzly bears as a function of their serum concentration of aspartate aminotransferase (AST) at capture predicted by model 1 of Table 1a. Predicted survival rates were estimated from the records of a) 30 female and b) 26 male grizzly bears captured for the Foothills Model Forest Grizzly Bear Project in western Alberta, Canada, during 1999–2003. Cut points for intervals represent multiples of the upper limit (142 U/liter) of the reference interval for AST in captive grizzly bears (Teare 2002) with the highest value (1,248 U/liter) at >8 times the reference interval. Light-shaded areas represent sex-specific 95% confidence intervals for model 1 of Table 1a and dark-shaded areas represent sex-specific 95% confidence intervals for model 3, a model for which AST had no significant effect on survival but also was supported by the data ($\Delta AIC_C = 1.35$, $w_i = 0.24$). The dashed lines denote the cumulative proportions of sampled female and male bears falling within the increasing range of AST intervals. We interpret these results to indicate that high AST levels may affect survival of some grizzly bears, but if it does, reduced survival is more likely affected by altered mobility and behavior than by direct physiological effects, for example, circulatory collapse. The large confidence intervals around survival estimates at higher AST levels reflect both the small sample sizes at these levels and the variation in responses among individual bears.

model in which AST and sex had an interactive effect on survival (model 2) also was supported by the analysis. However, it did not differ in strength of support from model 3, which did not include any (AST) survival effects.

Using model 1, we plotted predicted survival curves with associated 95% confidence intervals (95% *CI*s) for female and male grizzly bears with AST values ranging from 0 to 1,200 U/liter, which approximates the observed range of 38–1,248 U/liter (Fig. 2). Although mean survival rate decreased as AST values increased in both female and male grizzly bears, the overall effect was weak given overlap in confidence intervals between different AST values and broadening of confidence intervals as AST values increased. The larger confidence intervals at higher AST values reflected to some extent the small proportion of bears (9% or 5 of 56 bears) with AST values $\geq$ 6 times the reference interval for captive grizzly bears. At the end of the study, 13 of 31 bears with AST levels $>$ 142 U/liter were alive, 7 bears died, and the fate of 11 other bears was unknown. Of the 7 deaths, 3 were legal by hunting or in defense of life or property, 2 were illegal, and 2 were of unknown cause with carcasses recovered at 1 week and 3 weeks after capture.

Of 103 black bears used in the analysis, 102 were captured by leghold snare and 1 was captured by barrel trap. The sample was composed of 42 females (mean ± *SD*, range, respectively; age = 5.4 ± 3.1 years, 1.0–14.0 years) and 61 males (3.8 ± 2.4 years, 1.0–11.4 years). The mean AST concentration was 594 U/liter (*SD* = 911.0 U/liter, range = 39–5,340 U/liter) with 59% of values $>$ 205 U/liter, the upper limit of the reference interval for captive black bears (Teare 2002).

Following the same procedure used in the grizzly bear survival analysis, we found stronger support for a Markov emigration model (model 1; Table 1b) than for permanent (model 10) or random emigration models (model 9). When considering potential effects of biological covariates, support was stronger for models where survival varied by sex, and capture and resighting probabilities and recovery rate varied by age than for a model without biological covariates (model 11). We did not find, however, substantial support for AST as a covariate (model 1).

Mobility after capture.—We used capture and movement records of 91 grizzly bears captured 150 times for AIC_C model selection. Multiple models were supported, with many including capture-effect terms (Table 2a). The highest-ranked models ($\Delta AIC_C \leq 2$) indicated that movement rates varied as a function of sex and reproductive class (female, female with dependent offspring, or male), month, the interaction between month and day of month, and the number of days after capture. The month × day of month interaction suggested that trends in movement rates within months may have differed between bears, particularly during April and May, possibly as a result of occupying home ranges across a wide elevational gradient, that is, $>$ 1,600 m. An interaction term between method of capture and number of days after capture was supported by model 2, but the biological significance of this term was questionable because model 1 was better supported with fewer capture variables. A model without capture variables (model 10) was not supported by the data.

Predicted movement rate for grizzly bears as a function of the number of days after capture was represented best by a polynomial curve (Fig. 3a). Because movement rates always stabilized before 70 days after capture, we assumed that the movement rate at 70 days was equivalent to the mean population movement rate for a given sex and reproductive

Table 2.—Models selected using sample-size–adjusted Akaike information criterion (AIC_C) to test the hypothesis that the capture and handling of a) grizzly bears for the Foothills Model Forest Grizzly Bear Research Project in western Alberta, Canada (1999–2005), and b) American black bears for the Pisgah Bear Sanctuary Black Bear Research Project in North Carolina (1981–2002) caused a measurable decrease in their daily movement rates in the days after capture. The analyses are based on capture and movement records for 91 grizzly bears captured 150 times and 128 black bears captured 196 times.

	Variables[a]					
No.	Biological and sampling	Capture	AIC_C	$\Delta\text{AIC}_\text{C}$	w_i[b]	K[c]
a) Grizzly bears						
1	REP, MON_C, $\text{MON}_\text{C} \times \text{DAY}_\text{M}$	DAY_C, DAY_C^2, DAY_C^3	22,897.7	0.0	0.64	17
2	REP, MON_C, $\text{MON}_\text{C} \times \text{DAY}_\text{M}$	DAY_C, DAY_C^2, DAY_C^3, CAP $\times$ DAY_C	22,899.5	1.8	0.26	18
3	REP, MON_C, $\text{MON}_\text{C} \times \text{DAY}_\text{M}$	DAY_C, DAY_C^2, DAY_C^3, REP $\times$ DAY_C	22,901.6	3.9	0.09	19
4	MON_C, $\text{MON}_\text{C} \times \text{DAY}_\text{M}$	DAY_C, DAY_C^2, DAY_C^3, REP $\times$ DAY_C	22,909.9	12.2	0.00	17
5	REP, MON_C	DAY_C, DAY_C^2, DAY_C^3	22,923.3	25.6	0.00	13
6	REP, MON, MON^2	DAY_C, DAY_C^2, DAY_C^3	22,931.3	33.6	0.00	12
7	REP, MON_C, $\text{MON}_\text{C} \times \text{DAY}_\text{M}$	DAY_C, DAY_C^2	22,934.6	36.9	0.00	16
8	REP, DAY_J	DAY_C, DAY_C^2, DAY_C^3	22,943.6	46.0	0.00	11
9	REP, MON, MON $\times$ DAY_M	DAY_C, DAY_C^2, DAY_C^3	22,945.7	48.0	0.00	15
10	REP, MON_C, $\text{MON}_\text{C} \times \text{DAY}_\text{M}$		22,958.9	61.2	0.00	14
b) American black bears						
1	FIX, REP, MON, AGE	DAY_C, DAY_C^2, DAY_C^3	9,937.6	0.0	0.28	13
2	FIX, REP, MON	DAY_C, DAY_C^2, DAY_C^3, DAY_C $\times$ MON	9,938.2	0.6	0.21	13
3	FIX, REP, MON	DAY_C, DAY_C^2, DAY_C^3	9,939.0	1.4	0.14	12
4	FIX, REP, MON^2	DAY_C, DAY_C^2, DAY_C^3	9,939.4	1.8	0.11	12
5	FIX, REP, MON	DAY_C, DAY_C^2, DAY_C^3, DAY_C $\times$ AGE	9,940.3	2.7	0.07	13
6	FIX, REP, MON	DAY_C, DAY_C^2, DAY_C^3	9,940.9	3.3	0.05	14
7	FIX, REP, MON	DAY_C, DAY_C^2, DAY_C^3, DAY_C $\times$ CAP	9,941.5	3.9	0.04	13
8	FIX, REP	DAY_C, DAY_C^2, DAY_C^3	9,941.7	4.1	0.04	11
9	FIX, REP, MON_C	DAY_C, DAY_C^2, DAY_C^3	9,941.8	4.2	0.03	16
10	FIX, REP, MON, AGE		9,960.0	22.4	0.00	10

[a] Variables are AGE = age in years, CAP = capture method (leghold snare and helicopter darting for grizzly bears, and leghold snare and barrel trap for black bears), DAY_C = number of days after capture, DAY_J = Julian day, DAY_M = day of month, FIX = time interval between location fixes in hours, MON = month as a continuous variable, MON_C = month as a categorical variable, REP = sex and reproductive class (male, female, or female with dependent offspring), and × indicates an interaction term.

[b] AIC weight.

[c] Number of estimable parameters in model.

class in a given month. Mean movement rate immediately after capture was approximately 57% of normal (95% *CI* = 45–74%) with slight differences between reproductive classes and months. Using a jackknife procedure to estimate standard errors on model 1, we determined movement rates to peak at 28 days (*SE* = 4.3 days, 95% *CI* = 20–37 days) after capture irrespective of sex and reproductive class or month of capture.

We used capture and movement records of 128 American black bears captured 196 times for AIC_C model selection. Multiple models were supported, with most including capture-effect terms (Table 2b). The highest-ranked models ($\Delta\text{AIC}_\text{C} \leq 2$) indicated that movement rates varied as a function of the time interval between location fixes, sex and reproductive class, month, age, and the number of days after capture. A model without capture variables (model 10) was not supported by the data.

As with grizzly bears, predicted movement rates for black bears as a function of number of days after capture was represented best by a polynomial curve in which movement rates increased after capture then settled to an approximate mean value (Fig. 3b). Mean movement rate immediately after capture was approximately 77% of normal (95% *CI* = 64–88%) with slight differences between reproductive classes and months. Using a jackknife procedure to estimate standard errors on the most-supported model, we determined movement rates to plateau at 36 days (*SE* = 8.6 days, 95% *CI* = 19–53 days) after capture irrespective of sex and reproductive class, month of capture, or age. We also found that the time interval between location fixes affected estimation of movement rates such that movement rates became less as the interval between location fixes increased.

Mobility and muscle injury.—We examined the potential effect of muscle injury on movement rates by including serum concentration of AST in both species, and myoglobin in grizzly bears, as an interaction term with number of days after capture in the most-supported models from Table 2. The data set for these analyses was reduced to 96 captures involving 50 unique bears because AST and myoglobin values were not available for all captures. A model with AST as a covariate was more supported than model 1 in Table 2a by 2.5 AIC_C units. However, a model with myoglobin as a covariate was not supported. As with the data for grizzly bears, the data set for black bears was reduced to 183 captures involving 63 unique bears. A model with AST as a covariate was more supported than model 1 in Table 2b by 3.9 AIC_C units. Inspection of plots suggested that initial movement rates were lower for all sex and reproductive classes in both species when AST concentrations were high, such that mean movement rates for bears with AST levels 3–4 times greater than the upper limit of the reference

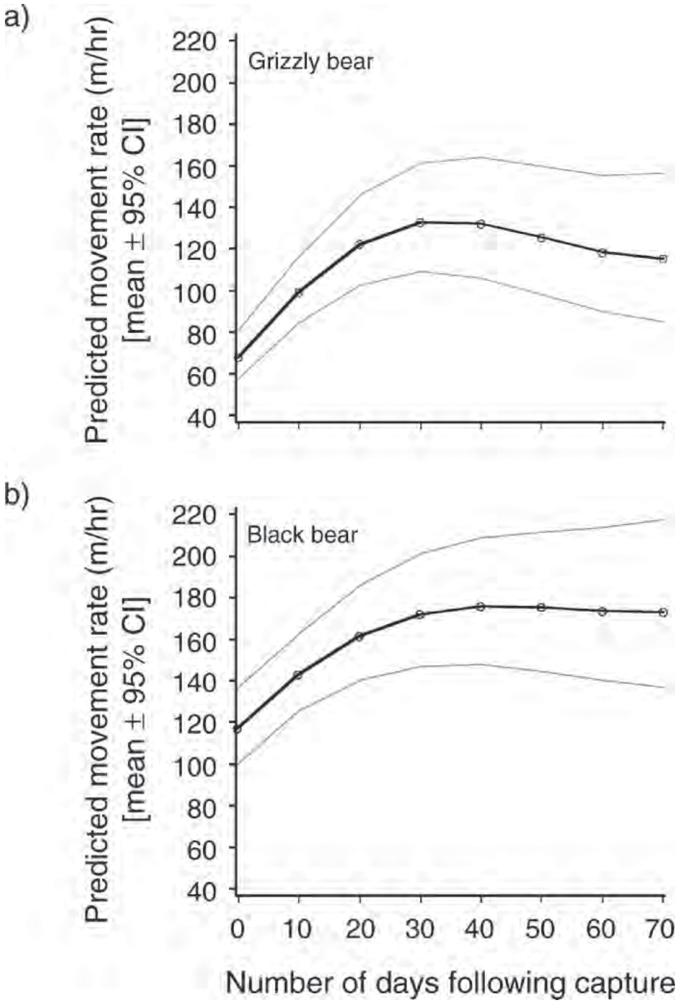

FIG. 3.—The movement rates for a) grizzly bears captured for the Foothills Model Forest Grizzly Bear Research Project in western Alberta, Canada (1999–2005), and b) American black bears captured for the Pisgah Bear Sanctuary Black Bear Research Project in North Carolina (1981–2002), as a function of the number of days after capture predicted from the most-supported model for each species in Table 2. The analyses are based on capture and movement records of 91 grizzly bears captured 150 times and 128 black bears captured 196 times. The plots are standardized for female grizzly bears (all ages) and female black bears (2.9 years old) without dependent offspring captured during the month of May.

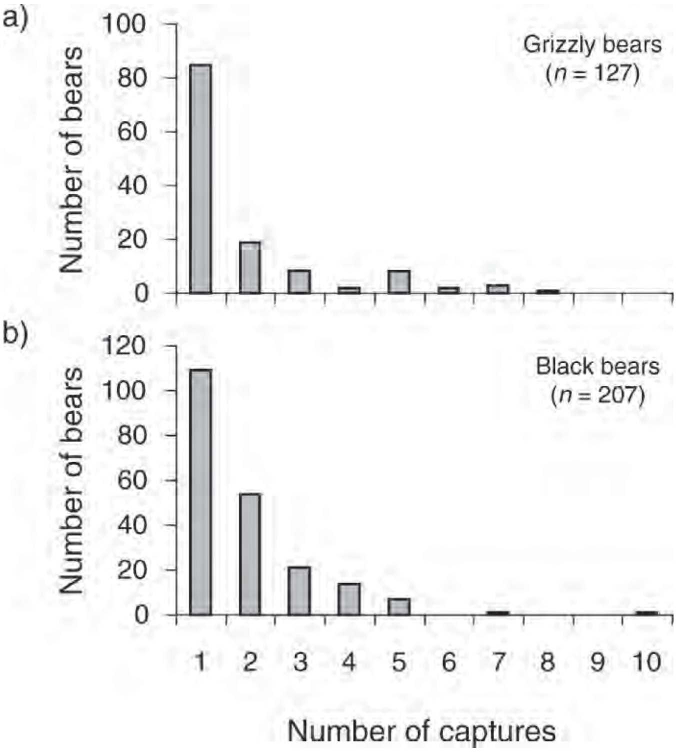

FIG. 4.—The numbers of individual a) grizzly bears and b) American black bears captured as a function of the number of captures occurring during the Foothills Model Forest Grizzly Bear Project in western Alberta, Canada (1999–2005), and the Pisgah Bear Sanctuary Black Bear Research Project in North Carolina (1981–2002).

interval were depressed approximately 20% more than mean movement rates for bears with normal AST levels.

Body condition and repeated captures.—We used capture records and BCI values from 127 grizzly bears captured 239 times to determine effect of repeated captures on body condition. Eighty-five bears were captured once only, whereas 42 bears were captured 2–8 times (Fig. 4a). Each sex and reproductive class (female, female with dependent offspring, or male) was adequately represented, that is, 28–50 bears per class. Multiple $\mathrm{AIC_C}$ models were supported, with the 4 most-supported models ($\Delta\mathrm{AIC_C} \leq 2$) all including capture-effect terms (Table 3a). The highest-ranked model (model 1) indicated BCI values varied as a function of sex and reproductive class, age, year, number of times captured, and an interaction between number of times captured and year. Another model with no capture effects (model 5) was marginally supported ($\Delta\mathrm{AIC_C} = 2.04$).

Mean BCI values generally increased with age in all reproductive classes (females, females with dependent offspring, or males). Rate of increase, however, was affected by the number of times a bear was captured such that bears captured repeatedly showed a slower rate of increase in BCI value with age than did bears captured once only (Fig. 5a). The difference in mean predicted BCI value between a 9-year-old bear captured once and a 9-year-old bear captured 5 times was 1.45, which is equivalent to a difference in body mass of approximately 25% (Cattet et al. 2002). The difference in body mass when captured 3 times was approximately 14%.

Ideally for Fig. 5, we should have shown predicted curves for all levels of multiple captures (2–10) encountered in this study. Doing so, however, would have resulted in either a single figure cluttered with many curves and overlapping confidence intervals, or a single figure with a cumulative curve (representing all capture levels ≥ 2) with a large error that would obscure any distinction with the curve for ‘‘captured once only,’’ or many additional figures with 1 for each capture level. We chose instead to show predicted curves for bears captured 5 times because this level was approximately midrange for number of captures per individual grizzly bear (2–8) and black bear (2–10). Because capture effect is directly

TABLE 3.—The models selected using sample-size–adjusted Akaike information criterion (AIC_C) to test the hypothesis that changes over time in the body condition of a) grizzly bears captured for the Foothills Model Forest Grizzly Bear Research Project in western Alberta, Canada (1999–2005), and b) American black bears captured for the Pisgah Bear Sanctuary Black Bear Research Project in North Carolina (1981–2002) were affected by the number of times a bear was captured. The analyses are based on capture records and body condition index values for 130 grizzly bears captured 241 times and 207 black bears captured 299 times.

	Variables[a]					
No.	Biological and sampling	Capture	AIC_C	ΔAIC_C	w_i[b]	K[c]
a) Grizzly bears						
1	REP, AGE, YR, YR^2	NO, NO × YR^2	293.8	0.00	0.21	10
2	REP, AGE, YR, YR^2, MON	NO, NO × YR^2	294.3	0.50	0.17	11
3	REP, AGE, YR, YR^2	NO, NO × YR	294.5	0.70	0.15	10
4	REP, AGE, YR, YR^2	NO, NO × YR, CAP × YR	294.7	0.89	0.14	11
5	REP, AGE, YR, YR^2		295.9	2.04	0.08	8
6	REP, AGE, YR, YR^2, REP × AGE	NO, NO × YR^2	296.0	2.12	0.07	12
7	REP, AGE, YR, YR^2	NO × YR^2	296.5	2.70	0.06	9
8	REP, AGE^2, YR, YR^2	NO, NO × YR^2	296.7	2.90	0.05	10
9	REP, AGE, YR, YR^2	NO	297.2	3.35	0.04	9
10	REP, AGE, YR^2	NO × YR	297.7	3.85	0.03	9
b) American black bears						
1	REP, REP × YR, AGE, AGE × YR	NO, NO × YR	655.3	0.0	0.28	16
2	REP, REP × YR, AGE, AGE × YR	NO, NO × YR, CAP × YR	656.7	1.0	0.17	17
3	REP, REP × YR, AGE, AGE × YR	NO, NO × YR	657.2	1.4	0.14	12
4	REP, REP × YR, AGE, AGE × YR, MON	NO, NO × YR	657.6	1.9	0.11	17
5	REP, REP × YR, AGE, AGE × YR, REP × AGE	NO, NO × YR	657.9	2.2	0.09	20
6	REP, REP × YR, AGE, AGE × YR	NO_C, NO_C × YR	658.3	2.6	0.08	18
7	REP, REP × YR, AGE, AGE × YR		658.6	2.8	0.07	14
8	REP, AGE, AGE × YR	NO, NO × YR	659.7	3.9	0.04	12
9	REP, REP × YR, AGE, AGE × YR	NO × YR	660.9	5.1	0.02	15
10	REP, REP × YR, AGE, AGE × YR, REP × AGE		661.8	6.1	0.01	10

[a] Variables are AGE = age in years at time of capture, CAP = capture method, MON = month of capture, NO = number of times a bear was captured, NO_C = categorical number of times a bear was captured, REP = sex and reproductive class, YR = year of capture, and × indicates an interaction term.

[b] AIC weight.

[c] Number of estimable parameters in model.

proportional to number of times captured, however, one can interpolate that curves for capture levels from 2 to 4 fall between predicted curves shown in Fig. 5 and curves for capture levels > 5 fall below the curve for 5 captures.

To determine if a grizzly bear's body condition affected its probability of being captured, we used the most-supported biological covariate model (model 3 from Table 1a) with BCI added as a covariate for recapture rate to estimate a slope coefficient for the relationship between recapture rate and BCI, that is, $S(\text{SEX})\ p(\text{SEX} + \text{BCI})\ r(\text{AGE})\ F(.)$. The estimated logit-scale slope was 0.82 ($SE = 0.49$, 95% $CI = -0.14$–1.79), suggesting a positive relationship between recapture rate and BCI. Because a slope of 0 was within the confidence interval, however, we considered the relationship insignificant.

We used capture records and BCI values from 207 American black bears captured 299 times to look at the effect of repeated captures on body condition. One hundred nine bears were captured once only, whereas 98 bears were captured 2–10 times (Fig. 4b). Overall, juvenile males were captured most often (102 captures) and adult females with dependent offspring least often (28 captures). Multiple AIC_C models were supported, with the 4 most-supported models ($\Delta AIC_C \leq 2$) all including capture-effect terms (Table 3b). The highest-ranked model (model 1) indicated that BCI values varied as a function of sex and reproductive class, age, number of times captured, and interactions between sex and reproductive class and year, age and year, and number of times captured and year.

As with grizzly bears, mean BCI values for black bears generally increased with age in all reproductive classes, and rate of increase was similarly affected by number of times a bear was captured (Fig. 5b). The difference in mean predicted BCI value between a 15-year-old bear captured once and a 15-year-old bear captured 5 times was 0.73 for females and males and 0.57 for females with dependent offspring, which is equivalent to differences in body mass of approximately 14% for female and male black bears and 11% for females with dependent offspring (Cattet et al. 2002). The difference in body mass when captured 3 times was approximately 7% in all sex and reproductive classes.

To determine if a black bear's body condition affected its probability of being captured, we used the most-supported biological covariate model (model 1 from Table 1b) with BCI added as a covariate for recapture rate to estimate a slope coefficient for the relationship between recapture rate and BCI, that is, $S(\text{SEX})\ p(\text{AGE} + \text{BCI})\ r(.)\ F(.)$. The estimated logit-scale slope was -0.042 ($SE = 0.18$, 95% $CI = -0.38$–0.30), suggesting a negative relationship between recapture rate and BCI. However, we considered the relationship insignificant because, similar to the grizzly bear analysis, a slope of zero was within the confidence interval.

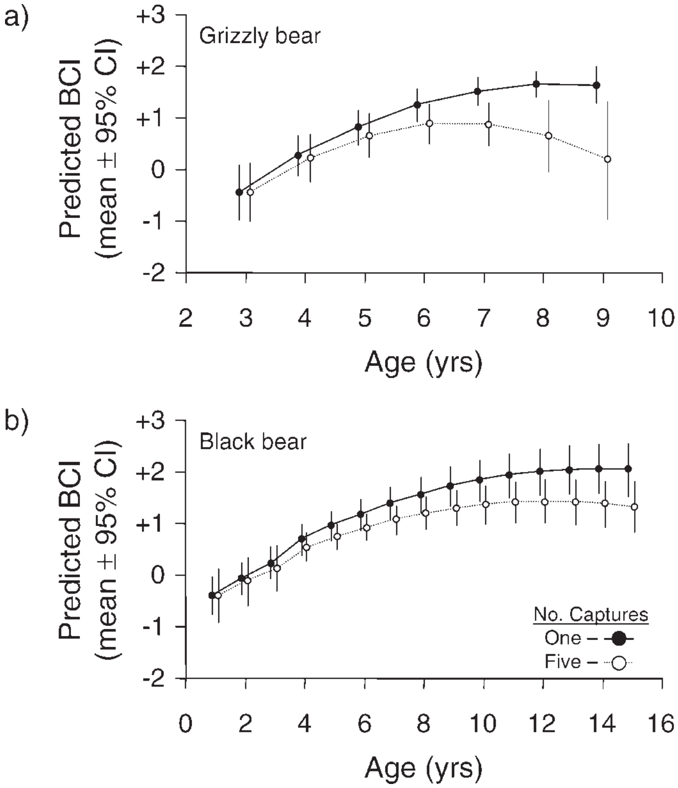

FIG. 5.—The relationship between body condition index (BCI) of a bear and its age as a function of number of times it was captured (once or 5 times) over the course of its lifetime predicted from the most-supported model for each species in Table 3. The analyses are based on capture records and BCI values for 130 grizzly bears captured 241 times and 207 black bears captured 299 times. The plots are standardized for a) male grizzly bears captured for the Foothills Model Forest Grizzly Bear Research Project in western Alberta, Canada (1999–2005), and b) male American black bears captured for the Pisgah Bear Sanctuary Black Bear Research Project in North Carolina (1981–2002). Although the age range for black bears (1–14 years) corresponds with the range of ages measured in captured male black bears, the age range for grizzly bears has been truncated at 9 years so that the total time interval of 6 years corresponds to the duration of sampling for this project, that is, 1999–2005. Ideally, we should have shown predicted curves for all levels of multiple captures (2–10) encountered in this study but this would have caused confusion and obscured any distinction with the curve for predicted BCI of bears "captured once only." We chose instead to show predicted curves for bears captured 5 times because this level was approximately midrange for number of captures per individual grizzly bear (2–8) and black bear (2–10). However, because capture effect is directly proportional to number of times captured, one can interpolate that curves for capture levels from 2 to 4 fall between predicted curves shown in the figure and curves for capture levels > 5 fall below the curve for "captured 5 times."

DISCUSSION

We conducted a retrospective study using standard types of data (serum biochemistry, radiotelemetry, capture–recapture, and body condition) collected in many conservation-oriented studies involving carnivores. Our goal was to evaluate whether long-term (≥1 month) effects of capture and handling were detectable and, if so, to identify possible implications this could have for the welfare of released animals and the interpretation of research results. Our analysis of data collected from 2 independent studies involving 2 species of bears, in geographically distinct areas, suggest that capture and handling affected study animals for a much longer duration than has been recognized generally. Specifically, we found evidence that: capture caused significant muscle injury in some bears, especially when captured by leghold snare; movement rates of many bears were affected for weeks after capture; and body condition of bears was negatively affected by capture, an effect directly proportional to the number of times a bear was captured and more evident with age.

Capture-related muscle injury.—Based on serum muscle enzyme (AST and CK) values from captures of 213 grizzly bears and 172 American black bears, we conclude that significant capture-related muscle injury (i.e., enzyme levels above reference interval values for captive bears) was indicated in samples collected from 102 grizzly bears captures and 134 black bear captures. Further, we believe extreme AST values (>5 times upper reference limit) measured in samples from 7 (6%) grizzly bears and 29 (18%) black bears captured by leghold snare were consistent with the occurrence of exertional (capture) myopathy, a noninfectious disease of wild and domestic animals characterized by damage to skeletal and cardiac muscles and associated with physiological imbalances following extreme exertion, struggle, and stress (Bartsch et al. 1977; Williams and Thorne 1996). Although AST in serum can originate from tissues other than muscle (e.g., liver and red blood cells), its strong positive correlation with concentrations of CK and myoglobin in grizzly bears, and with concentrations of CK in black bears, suggest that it was derived mostly from muscle.

Because serum concentrations of some blood constituents, including muscle enzymes, can be influenced by capture and handling, reference intervals for normal values are difficult to determine in wild species. As an alternative, we used reference intervals for captive grizzly bears and black bears (Teare 2002) as a frame of reference for comparison of muscle enzyme concentrations. Observation that serum muscle enzyme levels in wild black bears immobilized remotely by using drug-filled darts mounted on radiocollars (Powell 2005) are similar to those of captive black bears (mean ± *SD*; wild versus captive: AST—85 ± 15 U/liter versus 101 ± 52 U/liter; CK—133 ± 34 U/liter versus 163 ± 129 U/liter) corroborates comparisons between wild and captive counterparts. In our study, serum AST values in grizzly bears exceeded the upper limit of the reference interval for captive grizzly bears in 48% of samples measured, with the highest value (1,665 U/liter) at 12 times the upper limit, and serum CK values exceeded the upper limit of the reference interval in 40% of samples measured, with the highest value (37,280 U/liter) at 96 times the upper limit. Serum AST values in black bears exceeded the upper limit of the reference interval for captive black bears in 55% of samples measured, with the highest value (5,340 U/liter) at 26 times the upper limit, and serum CK values exceeded the upper limit of the reference interval in 78% of samples measured, with the highest value (109,780 U/liter) at 261 times the upper limit.

Muscle injury associated with capture and handling is the most likely explanation for these differences, a conclusion supported by findings from this and previous studies (e.g., Hellgren et al. 1989; Huber et al. 1997) that confirm that method of capture affects muscle enzyme levels. In general, capture by leghold snare is associated with higher levels of muscular exertion and injury than capture by helicopter darting or barrel trap (Cattet et al. 2003b; Powell 2005). For both species in our study, AST and CK concentrations in serum samples collected from bears captured by leghold snare exceeded the upper limit of reference intervals in greater proportion and magnitude than measured in samples collected from bears captured by other methods.

Serum levels of CK, AST, and myoglobin released from damaged muscle are used to assess occurrence and severity of muscle injury in human and veterinary laboratory medicine (Singh et al. 2005; Williams and Thorne 1996). These measures, however, provide only a ''rough'' indication of the extent of muscle fiber destruction; their accuracy as markers of muscle injury is constrained by the fact that serum concentrations reflect the net outcome of 2 dynamic opposing processes—leakage from damaged muscle and clearance from blood circulation. Nevertheless, there is ample evidence from other studies to suggest that muscle injury was significant, if not severe, in some grizzly bears and black bears based on comparisons of the magnitude of difference between measured values and upper limits for reference intervals. If we consider AST levels, we recorded values ingrizzly bears as much as 12 times the upper limit, and in black bears as much as 26 times the upper limit. By comparison, roe deer (*Capreolus capreolus*) that died of capture myopathy had 3- to 4-fold increases in serum AST level at 6–9 h after capture (Montané et al. 2002); red foxes (*Vulpes vulpes*) with exertional myopathy caused by capture with unpadded leghold traps had AST levels 13- to 16-fold greater than levels measured in free-ranging foxes shot as controls (Kreeger et al. 1990); horses (*Equus caballus*) with severe hind-limb muscle injury (Dabareiner et al. 2004) or severe diaphragmatic necrosis (Valentine et al. 2002) had 3- to 24-fold increases in serum AST level; and children with limbs crushed during an earthquake had 20- to 26-fold increases in mean serum AST level depending on whether 1 limb or multiple limbs were crushed (Dönmez et al. 2001). In addition to comparisons with published data, we also confirmed diagnosis of severe exertional myopathy in a grizzly bear that died 10 days after capture by leghold snare (Cattet et al., in press). Its serum AST concentration at capture (894 U/liter) was 6 times the upper limit of the reference interval for captive grizzly bears.

We suspect that factors contributing to the development of exertional myopathy in snared bears are similar to those identified for other species (Williams and Thorne 1996), primarily extreme stress induced by capture and extreme exertion while struggling to escape the snare. Nonetheless, we have no evidence to suggest that this condition is a direct cause of long-term mortality in bears. Analysis of survival rates in this study suggested that probability of survival for some grizzly bears decreased when AST levels were high, but the effect was weak, with confidence intervals at different AST values overlapping and the confidence interval around the mean probability of survival increasing as serum AST level increased (Fig. 2). We interpret these results to indicate that exertional myopathy may affect survival of some grizzly bears, but if it does, it is more likely as a consequence of altered behavior leading to increased vulnerability to death by hunting or poaching, or less success at acquiring resources (e.g., food and shelter), than as a direct result of adverse physiological effects, for example, circulatory collapse. We have no explanation for why high AST levels had no significant effect on survival of black bears in our study, even though a larger fraction (18% versus 6%) of those caught in snares had extreme values of AST consistent with exertional myopathy.

After muscle injury, increased concentrations of CK and myoglobin persist only a day or two (Lappalainen et al. 2002), and of AST as long as 5–7 days (Krefetz and McMillin 2005; Latimer et al. 2003), unless the injury is progressive. In our study, we found no evidence of persistently high (or low) serum AST, CK, or myoglobin concentrations in bears captured multiple times. Even in grizzly bears and black bears captured 2 or 3 times within periods ranging from 1 to 3 weeks, serum AST, CK, and myoglobin concentrations appeared mostly to reflect method of capture, being high when captured by leghold snare and lower when captured by helicopter darting or barrel trap. Although increases in serum muscle enzymes and myoglobin are short-term after muscle injury, the duration required for injured muscle to heal and for muscle function to return to normal is considerably longer. With minor injury, skeletal muscle can repair and regenerate within 4–8 weeks (Hill et al. 2003; Schneider-Kolsky et al. 2006). With more severe or extensive injury, pathologic changes to muscle structure (necrosis, mineralization, and atrophy) can affect strength and range of motion for a much longer duration (Porzio et al. 1997; Ross et al. 1999).

Mobility after capture.—Immediately after capture, movement rates of grizzly bears and American black bears were reduced for 3–6 weeks before returning to mean levels. Although numerous studies have investigated potential effects of capture on use of space by radiocollared animals (e.g., Chi et al. 1998; Moa et al. 2001; Windberg and Knowlton 1990), we are aware of only a few studies that have looked at movement rates in relation to capture and handling. Amstrup and Beecham (1976) and Craighead and Craighead (1972) concluded that the impact of research activity on daily movement rates of black bears and grizzly bears appeared to be negligible in their respective studies. We found, however, that sensitivity of detecting differences in movement rates of black bears diminished quickly as the interval between location fixes increased, a finding that underscores an advantage of the greater temporal resolution of GPS collars over conventional VHF transmitters, as has been described by others (Obbard et al. 1998; Schwartz and Arthur 1999). Consequently, Amstrup and Beecham (1976) and Craighead and Craighead (1972) may not have detected changes in movement because of long intervals between location estimates.

Our analysis identified that movement rates of bears also were influenced by month of year, day of month, and reproductive class of bear. Other studies have shown that different reproductive classes move at different rates, especially during the spring breeding season when male grizzly and black bears move at greater rates than do females (Amstrup and Beecham 1976; Ballard et al. 1982; Powell et al. 1997). This has been explained as movements of females reflect efforts to secure food sources, whereas movements of males maximize overlap with home ranges of females (Powell et al. 1997; Rogers 1987). Daily movement rates of grizzly bears in our study differed by day of month as well as by month. A plausible explanation for this interaction between day and month is that the grizzly bear study involved animals inhabiting home ranges across a wide elevational gradient (>1,600 m). Between extremes of home ranges in alpine versus low-elevation agricultural areas, differences in local climate (e.g., precipitation and snowmelt) and plant phenology likely affected movement rates of grizzly bears in different ways at different times (Munro et al. 2006). This was especially evident during April and May when snow was still plentiful at higher elevations and bears remained in or near dens, but at lower elevations snow was scarce and bears were moving in search of food. In general, through consideration of these biological and environmental factors and their potential interactions in our models, we were able to account for more bear-to-bear variation in movement rates and increase the power of the analyses to detect capture effects.

Severity of muscle injury, as reflected by serum AST concentrations, affected movement rates of grizzly bears and black bears. However, this effect was evident only in bears with AST levels > 3 times the upper limit of the reference interval. Movement rates also were depressed in bears with low AST levels but this likely was caused by factors other than muscle injury, because the prolonged effect of capture on movement rates occurred in many bears irrespective of capture method used. This finding warrants more detailed investigation of specific and cumulative effects of other stressors that bears may be exposed to during and after capture, for example, sample collection, marking, and carrying radiotransmitters.

Body condition and repeated captures.—The finding that capture and handling affected movement rates for a prolonged period in many bears prompted us to question whether alterations in movement rates could in turn affect assimilation and use of stored energy. As a measure of stored energy, we used a BCI developed for bears that correlates well with the combined mass of fat and skeletal muscle in a bear relative to its body size (Cattet et al. 2002). Because it is not possible to calculate a BCI value for a bear without 1st capturing it, we compared body condition in bears captured once only or captured the 1st time (the control group) to body condition in bears captured repeatedly ($\geq$2 times; the treatment group). We hypothesized that capture and handling affected changes over time in body condition of bears in a negative manner, and the effect would be proportional to the number of times a bear was captured. An implicit assumption in this analysis was that bears captured once and bears captured repeatedly would show similar relationships between body condition and age in the absence of captures. In other words, bears captured repeatedly also were a random sample of the population. This assumption was supported by the fact we were unable to confirm a significant relationship between BCI values for individual bears and their probability of being captured (or recaptured).

We found that body condition in both species tended to increase with age, but rate of change was inversely proportional to number of times a bear was captured, that is, the more often a bear was captured, the lower its age-related rate of change in body condition. Further, this effect became more apparent with age. When translating BCI values into body mass (kg) and comparing between adult bears captured 3 times versus bears of the same age and length captured once, we found a difference in body mass of approximately 14% in grizzly bears and 7% in black bears, and when comparing with bears captured 5 times, a difference in body mass of approximately 25% in grizzly bears and 11–14% in black bears. The significance of a greater effect on grizzly bears is uncertain given that a model without capture effects (model 5 in Table 3a) was marginally supported by our analysis ($\Delta \text{AIC}_\text{C} = 2.04$). Nevertheless, we conclude that a long-term consequence of capture and handling for both species is a reduction in energy storage and the magnitude of this effect increases with the number of captures. We suggest that this effect may occur because either energy intake is decreased (e.g., reduced foraging), or energy use is increased (e.g., healing of injured tissues), or a combination of both.

The negative effects of capture and handling on body condition have potential, in turn, to affect reproduction and lean body growth negatively, especially in bears captured multiple times. The relationships between body condition and these biological functions have been examined in many mammals (Boltnev et al. 1998; Gittleman and Thompson 1988), including grizzly bears (Stringham 1990b), black bears (Samson and Hout 1995; Stringham 1990a), and polar bears (*Ursus maritimus*—Atkinson and Ramsay 1995; Atkinson et al. 1996). Among bears, solitary adult females that enter dens in autumn in poor body condition are least likely to be seen with offspring the following spring. For those that produce cubs successfully, litter weight at den emergence is dependent upon their body condition in the previous autumn (Atkinson and Ramsay 1995; Samson and Hout 1995). Individuals with better body condition produce heavier cubs. For polar bears, heavier cubs are more likely to survive their 1st spring to summer period on the sea ice (Ramsay and Stirling 1988) and, in the case of females, are more likely to become large adults (Atkinson et al. 1996). We expect that heavier grizzly and black bear cubs also survive better.

Implications for wildlife welfare and research.—Although our findings have important implications for researchers and management agency personnel involved in the capture and handling of bears, we believe they are also pertinent to the conservation, research, and management of other wild carnivores. Indeed, methods of capture we used and types of data we collected are common to many research programs. It seems plausible that different species also will respond similarly when faced with similar stressors. This possibility should at the very least challenge persons capturing wild animals to evaluate their capture procedures and research results carefully. Without this effort, one cannot conclude with any certainty that capture effects are negligible.

A welfare implication of this study concerns use of leghold snares, a method of capture used commonly for ursids, but also for other wild carnivores, especially canids and felids. Our findings show that capture by this method relative to capture by helicopter darting and barrel traps is more likely to cause significant muscle injury (serum muscle enzyme levels > reference values), and in some cases exertional myopathy (serum muscle enzyme levels > 5 times reference values). Further, high serum levels of muscle enzymes detected in American black bears captured by leghold snare in this study suggest that use of cushioning devices, such as automobile hood springs, may not reduce severity of muscle injury or risk of exertional myopathy. Obviously, need exists to modify application of this method to reduce injury or to develop safer capture techniques that are as effective and practical as leghold snares. Use of trap-monitoring devices that signal when a bear is captured, therefore minimizing restraint time, may help reduce capture-related injury and enable researchers to determine duration of restraint (Larkin et al. 2003). Use of motion-activated video cameras at trap sites would allow researchers to assess animals' reactions to capture, which could potentially aid in development of better snaring techniques by illustrating how injury occurs, and how injury may be avoided. In parallel with developing and improving traps, there is also need to develop sensitive techniques to detect and evaluate injury on-site before a captured animal is released. Analysis of serum biochemical markers, as was done in our study, is of limited use because of the delay between collection and analysis of blood.

Another welfare implication is the potential negative effect of multiple captures of individual animals on body condition. As body condition fades, so too does an animal's potential for growth, reproduction, and survival. Clearly, researchers need to find ways to minimize occurrence of repeated captures of individual animals and for mark–recapture–type study designs where repeated sampling is required, explore the feasibility of less invasive approaches than animal capture, for example, DNA hair census.

A research implication of this study is that failure to recognize and account for long-term effects of capture and handling can potentially confound results leading to erroneous interpretations. For example, descriptions of activity patterns or determination of home ranges may be inaccurate if time elapsed after capture is not considered as a potential factor in analysis of movement rates or locations. Similarly, interpretation of body condition trends in association with environmental variables (e.g., measures of habitat quality) may be incorrect if number of times an animal is captured is not also considered in analyses as a potentially confounding factor.

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LITERATURE CITED

ALIBHAI, S. K., Z. C. JEWELL, AND S. S. TOWINDO. 2001. Effects of immobilization on fertility in female black rhino (*Diceros bicornis*). Journal of Zoology (London) 253:333–345.

AMSTRUP, S. C., AND J. BEECHAM. 1976. Activity patterns of radio-collared black bears in Idaho. Journal of Wildlife Management 40:340–348.

ANIMAL BEHAVIOR SOCIETY. 2003. Guidelines for the treatment of animals in behavioural research and teaching. Animal Behaviour 65:249–255.

ARNEMO, J. M., ET AL. 2006. Risk of capture-related mortality in large free-ranging mammals: experiences from Scandinavia. Wildlife Biology 12:109–113.

ATKINSON, S. N., AND M. A. RAMSAY. 1995. The effects of prolonged fasting on the body composition and reproductive success of female polar bears (*Ursus maritimus*). Functional Ecology 9:559–567.

Atkinson, S. N., I. Stirling, and M. A. Ramsay. 1996. Growth in early life and relative body-size among adult polar bears (*Ursus maritimus*). Journal of Zoology (London) 239:225–234.

Ballard, W. B., S. D. Miller, and T. H. Spraker. 1982. Home range, daily movements, and reproductive biology of brown bear in southcentral Alaska. Canadian Field-Naturalist 96:961–965.

Barker, R. J. 1997. Joint modeling of live-recapture, tag-resight, and tag-recovery data. Biometrics 53:666–677.

Barker, R. J., and G. C. White. 2001. Joint analysis of live and dead encounters of marked animals. Pp. 361–366 in Integrating people and wildlife for a sustainable future. Proceedings of the second international wildlife management congress, Gödölló, Hungary (R. Fields, ed.). Wildlife Society, Bethesda, Maryland.

Bartsch, R. C., E. E. McConnell, G. D. Imes, and J. M. Schmidt. 1977. A review of exertional rhabdomyolysis in wild and domestic animals and man. Veterinary Pathology 14:314–324.

Beier, L. R., S. B. Lewis, R. W. Flynn, G. Pendleton, and T. V. Schumacher. 2005. A single-catch snare to collect brown bear hair for genetic mark–recapture studies. Wildlife Society Bulletin 33:766–773.

Boltnev, A. I., A. E. York, and G. A. Antonelis. 1998. Northern fur seal young: interrelationships among birth size, growth, and survival. Canadian Journal of Zoology 76:843–854.

Boulanger, J., G. Stenhouse, and R. Munro. 2004. Sources of heterogeneity bias when DNA mark–recapture sampling methods are applied to grizzly bear (*Ursus arctos*) populations. Journal of Mammalogy 85:618–624.

Bunck, C. M., C. Chen, and K. H. Pollock. 1995. Robustness of survival estimates from radio-telemetry studies with uncertain relocation of individuals. Journal of Wildlife Management 59:790–794.

Burnham, K. P. 1993. A theory for combined analysis of ring recovery and recapture data. Pp. 199–213 in Marked individuals in the study of bird populations (J.-D. Lebreton and P. M. North, eds.). Birkhauser Verlag, Basel, Switzerland.

Burnham, K. P., and D. R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York.

Canadian Council on Animal Care. 2003. CCAC guidelines on: the care and use of wildlife. Canadian Council on Animal Care, Ottawa, Ontario, Canada.

Cardinet, G. H., III. 1997. Skeletal muscle function. Pp. 407–440 in Clinical biochemistry of domestic animals (J. J. Kaneko, J. W. Harvey, and M. L. Bruss, eds.). 5th ed. Academic Press, San Diego, California.

Cattet, M. R. L., N. A. Caulkett, M. E. Obbard, and G. B. Stenhouse. 2002. A body condition index for ursids. Canadian Journal of Zoology 80:1156–1161.

Cattet, M. R. L., N. A. Caulkett, and G. B. Stenhouse. 2003a. Anesthesia of grizzly bears using xylazine–zolazepam–tiletamine. Ursus 14:88–93.

Cattet, M. R. L., K. Christison, N. A. Caulkett, and G. B. Stenhouse. 2003b. Physiologic responses of grizzly bears to different methods of capture. Journal of Wildlife Diseases 39:649–654.

Cattet, M., G. Stenhouse, and T. Bollinger. In press. Exertional myopathy in a grizzly bear (*Ursus arctos*) captured by leg-hold snare. Journal of Wildlife Diseases.

Chi, D. K., D. Chester, and B. K. Gilbert. 1998. Effects of capture procedures on black bear activity at an Alaskan salmon stream. Ursus 10:563–569.

Clinchy, M., C. J. Krebs, and P. J. Jarman. 2001. Dispersal sinks and handling effects: interpreting the role of immigration in common brushtail possum populations. Journal of Animal Ecology 70:515–526.

Côté, S. D., M. Festa-Bianchet, and F. Fournier. 1998. Life-history effects of chemical immobilization and radiocollars on mountain goats. Journal of Wildlife Management 62:745–752.

Craighead, F. C., Jr., and J. J. Craighead. 1972. Grizzly bear prehibernation and denning activities as determined by radiotracking. Wildlife Monographs 32:1–35.

Creel, S., N. M. Creel, and S. L. Monfort. 1997. Radiocollaring and stress hormones in African wild dogs. Conservation Biology 11:544–548.

Dabareiner, R. M., D. G. Schmitz, C. M. Honnas, and G. K. Carter. 2004. Gracilis muscle injury as a cause of lameness in two horses. Journal of the American Veterinary Medical Association 224:1630–1633.

DelGiudice, G. D., B. A. Sampson, D. W. Kuehn, M. C. Powell, and J. Fieberg. 2005. Understanding margins of safe capture, chemical immobilization, and handling of free-ranging white-tailed deer. Wildlife Society Bulletin 33:677–687.

Dönmez, O., A. Meral, M. Yavuz, and O. Durmaz. 2001. Crush syndrome of children in the Marmara earthquake, Turkey. Pediatrics International 43:678–682.

Foley, C. A. H., S. Papageorge, and S. K. Wasser. 2001. Noninvasive stress and reproductive measures of social and ecological pressures in free-ranging African elephants (*Loxodonta africana*). Conservation Biology 15:1134–1142.

Gannon, W. L., R. S. Sikes, and the Animal Care and Use Committee of the American Society of Mammalogists. 2007. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 88:809–823.

Garshelis, D. L. 2006. On the allure of noninvasive genetic sampling—putting a face to the name. Ursus 17:109–123.

Gittleman, J. L., and S. D. Thompson. 1988. Energy allocation in mammalian reproduction. American Zoologist 28:863–875.

Golden, H. N., B. S. Shults, and K. E. Kunkel. 2002. Immobilization of wolverines with Telazol® from a helicopter. Wildlife Society Bulletin 30:492–497.

Haulton, S. M., W. F. Porter, and B. A. Rudolph. 2001. Evaluating 4 methods to capture white-tailed deer. Wildlife Society Bulletin 29:255–264.

Hellgren, E. C., M. R. Vaughn, and R. L. Kirkpatrick. 1989. Seasonal patterns in physiology and nutrition of black bears in Great Dismal Swamp, Virginia–North Carolina. Canadian Journal of Zoology 67:1837–1850.

Hill, M., A. Wernig, and G. Goldspink. 2003. Muscle satellite (stem) cell activation during local tissue injury and repair. Journal of Anatomy 203:89–99.

Hovey, F. W., and B. N. McLellan. 1996. Estimating population growth of grizzly bears from the Flathead River drainage using computer simulations of reproduction and survival rates. Canadian Journal of Zoology 74:1409–1416.

Huber, D., J. Kusak, Z. Žvorc, and R. B. Rafaj. 1997. Effects of sex, age, capturing method, and season on serum chemistry values of brown bears in Croatia. Journal of Wildlife Diseases 33:790–794.

Hulland, T. J. 1993. Muscle and tendon. Pp. 183–264 in Pathology of domestic animals (K. V. F. Jubb, P. C. Kennedy, and N. Palmer, eds.). Vol. 1. 4th ed. Academic Press, Inc., New York.

Johnson, K. G., and M. R. Pelton. 1980. Prebaiting and snaring techniques for black bears. Wildlife Society Bulletin 8:46–54.

Kiessling, W. R., K. Ricker, K. W. Pflughaupt, H. G. Mertens, and I. Haubitz. 1981. Serum myoglobin in primary and secondary skeletal muscle disorders. Journal of Neurology 224:229–233.

Kock, M. D., R. K. Clark, C. E. Franti, D. A. Jessup, and J. D. Wehausen. 1987a. Effects of capture on biological parameters in free-ranging bighorn sheep (*Ovis canadensis*): evaluation of normal, stressed and mortality outcomes and documentation of postcapture survival. Journal of Wildlife Diseases 23:652–662.

Kock, M. D., D. A. Jessup, R. K. Clark, and C. E. Franti. 1987b. Effects of capture on biological parameters in free-ranging bighorn sheep (*Ovis canadensis*): evaluation of drop-net, drive-net, chemical immobilization and the net gun. Journal of Wildlife Diseases 23:641–651.

Kock, M. D., D. A. Jessup, R. K. Clark, C. E. Franti, and R. A. Weaver. 1987c. Capture methods in five subspecies of free-ranging bighorn sheep: an evaluation of drop-net, drive-net, chemical immobilization and the net-gun. Journal of Wildlife Diseases 23:634–640.

Kreeger, T. J., P. J. White, U. S. Seal, and J. R. Tester. 1990. Pathological responses of red foxes to foothold traps. Journal of Wildlife Management 54:147–160.

Krefetz, R. G., and G. A. McMillin. 2005. Enzymes. Pp. 236–261 in Clinical chemistry: principles, procedures, correlations (M. L. Bishop, E. P. Fody, and L. E. Schoeff, eds.). 5th ed. Lippincott Williams & Wilkins, Baltimore, Maryland.

Lappalainen, H., E. Tiula, L. Uotila, and M. Mänttäri. 2002. Elimination kinetics of myoglobin and creatine kinase in rhabdomyolysis: implications for follow-up. Critical Care Medicine 30:2212–2215.

Larkin, R. P., T. R. VanDeelen, R. M. Sabick, T. E. Gosselink, and R. E. Warner. 2003. Electronic signaling for prompt removal of an animal from a trap. Wildlife Society Bulletin 31:392–398.

Latimer, K. S., K. W. Prasse, and E. A. Mahaffey. 2003. Duncan and Prasse's veterinary laboratory medicine: clinical pathology. 4th ed. Blackwell Publishing, Ames, Iowa.

Laurenson, M. K., and T. M. Caro. 1994. Monitoring the effects of non-trivial handling in free-living cheetahs. Animal Behaviour 47:547–557.

Lebreton, J.-D., K. P. Burnham, J. Clobert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecological Monographs 62:67–118.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed models. SAS Institute Inc., Cary, North Carolina.

Lukacs, P. M., et al. 2007. Concerns regarding the call for pluralism of information theory and hypothesis testing. Journal of Applied Ecology 44:456–460.

Lunn, N. J., I. Stirling, and D. Andriashek. 2004. Selection of maternity dens by female polar bears in western Hudson Bay, Canada and the effects of human disturbance. Polar Biology 27:350–356.

Marco, I., L. Viñas, R. Velarde, J. Pastor, and S. Lavin. 1997. Effects of capture and transport on blood parameters in free-ranging mouflon (*Ovis ammon*). Journal of Zoo and Wildlife Medicine 28:428–433.

Milliken, G. A., and D. E. Johnson. 2002. Analysis of messy data, volume III: analysis of covariance. Chapman & Hall/CRC, New York.

Millspaugh, J. J., et al. 2001. Fecal glucocorticoid assays and the physiological stress response in elk. Wildlife Society Bulletin 29:899–907.

Moa, P., A. Negård, K. Overskaug, and T. Kvam. 2001. Possible effects of the capture event on subsequent space use of Eurasian lynx. Wildlife Society Bulletin 29:86–90.

Montané, J., I. Marco, X. Manteca, J. López, and S. Lavin. 2002. Delayed acute capture myopathy in three roe deer. Journal of Veterinary Medicine, Series A 49:93–98.

Munro, R. H. M., S. E. Nielsen, M. H. Price, G. B. Stenhouse, and M. S. Boyce. 2006. Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. Journal of Mammalogy 87:1112–1121.

Obbard, M. E., B. A. Pond, and A. Perera. 1998. Preliminary evaluation of GPS collars for analysis of habitat use and activity patterns of black bears. Ursus 10:209–217.

Peterson, M. N., R. R. Lopez, P. A. Frank, M. J. Peterson, and N. J. Silvy. 2003. Evaluating capture methods for urban white-tailed deer. Wildlife Society Bulletin 31:1176–1187.

Porzio, P., J. A. Tender, and K. E. Baptiste. 1997. Exertional rhabdomyolysis in an adult Siberian husky. Journal of Veterinary Emergency and Critical Care 7:43–48.

Powell, R. A. 2005. Evaluating welfare of American black bears (*Ursus americanus*) captured in foot snares and in winter dens. Journal of Mammalogy 86:1171–1177.

Powell, R. A., and G. Proulx. 2003. Trapping and marking terrestrial mammals for research: integrating ethics, performance criteria, techniques, and common sense. Institute for Laboratory Animal Research (ILAR) Journal 44:259–276.

Powell, R. A., J. W. Zimmerman, and D. E. Seaman. 1997. Ecology and behaviour of North American black bears: home ranges, habitat and social organization. Chapman & Hall, London, United Kingdom.

Proulx, G. (ed.). 1999. Mammal trapping. Alpha Wildlife Research and Management Limited. Sherwood Park, Alberta, Canada.

Ramsay, M. A., and I. Stirling. 1988. Reproductive biology and ecology of female polar bears (*Ursus maritimus*). Journal of Zoology (London) 214:601–634.

Rogers, L. L. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. Wildlife Monographs 97:1–72.

Ross, W. A., J. B. Kaneene, J. P. Caron, K. F. Gallagher, and J. C. Gardiner. 1999. Factors influencing recovery from and duration of lameness in Michigan (USA) horses. Preventive Veterinary Medicine 40:127–138.

Samson, C., and J. Hout. 1995. Reproductive biology of female black bears in relation to body size in early winter. Journal of Mammalogy 76:68–77.

Schaub, M., and R. Pradel. 2004. Assessing the relative importance of different sources of mortality from recoveries of marked animals. Ecology 85:930–938.

Schneider-Kolsky, M. E., J. H. Hoving, P. Warren, and D. A. Connell. 2006. A comparison between clinical assessment and magnetic resonance imaging of acute hamstring injuries. American Journal of Sports Medicine 34:1008–1015.

Schwartz, C. C., and S. M. Arthur. 1999. Radiotracking large wilderness mammals: integration of GPS and ARGOS technology. Ursus 11:261–274.

Shivik, J. A., D. J. Martin, M. J. Pipas, J. Turnan, and T. J. DeLiberto. 2005. Initial comparison: jaws, cables, and cage-traps to capture coyotes. Wildlife Society Bulletin 33:1375–1383.

Singh, D., V. Chander, and K. Chopra. 2005. Rhabdomyolysis. Methods and Findings in Experimental and Clinical Pharmacology 27:39–48.

Stenhouse, G., J. Boulanger, J. Lee, K. Graham, J. Duval, and J. Cranston. 2005. Grizzly bear associations along the eastern slopes of Alberta. Ursus 16:31–40.

Stenhouse, G. B., and K. Graham. 2005. Foothills Model Forest Grizzly Bear Research Program 1999–2003 final report. Foothills Model Forest, Hinton, Alberta, Canada. http://www.fmf.ca/GB/GB_report7.pdf. Accessed 6 January 2006.

Stoneberg, R. P., and C. J. Jonkel. 1966. Age determination in black bears by cementum layers. Journal of Wildlife Management 30:411–414.

Storms, T. N., J. Schumacher, N. Zagaya, D. A. Osborn, K. V. Miller, and E. C. Ramsay. 2005. Determination and evaluation of an optimal dosage of carfentanil and xylazine for the immobilization of white-tailed deer (*Odocoileus virginianus*). Journal of Wildlife Diseases 41:559–568.

Stringham, S. F. 1990a. Black bear reproductive rate relative to body weight in hunted populations. Ursus 8:425–432.

Stringham, S. F. 1990b. Grizzly bear reproductive rate relative to body size. Ursus 8:433–443.

Swihart, R. K., and N. A. Slade. 1985. Testing for independence of observations in animal movements. Ecology 66:1176–1184.

Teare, J. A. (ed.). 2002. Reference ranges for physiological values in captive wildlife. International Species Information System, Apple Valley, Minnesota.

Valentine, B. A., P. D. Hammock, D. Lemiski, F. E. Hughes, L. Gerstner, and K. E. Bird. 2002. Severe diaphragmatic necrosis in four horses with degenerative myopathy. Canadian Veterinary Journal 43:614–616.

Verbeke, G., and G. Molenberghs. 2000. Linear mixed models for longitudinal data. Springer-Verlag, New York.

Vyas, N. B. 1999. Factors influencing estimation of pesticide-related wildlife mortality. Toxicology and Industrial Health 15:187–192.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46, supplement:120–138.

Williams, E. S., and E. T. Thorne. 1996. Exertional myopathy. Pp. 181–193 in Noninfectious diseases of wildlife (A. Fairbrother, L. N. Locke, and G. L. Hoff, eds.). 2nd ed. Iowa State University Press, Ames.

Windberg, L. A., and F. F. Knowlton. 1990. Relative vulnerability of coyotes to some capture procedures. Wildlife Society Bulletin 18:282–190.

Wobeser, G., and A. G. Wobeser. 1992. Carcass disappearance and estimation of mortality in a simulated die-off of small birds. Journal of Wildlife Diseases 28:548–554.

Zimmerman, J. W., and R. A. Powell. 1995. Radiotelemetry error: location error method compared with error polygons and confidence ellipses. Canadian Journal of Zoology 73:1123–1133.

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USING TELEMETRY EQUIPMENT FOR MONITORING TRAPS AND SNARES

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USING TELEMETRY EQUIPMENT FOR MONITORING TRAPS AND SNARES

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Abstract: Specialized radio transmitters were developed for use in monitoring large mammal trap and snare activity. Prototype devices were manufactured by 4 wildlife telemetry companies based on specifications we developed in consultation with electronic engineering personnel. Power outputs from individual transmitters ranged from 10 to 100 milliwatts (mw). Range testing in the gently rolling terrain of northeastern Colorado indicated that ground-tracking distances with truck-mounted dual beam antennas exceeded 40 km. Field tests were conducted using transmitters with traps and footsnares set for coyotes (*Canis latrans*) in California, black bears (*Ursus americanus*) in Oregon, and mountain lions (*Felis concolor*) in Arizona. Our results indicated that electronic monitoring could be a practical approach to reducing field operating costs and check times for devices set in remote areas. Other applications for the technology, such as use with cage traps in suburban areas, also appear feasible.

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Key words: black bear, *Canis latrans*, coyote, *Felis concolor*, mountain lion, trap, trap monitoring, snare, *Ursus americanus*

In recent years there has been increased interest by wildlife managers in developing telemetry technology for monitoring activity of animals at traps and snares set in remote areas. Decreased time between trap checks could also ensure quicker responses by trappers, thus reducing the likelihood of stress or injury to captured animals. The use of specialized radio telemetry equipment allows for monitoring of multiple trap sites from great distances, expanding the ability of a single trapper to handle numerous, widely spaced sites.

Past attempts to monitor traps and snares using radio transmitters involved the use of modified radio collars or low-powered transmitters (Anderka 1979, Nolan et al. 1984). Some wildlife managers and researchers found this equipment useful, but effective ranges were limited, particularly in remote rugged terrain. The purpose of this study was to develop long-range telemetry equipment and examine its feasibility for monitoring activity of traps and snares in situations where they are essential tools for managing carnivore predation on livestock in the western United States.

We thank federal Animal Damage Control (ADC) personnel S. Dieringer, M. Manning, J. Murdock, W. Robertson, and K. Tope for assisting with field evaluations and the Denver Wildlife Research Center engineering staff for invaluable help in developing specifications and bench-testing prototypes. E. Knittle, Denver Wildlife Research Center, piloted the aircraft and assisted us in conducting initial range tests.

METHODS AND STUDY LOCATIONS

Performance requirements for telemetry equipment were determined based on discussions with ADC personnel. We determined that transmitters needed to have sufficient power to produce a radio signal that could be received over rough terrain at distances >8 km. Also, they were required to be lightweight, durable, weatherproof, and easy to use. Other requirements included replaceable batteries, an on/off switch, and a magnetic switch to change the pulse rate from 30 to 90 pulses/min to signal activity changes.

Companies manufacturing wildlife telemetry equipment were given the specifications and asked to submit prototype transmitters. Four companies submitted 3 prototype transmitters each for our examination. Individual models were identified as A, B, C, and D (Fig. 1). Reference to trade names or commercial enterprises is for identification only and does not constitute endorsement by the authors or the United States Department of Agriculture. All transmitters were initially bench-tested by electronics personnel to determine if power requirements were achieved.

Initial range tests were conducted in the grasslands of northeastern Colorado by attaching each transmitter to a poly-vinyl chloride (PVC) pipe approximately 1 m above the ground. We used a truck-mounted dual beam yagi antenna system to determine maximum transmitter ranges from the same location on the ground. A Cessna 172 aircraft with a wing-

Figure 1. Prototype transmitters from 4 radio telemetry companies.

Table 1. Types, outputs, and ranges of 4 types of transmitters used for trap monitoring.

Transmitter type	Output (mw)	Maximum range from Ground (km)	Maximum range from Aircraft (km)
A	100	40.0	151.0
B	100	32.0	132.0
C	10	26.0	119.0
D	10	18.5	119.0

mounted yagi antenna was used to determine maximum ranges from the air. Maximum range was determined at a distance when the signal could no longer be detected by the receiver.

Field evaluations were conducted from December 1992 to November 1994 using prototype transmitters on traps and footsnares set for coyotes *(Canis Latrans)*, black bears *(Ursus americanus)*, and mountain lions *(Felis concolor)*. We provided prototype units and instructions to several Animal Damage Control Specialists (ADCS) in the ADC program for use in conjunction with their normal activities using traps or snares for problem carnivores.

Our first field trials involved monitoring softcatch traps set for coyotes in gently rolling grasslands in southern California. Transmitters were connected to traps and placed in surrounding vegetation at heights ranging from ground level to 2 m. A string was attached to a magnet located on the magnetic switch and to the bottom of the trap frame. The transmitter pulse rate increased when the magnet was removed by a trap being pulled from its bed.

A second trial was conducted using Aldrich footsnares set to capture black bears in mountainous regions of western Oregon. This area was heavily wooded with Douglas fir (*Pseudotsuga tsuga*) on steep mountain slopes. Transmitters were affixed to trees adjacent to cubby sets containing the Aldrich footsnares (Fig. 2). A string was attached to the throw-arm of the snare and to the magnet on the transmitter. When the throw-arm was released, the magnet was removed from the transmitter, initiating a change in pulse rate of the radio signal.

The third trial was conducted in the rugged desert mountain terrain of southeastern Arizona. This area was characterized by steep rocky canyons and mountains dominated by *Juniperus* spp. and *Acacia* spp. Lackey footsnares were set on trails or at livestock kill sites to capture depredating mountain lions. Transmitters were placed in adjacent trees and strings attached from the magnet to the throw-arms of the snares.

RESULTS AND DISCUSSION

Four telemetry companies provided prototype transmitters ranging in price from $195 to $318 and averaging $242.

The Custom Electronics telemetry receivers used in this study cost $900; the 4-element yagi antennas cost $80. The transmitters varied in construction, but all were designed to meet the specified performance requirements. Individual units had power outputs ranging from 10 to 100 mw (Table 1). Initial range tests showed reception distances ranging from 18.5 to 40 km on the ground to over 151 km from the fixed-wing aircraft at an above-ground altitude of 915 m.

During field trials, project personnel captured 6 coyotes, 2 bobcats (*Lynx lynx*), 4 black bears, and 3 mountain lions. Transmitters functioned properly and trap activity could be monitored from distances up to 21 km. The transmitter did not appear to affect trapping efficiency during any of the 3 tests.

Electronic monitoring of trap sites improved the efficiency of checking equipment set in remote areas. For example, the time required to check bear snares daily in Oregon was reduced from 8.50 to 2.75 hours. Similarly, the time required for checking mountain lion sets in Arizona was reduced from 12 to 4 hours daily. The ADCS were alerted any time snare throw-arms were sprung, or traps were pulled from their beds. Daily radio monitoring of equipment with transmitters also increased the efficiency of traplines by reducing the time that traps and snares were inoperable due to noncapture or nontarget animal disturbances. The ADCS were able to check equipment more frequently to reduce the time an animal was restrained. Faster response times should be helpful in a variety of situations to reduce injuries or exposure of captured animals.

During all captures, transmitters changed pulse rates as required. However, some problems were encountered with attachments of the magnets to transmitters. In 1 case, a snare was dug up by a small mammal. The snare was pulled off the throw-arm rendering it inoperable. Because the throw-arm did not fire, the transmitter did not change pulse rate and the inoperable set could not be detected. In another instance, a bear entered from the backside of a cubby set and removed the bait without activating the snare or the transmitter. At 1 leghold trap set, an animal activated the trap without moving the magnet on the transmitter switch; thus the pulse rate did not change. At another set, a cow moved the string which pulled the magnet from the transmitter. These examples indicated the need for periodic visual inspections of trap sites, or perhaps additional work on triggering mechanisms for transmitters.

We preferred prototypes with transmitters housed in aluminum flashlight cases. This allowed for easy battery changes and for convenient mounting of the units on nearby trees. Transmitters using magnetic on/off switches were preferred to those with push button type switches. Push button switches were often accidently activated during transport or handling of transmitters; activation could only be detected by use of a radio receiver. Magnetic switches ensure the unit is functioning only when the magnet is removed.

Figure 2. Trap monitoring transmitter attached to tree.

Trap monitoring equipment may have several other potential uses that we did not examine. Transmitters could be used on cage traps, as well as on foothold and snares or other animal capture devices. They could be utilized in suburban areas where accidental capture of pets may be a potential problem. Telemetry equipment could be used to monitor equipment set to capture bears or lions in suburban areas or in campgrounds where a captured animal may be a threat to human health and safety. Capture devices equipped with transmitters would ensure quick response times when threatened or endangered species such as gray wolves (*Canis lupus*) or grizzly bears (*Ursus arctos*) must be captured. Electronic monitoring might also be useful as a mitigating measure in areas where threatened or endangered species could be inadvertently captured during animal control operations. In many such cases, the cost of telemetry systems would be recovered by increased program efficiency. Nonetheless, the equipment cost, limitations on availability of radio frequencies, and the continuing need for periodic visual inspection of sites will probably limit the current application of electronic monitoring to specific, appropriate situations.

LITERATURE CITED

Anderka, F.W. 1979. Modulators for miniature tracking transmitters. Pages 181-184 *in* C. J. Amlander, Jr. and D. W. Macdonald, eds. A handbook on biotelemetry and radio tracking. Pergamon Press, New York.

Nolan, J.W., R.H. Russell, and F.W. Anderka. 1984. Trap monitoring transmitters for the Aldrich grizzly bear snare. J. Wildl. Manage. 48: 942-945.

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REVIEW:

WELFARE OUTCOMES OF LEG-HOLD TRAP USE IN VICTORIA

PREPARED BY NOCTURNAL WILDLIFE RESEARCH PTY LTD

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CONTENTS

(i)
GLOSSARY OF ABBREVIATIONS AND TERMS

ACTH	Adrenocorticotrophic hormone
AEC	Animal Ethics Committee
ALB	Albumin
ALP	Alkaline phosphatase
ALT	Alanine aminotransferase
Anxiety	Prolonged apprehension or worry that may affect mood, behavior and physiological activity
AST	Aspartate aminotransferase
ATP	Adenosine triphosphate
Autotomy	Removal (usually by biting or chewing) by an animal of its own appendage as a means to escape and self-directed trauma in response to nerve injury
Canid	Member of the family 'Canidae' (eg. dogs and foxes)
Cl^-	Chloride
CK	Creatine phosphokinase
CK-MM sub-fraction	Isoenzyme sub-fraction of CK expressed by skeletal muscles
CNS	Central Nervous System
dB	Decibel – a unit of relative sound loudness
Exotic pest	A species translocated from a foreign ecosystem now existing in a free-living (wild) state that is considered to negatively impact upon a particular resource or value
Feral pest	A once domesticated species now existing in a free-living (wild) state that is considered to negatively impact upon a particular resource or value
Foot-hold trap	A trap employing two jaws hinged and held open by a trigger mechanism that when stepped on closes by spring action around the foot or leg, preventing the animal from escaping. Some overseas trapping standards and commercial literature define a foot-hold trap as one where the 'jaw spread' is less than six inches. In this review the terms leg-hold and foot-hold are used interchangeably as specified by the authors cited and with reference to Victorian legislation that makes no distinction between leg-hold and foot-hold traps
Fourth (4th) generation Victor Soft-Catch trap	A padded ('rubber jawed') trap manufactured by Woodstream Corporation in Pennsylvania (USA) that has been progressively modified since its initial versions were reported in published studies in the early 1980s. Published accounts since the early 1990s assess '4th generation' versions that are reported to have greater efficacy and different attributes compared to previous trap generations
Gl	Glucose
Hb	Haemoglobin
HbO	Oxyhaemoglobin
HPA	Hypothalamic-pituitary-adrenal axis
IM	Intra-muscular
Ischemia	A decrease in the blood flow to a tissue or organ
ISO	International Organisation for Standardization
Jaw spread	Distance between opposing jaws of leg-hold (or foot-hold) traps when open and set
Laminated steel jaw traps	Flat jaw (no teeth or serrations) style leg-hold trap, with metal added to the jaws to increase their surface area
LDH	Lactate dehydrogenase
Leg-hold trap	A trap employing two jaws held open by a trigger mechanism that when stepped on closes by spring action around the foot or leg, preventing the animal from escaping. Some overseas trapping standards and commercial literature define a leg-hold trap as one where the 'jaw spread' is greater than six inches. In this review the terms 'leg-hold' and 'foot-hold' are used interchangeably as specified by the authors cited and with reference to Victorian legislation that makes no distinction between leg-hold and foot-hold traps
LIP	Lipase
LTD	Lethal Trap Device
Macropods	Member of the family Macropodidae (eg. kangaroos and wallabies)
MCV	Mean corpuscular volume
$mg\ kg^{-1}$	Milligrams per kilogram
N	Newtons – a unit of force
Na	Sodium

GLOSSARY OF ABBREVIATIONS AND TERMS cont.

N:L ratio	Neutrophil to lymphocyte ratio
Non-target species	Animals that are not the target of control and are ‘by-catch’ or affected unintentionally
NT:T ratio	Non-target to target species ratio
Oedema	The presence of abnormally large amounts of fluid in the intercellular tissue spaces
Pain	An unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage
PCV	Packed cell volume
RBC	Red blood cell
RCC	Red (blood) cell count
Self-mutilation	Used to describe self-inflicted bite wounding, usually of trapped limb
Serrated steel jaw trap	Tooth-style leg-hold trap made from steel and spring operated by pressure applied to a plate or treadle in the centre of the device
Soft jaw or rubber jaw traps	Flat jaw (no teeth) style leg-hold traps which have rubberised padding added to the jaws and is spring operated by pressure applied to a plate or treadle in centre of the device
Target species	Animals that are the target of control and captured or affected intentionally
TP	Total protein
Treadle-snare	Tennis racquet-shaped device, spring arm operated by pressure applied to a plate or treadle in centre of the device which pulls tight on a cable that may be plastic/rubber coated that snares the animal
TS	Trap selectivity – one measure of the ‘target-specificity’ of a trap
TTD	Tranquilliser Trap Device
WBC	White blood cell
WCC	White cell count
WTO	World Trade Organisation

(ii)

EXECUTIVE SUMMARY

BACKGROUND

1. In a significant portion of the current distribution of sheep and cattle in Australia, the dingo (*Canis lupus dingo*) and its hybrids (generically known as *wild dogs*) are implicated as a predator of livestock (predominantly sheep). Surplus killing behaviour of dingoes may result in a large number of livestock deaths and wounding.

2. In Australia, trapping and leg-hold snaring is mainly used for wild dog control in locations where shooting or poison baits are deemed to be inappropriate given proximity to settlements, where baiting has little impact or where legal restrictions are imposed on where baits may be laid.

3. Leg-hold traps (and snares) have received much attention from animal welfare and anti-trapping lobby groups worldwide over poor welfare outcomes. The leg-hold trap was banned in the UK in 1958 and is now banned in at least 80 countries. Restriction on the use of many leg-hold traps will commence in New Zealand by 2011. In Victoria, the use of large steel-jawed (eg. Lane's) leg-hold traps for wild dog control is still authorised in proclaimed exclusion zones.

4. The purpose of a restraining trap (or snare) is to reliably capture and hold the animal unharmed with the minimum of stress until the trap is checked and the animal can be euthanased or released. Overall welfare of the target and non-target species from the moment of capture until intervention due to euthanasia, death through other causes or after release from the trap is relevant to the overall and relative humaneness of traps.

5. Traps with the best relative humaneness will minimise suffering and permit an acceptable balance of the harms associated with trapping against the benefit of effective trapping of wild dogs.

NON-TARGET SPECIES

6. Animals that are captured unintentionally by traps are commonly referred to as 'non-target' species. A trap is considered to be more selective if it captures a higher proportion of "target" species rather than wildlife, domestic or exotic animals that are incidental to the objectives of the control programme. Other factors that affect trap selectivity include the location and manner in which it is set and the attractants used.

7. A reduction in the capture of non-target species implies a corresponding reduction in negative welfare impacts that have no beneficial outcome. If few traps are occupied by non-target species, there is a greater potential for the capture of target species.

8. Common wombats, swamp and red-necked wallabies, brushtail possums and eastern grey kangaroos are very common non-target species taken by leg-hold traps in south-eastern Australia, along with exotic non-target species such as the red fox, feral cat and European rabbit. Superb lyrebirds, goannas, echidnas, emus and corvids are also frequent non-target captures.

9. The behaviour of some non-target species may make them susceptible to capture. The common wombat's propensity to mark areas of disturbance may promote their capture at trap sites prepared by digging, clearing or movement of logs or trap setting at the base of trees.

WELFARE IMPACTS

10. Trapping releases predictable physiological responses as a reaction to a range of stressors encountered during capture. Attempts to measure the welfare impact of trapping can be made by measuring the magnitude of the biological response, pre-pathological state and consequent pathology.

11. Potentially there may be a wide range of stressors associated with trapping, many of which are not directly related to the trap mechanism. Startle, primary acute trauma and pain, restraint, handling, noise, light, loss of cover, social and spatial dislocation, food, odour, water and thermal stressors may act in various combinations to influence the degree to which animals resist traps and the overall stress and welfare outcomes of trapping.

12. Secondary physical trauma (eg. ischemia, predation, insect attack etc), chronic pain, anxiety and fear, self-mutilation, capture myopathy, exhaustion, impacts on young (loss of dependent young, ejection of pouch young and abortion etc), starvation, dehydration, hypothermia, hyperthermia and death are pathological endpoints of stress and the consequence of exposure to intense stressors or a combination of stressors. Good welfare outcomes of trapping should seek to prevent or mitigate such consequences.

13. The assessment of injuries using trauma scales to determine welfare is limited in its ability to estimate the impact of many stressors and pathological outcomes of trapping. A key deficiency associated with the use of trauma scoring in trap studies is that the amount of time that an animal spends in captivity is rarely known with any accuracy.

14. Data logging systems that reveal the capture time, duration and relative activity of animals are likely, in conjunction with physiological indicators such as CK, AST, ALP, ALT and N:L ratios as well as whole body necropsies, to enable the most useful, practical and unequivocal insights into the relative welfare impacts of traps.

15. Many of the haematological and biochemical indicators are standardised, cost-effective and widely available laboratory tests that, if properly applied, could provide sufficient information to monitor relative welfare states and promote adaptive management of trapping practices towards better welfare outcomes.

COMPARISON OF DEVICES

16. Padding of leg-hold trap jaws has been attempted with cloth, plastic or rubber tubing in an *ad hoc* manner in a number of overseas and Australian studies. This results in less injury than that produced by unmodified devices, but does not offer superior outcomes compared to those associated with commercially available padded traps.

17. International literature suggests that in most cases, leg-hold snares are less effective than leg-hold traps for canid control. Some data suggests that treadle-snares cause greater stress to red foxes than other capture devices and the continued use of the treadle-snare should be reviewed with reference to these new data.

18. Laminated leg-hold traps have been found in some studies to reduce the incidence of trap related injury, when compared to similar non-laminated devices. Currently there is no clear scientific consensus that laminated traps have the potential to deliver better welfare outcomes compared to commercially available padded leg-hold traps.

Lamination of existing leg-hold traps is unlikely to produce significantly improved welfare benefits compared to padded devices.

19. Devices that conform to the ‘fourth generation’ of the Victor Soft-Catch #3 trap probably represent current best practice in canid trapping that can be determined from published information. There appears to be potential for optimal welfare outcomes using commercially available padded leg-hold traps that use short restraining cables, standard pan tension systems, are suited to the attachment of TTDs or LTDs, are more familiar to trappers and are well supported by published efficacy data for the capture of canids.

PROMOTING BETTER WELFARE OUTCOMES

20. In order to promote current best practice and reliable welfare outcomes, mechanical trap specification should be established that clearly define minimum performance based attributes. Important trap specifications should include trap size and jaw spread, trap weight, closure speed, impact force, clamping force, jaw offset distances, padding material and pan tension characteristics. Ancillary features used with traps such as the type and number of in-line springs, swivels and anchoring methods should also be specified. A minimum benchmark could be based upon the fourth generation Victor Soft-Catch #3 trap using the manufacturer’s data or physical measurements.

21. Evaluating trap performance and routine testing and maintenance of traps will reduce the likelihood of failure in the field and poor welfare outcomes that result. The performance characteristics of traps such as spring tensions and closing speed will greatly influence the position on the limb where animals are restrained and the resulting trauma sustained.

22. A positive relationship exists between the periods of time held in captivity and the degree of injury and stress. In most countries in the developed world, trap inspection periods of at least once per day are a minimum standard. Nocturnal animals are likely to experience additional stress if held for prolonged periods during the day. In the absence of novel ways to demonstrably improve the welfare of animals held for periods in excess of one day, trap inspection periods should be at least once per day.

23. Various studies have contrasting recommendations concerning the merits of anchored or ‘drag’ fixed trap restraints. It would be appropriate to monitor the welfare outcomes, using appropriate scientific protocols, where both options are used for target and non-target animals and adopt the most beneficial practice.

24. In-line spring specifications that have been developed in North America are unlikely to have catered for species such as macropods that are capable of developing very large amounts of momentum over short distances. The specification of in-line springs in trap restraining chains should be adequate to ensure that the large forces of momentum produced by macropods (eg. kangaroos and wallabies) and predators are based upon realistic calculations of force that can be produced given the length of the chain, acceleration and their mass.

25. Pan tensioning (adjustment of ‘trigger’ sensitivity) is a proven, practical and inexpensive way to increase target-specificity and improve welfare outcomes. It will be most effective if applied to standard trap types and trap setting procedures and based upon empirical studies that seek to understand the most appropriate trigger forces that allow reliable capture of target species and exclusion of non-targets. Regular and standardised assessment of the performance of pan tensioning devices should be undertaken in the normal maintenance of overall trap performance.

26. Trap size and jaw spread affects the incidence of non-target captures and is probably an important way to limit capture of macropods and other non-target species. There is no evidence to suggest that capture rates and trap efficacy are significantly reduced by using leg-hold traps that have a reduced jaw area/size.

27. Use of Tranquilliser Trap Devices (TTDs) may have significant advantages for increasing the efficacy and welfare outcomes of traps. A Lethal Trap Device (LTD) formulation that causes the rapid death of trapped dogs and foxes may prevent injury sustained soon after capture and prevent the distress of prolonged confinement and/or after debilitation. Both approaches may also reduce the potential for dogs to escape if they are not adequately restrained by the trap.

28. Trap monitoring systems may be desirable if they prompt trap attendance soon after capture. Most nocturnal target and non-target species are probably captured during the night. Trap attendance after some hours or after an entire evening of captivity may not greatly increase welfare outcomes as much of the significant trauma will occur within the first few hours (possibly within the first hour) of capture.

29. The potential exists for lure/odour compounds to increase the target specificity of carnivore trapping by repelling native herbivores (eg. macropods and wombats) from trap sets. Deterrence of native herbivores would be a major advance to limit the capture of a significant number of non-target animals.

30. Practices that are used to release non-target species should be reviewed and appropriate equipment and training needs considered to ensure firstly that criteria for the choice between euthanasia and release are known and secondly that if release is attempted it can be done safely, humanely and in conjunction with simple treatments that could reduce post-capture stress and pathology. Macropods and birds may be highly susceptible to capture myopathy and in the absence of knowledge concerning the existence of this disease, routine euthanasia may be the most appropriate action.

31. Existing euthanasia recommendations for the use of firearms are probably inadequate and impractical under some circumstances for a range of non-target species and should be reviewed.

32. There is a large potential to adapt and modify trapping devices and practices to increase their effectiveness and produce improved welfare outcomes appropriate for local conditions. However, much of the published literature indicates *ad hoc* field experimentation with inadequate experimental controls and/or the use of multiple modifications or erratic variations in adaptations of the devices. This does not provide a good scientific basis for assessment and technique development.

33. This review concludes with a series of recommendations to promote the adoption of best practice trapping of canids to improve welfare outcomes and foster a culture of continuous improvement.

1.0 AIMS, OBJECTIVES AND METHODS

1.1 Aim:

The client has requested that Nocturnal Wildlife Research (NWR) Pty Ltd provide a comprehensive literature review to identify the nature of welfare impacts produced by leg-hold and foot-hold traps (here after referred to as *leg-hold* traps) with reference to Victorian species, and outline directions to promote improvement in welfare outcomes.

1.2 Objectives:

- Identify (target and non-target) species within Victoria that are susceptible to leg-hold trapping and describe the relative incidence of capture from published records;
- Describe the welfare impacts that can be anticipated from the use of leg-hold traps;
- Review the merits of trap types, actions and strategies that have the best potential to mitigate a range of welfare impacts.

1.3 Methods

Literature review

A literature review was conducted using CAB abstracts, Web of Science, Biosis, PubMed and Google Scholar search engines. The search focused upon compiling a bibliography for the:

- History, current use, regulation and development of leg-hold traps;
- Welfare impacts of leg-hold traps including trapping stressors, associated pathology and techniques to measure behavioural, pathological, biochemical and haematological indicators of poor welfare and stress;
- Assessment of different trap types in Australia and overseas for their comparative humaneness and welfare impacts.

Identifying target species

A review was conducted for studies of trapping and restraint of dingoes (*Canis lupus dingo*) and red foxes (*Vulpes vulpes*) in Australia and published information on the impacts of trapping upon non-target species. Literature relating to the trapping and restraint of coyotes (*Canis latrans*), wolves (*Canis lupus*), domestic dogs (*Canis lupus familiaris*), silver foxes (*Vulpes vulpes*) and Arctic foxes (*Alopex lagopus*) in overseas studies were used extensively.

Identifying non-target species

Non-target species in Victoria were identified by reviewing the scientific literature for records of target and non-target captures where a range of leg-hold traps and snares have been used for wild dog and fox control[1]. The occurrence of these species within the leg-hold trap exemption zone (Figure 1) was investigated by using species distribution data from the Victorian Wildlife Atlas (Department of Sustainability and Environment: Victoria). By combining all trapping studies a pool of 1123 wild dog captures were identified, along with associated non-target captures. The relative incidence of non-target species captured relative

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[1] Contemporary data for the trapping of target and non-target animals was sought from the Department of Primary Industries (Victoria) for this review but it was not provided.

to each 100 wild dog captures was used to express the likely susceptibility of various species to capture with leg-hold devices expressed as a subjective score of *very common* (≥ 10 records per 100 wild dog captures), *common* (1 – 9 records per 100 wild dog captures) or uncommon (≤ 1 record per 100 wild dog captures).

Haematology and biochemistry data for red fox captures

During 1990 – 1994 routine blood sampling of foxes captured in the urban area of Melbourne (Marks *et al.* 1998; 1999a; 1999b) was undertaken and haematology and blood biochemistry profiles were produced. Treadle-snares, Victor® Soft-Catch™ and cage traps were used to sample foxes, along with the use of netting. A sample of shot foxes was taken at the end of the study. Relevant haematology and biochemistry data are compared with published data for foxes taken by different trap types and for different durations of captivity and sampling techniques. Details of the analysis are contained in Marks (submitted) (Appendix 1).

2.0 BACKGROUND

2.1 Use of leg-hold devices in Victoria

In a significant portion of the distribution of sheep and cattle in Australia, the dingo (*Canis lupus dingo*) and its hybrids (generically known as *wild dogs*) are implicated as a predator of livestock (Fleming *et al.* 2001). Sheep (*Ovis aries*) and goats (*Capra hircus*) are highly vulnerable to predation by wild dogs primarily due to their ineffective anti-predator strategy of fleeing and mobbing (Allen *et al.* 2004). The control of exotic red foxes (*Vulpes vulpes*) is also undertaken to protect lambs and to support the conservation of wildlife species (Saunders *et al.* 1995). As in other countries, the fox is considered a sporting resource (Reynolds *et al.* 1996) and a vector of some zoonotic diseases such as echinococcus (Jenkins *et al.* 1992, Saunders *et al.* 1995). Wild dogs are believed to cost $AU66.3 million in lost agricultural production and control effort (McLeod 2004) and are a much more significant predator of livestock than foxes. Leg-hold traps have been used for the selective removal of individual dogs that attack livestock, and prior to the development of poison baiting, trapping was the primary means of wild dog control in Australia (Harden *et al.* 1987). Trapping and leg-hold snaring is currently used for wild dog control in locations where shooting or poison baits are deemed to be inappropriate given proximity to settlements, where legal restrictions are imposed on where baits may be laid (Croft *et al.* 1992) or where baiting has little impact (Fleming *et al.* 1998). The surplus killing behaviour by individual or a small number of dingoes may result in a large number of sheep being killed in one attack (Thomson 1992, Allen *et al.* 2001). Consequently, the targeted trapping of dingoes that have commenced predation of livestock may be an important strategy to limit attacks on properties by individual dogs rather than as a means to produce wide-scale reductions in population abundance.

In Victoria, livestock predation by wild dogs is largely restricted to the eastern highlands, where pastures were established in areas surrounded by a large forest boundary, which contains endemic dingo populations (Fleming *et al.* 2001). Wild dogs are listed as an 'established pest animal' under the *Catchment and Land Protection Act 1994* (CALP). Wild dog control is mainly carried out by staff of the Department of Primary Industries (DPI), although some control is also undertaken by private land holders. Under Section 30 of the *Domestic (Feral and Nuisance) Animals Act 1994*, an owner of animals kept for farming purposes (or an authorised officer) is permitted to destroy any dog found at large in the place where those animals are confined. Section 15 of the *Prevention of Cruelty to Animals Act 1986* (POCTA) details the offences and the exempted areas for using both large and small leg-hold traps (Figure 1). The *Prevention of Cruelty to Animals Regulations 1997* define a large leg-hold trap as one with a jaw spread not less than 12 cm wide, and a small leg-hold trap as one with a jaw spread less than 12 cm. Other than the term 'spring operated steel jaw leg-hold trap' contained in Section 15 of POCTA, there is no specific definition in the legislation that takes into account the recent modifications and newer models of leg-hold traps[2]. Section 6 of the POCTA Act exempts anything done in accordance with the CALP Act, although leg-hold trapping is not specifically mentioned in the CALP Act.

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[2] The treadle snare was designated to be the device of choice used by Victorian government trappers since 1987 although large serrated steel-jawed traps were still used concurrently until 2004 under authorisation under the CALP Act. Since 2000 large 'rubber jawed' (Lane's type) traps began to be used in Victoria in small numbers until 2006 when they are were adopted increasingly until the phasing out of treadle snare use by December 2007. After the bushfires in 2003, some 790 rubber jawed traps (Jake and modified Bridger #5) have been purchased by DPI in Victoria (B. Roughead, personal communication).

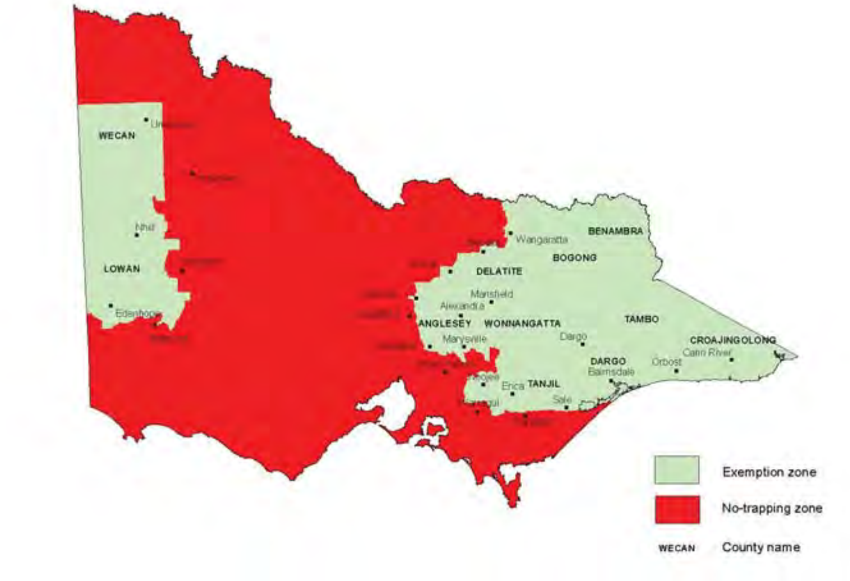

Figure 1. Areas of Victoria where trapping with steel-jawed leg-hold traps is prohibited (no trapping zone) and the exemption zone (exemption zone) where trapping conducted in accordance with the Catchment and Land Protection Act (1994) is authorised.

2.2 Traps and snares used world-wide for canid control

There are four broad categories of restraining traps and snares that have been used for canid control; leg-hold (or foot-hold) traps[3], leg-hold snares, cage (or box) traps and neck snares (Powell *et al.* 2003, Iossa *et al.* 2007). Killing traps and neck snares are not used in Australia[4] and are primarily confined to North American fur harvesting along with deadfall traps, spring traps, lethal snares, drowning traps and pitfall traps (Powell *et al.* 2003, Iossa *et al.* 2007). Snares and deadfall devices have a long history of invention by trappers in North America (Petrides 1946). Novel capture techniques including drive nets have been used to capture wolves in forest habitat in Poland (Okarma *et al.* 1997) and the use of tranquilliser rifles in North America (Gese *et al.* 1996) but these have not found wide use in Australia and will not be discussed further.

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[3] The foot is the pedal extremity of a vertebrate animal's leg (including the tarsus, metatarsus and phalanges). The leg refers to the entire limb used for locomotion in vertebrates, suggesting that a leg-hold trap will restrain animals at any point of the limb. There is no universally accepted, evidence-based definition to distinguish "leg-hold" from "foot-hold" trap, although some commercial literature and North American standards define foot-hold traps as having jaw spreads less than six inches across. In this review the terms are used as specified by the authors of the papers referred to, are not retrospectively defined and are made with reference to Victorian legislation that does not distinguish between foot-hold and leg-hold traps.

[4] Although some Australian commercial suppliers advertise certain 'killing traps', their legal status in various states is unclear and beyond the scope of this review.

2.2.1 Leg-hold traps

Steel-jawed leg-hold traps have been one of the principal devices used to capture fur-bearing animals world-wide (Payne 1980). They have a long history of use in Europe and North America, particularly in the fur industry after the 1850s, corresponding to the development of mass-produced devices and ongoing experimentation leading to the familiar form of steel-jawed leg-hold traps by the late 1800s (Gerstell 1985). In the United States, leg-hold traps are used for the capture of furbearing mammals, for recreational trapping, pest animal control and as a tool to aid subsistence living in wilderness areas. In the United States they are the primary control measure for coyotes involved in livestock damage (Andelt *et al.* 1999, Conover 2001). In New Zealand, leg-hold traps have been a major control technique for the exotic brushtail possum (*Trichosurus vulpecula*) (Warburton *et al.* 2004).

Research into the development of more humane traps to replace conventional leg-hold traps has been ongoing for over a century (Drahos 1952). More recently, research has expanded as steel-jawed traps have received attention from animal welfare and anti-trapping lobby groups world-wide, over negative welfare outcomes caused by their use (Gentile 1987). The traps that have been most commonly used during the 20th century for wild dog control in Australia are toothed, steel-jawed leg-hold traps, as described by Newsome *et al.* (1983). These traps have a large jaw spread and are sprung by one or two leaf springs. They are commonly called Lane's traps[5] (Lane's two springs: Stockbrands Pty Ltd, Western Australia). A range of other devices such as the Oneida #14 traps (one spring: Woodstream Corporation, Pennsylvania), Victor #3 and #4 off-set traps (Woodstream Corporation, Pennsylvania), Montgomery #2 and #3 step-in traps (Montgomery Traps Incorporated, Pennsylvania) have also been used in Australia. A conservative estimate reveals 120 commercial variations of steel-jawed leg-hold devices that have toothed or smooth jaws and at least 15 manufacturers that are primarily based in North America. A list of the major steel jaw trap types and manufacturers is listed in Appendix 2.

'Laminated' traps have been designed or modified to increase the width of the trap jaws and the surface area of the jaw face to distribute and displace the energy of the spring as it holds the paw of the captured animal (Hubert *et al.* 1997). This is often achieved by welding an additional steel bar to the jaw face, which also provides a smooth surface area that reduces lacerations as the animal's paw moves between the jaws. Increasing the spring tension of the jaws when holding the paw is believed to reduce cutting or sawing movements (Houben *et al.* 1993, Phillips *et al.* 1996b). Lamination is primarily a modification of existing trap types that have acceptable capture success and are in wide distribution. The main impetus for these modifications has been the need for the fur industry in North America to meet new trap standards. Additional modifications to laminated trap devices include installing heavier springs, adding centre mounted anchor chains, swivels, shock absorbing coil springs and offseting the jaws (Hubert *et al.* 1997). The list of steel-jawed leg-hold traps in Appendix 2 denotes trap designs that can be obtained in laminated variations. In a survey of trap types used in Australia, a wide range of commercial 'laminated' traps (eg. Duke™, Jake™, Bridger™, Victor® etc) were reported to be used (Nocturnal Wildlife Research Pty Ltd, unpublished data).

A range of steel-jawed leg-hold traps have been modified on an *ad hoc* basis by placing padding on their jaws, although published specifications and performance assessments appear to be absent. Claims that leg-hold traps are 'padded' can be based upon a wide range of modifications to the trap with varying materials and benefit for reducing trauma. Lane's traps were modified by Harden (1985) and the jaws were padded with polythene piping and offset

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[5] The design is based on the traps originally exported from England to Australia by Henry Lane for the control of rabbits. In 1919 he moved production to Newcastle (NSW) to provide for the demand for subsistence trapping. A padded device for control of dogs is still sold under the 'Lane's' name by Stockbrands Pty Ltd, Western Australia.

by ensuring a narrow gap remained between the two jaws when the trap was closed. McIlroy *et al.* (1986) used Oneida No. 14 jump traps modified by filing away the interlocking spikes on the jaws, and binding the jaws with muslin cloth. Thompson (1992) used padded Lane's leg-hold traps following the methods described by Newsome *et al.* (1983) (Appendix 3). The Victor #3 Soft-Catch (Woodstream Corporation: Pennsylvania) was the first commercially manufactured padded leg-hold trap to be widely assessed for its ability to limit capture injuries in coyotes (Olsen *et al.* 1986, Linhart *et al.* 1988) and the device has appeared in a number of variations. These traps are made with offset jaws (when closed, a gap of 6–8 mm remains between the jaws) and have a rubberised pad on each jaw that is designed to cushion the impact of the closing jaws on the animal's limb. The padding also provides a surface that prevents the limb from sliding along or out of the jaws. The trigger force that activates the trap can be adjusted by a bolt on the pan swivels. The #3 trap is predominantly used for capturing wild dogs has a jaw spread of 15 cm, and the smaller #1½ trap for capturing feral cats and red foxes has a jaw spread of 13 cm. The fourth generation Victor Soft-Catch #3 trap has replaceable synthetic rubber jaws and a short 15cm long centre mounted swivel chain as a means to prevent limb damage. The # 3½ EZ Grip trap is a heavier device (Livestock Protection Company, Alpine, Texas) that has been used for the capture of wolves and coyotes. This and the former Victor Soft-Catch represents the only widespread commercially available padded traps that have data published concerning scientific field assessments. In a survey of trap types used in Australia, a wide range of commercial 'rubber-jawed' traps were reported to be used, including Duke™and Jake™ brands (Nocturnal Wildlife Research Pty Ltd, unpublished data).

2.2.2 Leg-hold snares

A range of leg-hold snares have been developed and used in North America for canid control. The most common include the Novak foot-snare (E.R. Steele Products: Ontario, Canada), Fremont foot-snare (Fremont Humane Traps: Beaumont, Atlanta, USA), Panda foot-snare (E.E. Lee: Green Mountain Inc.), the Belisle snare (Edouard Belisle: Sainte-Veronique, Quebec, Canada) and the WS-T snare (Wildlife Services Specialists: USA) (see Skinner *et al.* 1990 for diagrams). The Aldridge trap is a popular snare design for the capture of bears and because of its portability, is used in a range of habitats and applications (Johnson *et al.* 1980), yet a slow trigger mechanism may increase the number of toe captures and the device cannot be buried (Lemieux *et al.* 2006). The treadle-snare (Glenburn Motors: Yea, Victoria, Australia) is shaped like a small banjo, has two wire springs and a circular pan or treadle. A wire cable snare is placed around the pan and when triggered the snare is thrown up the animal's limb and tightened by the springs (Meek *et al.* 1995, Saunders *et al.* 1995, Fleming *et al.* 1998) (Appendix 3). The RL04 is a newer variety of snare developed for bear capture and uses a rubber padded snare that is placed in a PVC cylinder that reduces non-target capture, eliminates hind foot and toe captures and produces minimal tissue damage (Reagan *et al.* 2002, Lemieux *et al.* 2006). Most snares use unpadded wire or cable to hold the limb, but recent Kevlar based restraining devices have been used in the UK and have proven successful in the capture of European badgers (*Meles meles*) with little indication of injury (Kirkwood 2005).

2.2.3 Neck snares

Non-lethal neck snares can be free running so that the noose can relax when the animal stops pulling, or they may be spring operated. The United Kingdom (UK) is one of few European countries where neck snares are permitted, primarily for the capture of red foxes and rabbits for population control (Kirkwood 2005). The Collarum restraint (neck snare) (Green Mountain Inc.: Lander, Wyoming) uses a baited tab pull-arm that triggers a pair of coiled springs, a throw arm that propels a cable loop over the head and neck of coyotes and a stop system prevents the animal from being choked (Shivik *et al.* 2000, Shivik *et al.* 2002).

The Gregerson, Kelley and DWRC neck snares have a ratchet system that cause the snare to progressively tighten so that the animal is killed by strangulation; these have been widely used to kill coyotes in the United States (Phillips *et al.* 1996a). Other snare systems have been made from 0.16 cm diameter cable in a range of designs and are commonly used in predator runs beneath wire fences to kill coyotes by strangulation (Phillips 1996). A power snare that used a spring mechanism to tighten the noose and to strangle red foxes was tested as a possible lethal means of harvesting (Proulx *et al.* 1990). Commercially available power killing snares included the King (Western Creative Services Ltd: Winipeg, Canada), the Mosher (Mosher: Mayorthorpe, Canada) and Olecko (Olecko: Winipeg, Canada) (Proulx *et al.* 1990).

2.2.4 Cage (or box) traps

Cage (or box) traps have not been widely used to trap canids and are not regarded as efficient capture devices (Powell *et al.* 2003), and given their bulk, transport is difficult under field conditions (Way *et al.* 2002). Way *et al.* (2002) found that cage traps were expensive, not target-specific and they required a long period of pre-baiting (free-feeding) before they were successful in rural locations. Nonetheless, cage traps have been used with some success to trap urban red foxes in the UK (Baker *et al.* 1998, Baker *et al.* 2001) and Australia (Robinson *et al.* 2001) (Appendix 3), kit foxes (Zoellick *et al.* 1986) and urban coyotes (Shivik *et al.* 2005). Trapping injuries from cage traps are minor when compared to corresponding studies that used leg-hold/foot-hold traps, yet coyotes had the potential to injure themselves by biting and throwing themselves against the trap (Way *et al.* 2002). It is possible that the success of cage traps used for coyotes in urban areas is due to habituation and familiarity in negotiating human made obstacles which makes them more vulnerable than coyotes in rural areas which are difficult to capture in cage traps (Shivik *et al.* 2005). Some novel cage (box) traps have sought to immediately release hydrogen cyanide gas to rapidly kill captive animals, predominantly to assist in the recovery of ectoparasites (Nicholson *et al.* 1950), yet these are probably impractical and too hazardous for most pest animal control applications.

2.2.5 Kill traps

Kill traps have been assessed for the lethal harvesting of furbearer species in North America such as mink (*Mustela vison*) (Proulx *et al.* 1990, Proulx *et al.* 1991), fishers (*Martes pennanti*) (Proulx *et al.* 1993a; 1993b) and lynx (*Felis lynx*) (Proulx *et al.* 1995). The Sauvaggeau 2001-8 (Les Pièges du Quèbec: St Hyacinthe) is a trap with two killing bars powered by torsion springs (Proulx *et al.* 1994b). The Kania trap (E. Kania: Winlaw, British Columbia) is another lethal trap with a striking bar (Proulx *et al.* 1993). Other kill traps include the C120 Magnum and Conibear 120 that were developed to quickly render furbearers unconscious and promote a quick death. In trials of the C120 Magnum kill trap to harvest martens, a wide range of other species were taken, including weasels (*Mustela erminea*), mink, red squirrels (*Tamiasciurus hudsonicus*), flying squirrels (*Glaucomys sabrinas*), grey jays (*Perisoreus canadensis*), and whet owl (*Aegolius acadicus*) (Proulx *et al.* 1989). Given the lack of target specificity and the risk of such powerful devices to domestic cats and dogs, their testing has not been pursued for canid control (Proulx *et al.* 1990, Skinner *et al.* 1990).

2.3 Worldwide regulation of leg-hold traps

The leg-hold trap was banned in the UK in 1958 under the provisions of the Pest Act (1954) and is now banned in some 80 countries (Fox 2004a, in Iossa *et al.* 2007)[6]. A range of leg-hold traps including all long-spring and unpadded double-coil spring traps larger than #1, with the exception of those with the Soft-Catch modification (Warburton *et al.* 2004) will be prohibited in New Zealand by 2011 under legislation passed in 2007.

The Canadian General Standards Board (Anon 1996) and Agreement on International Humane Trapping Standards (Anon 1997) developed trapping standards that followed the establishment of the Federal Provincial Committee for Humane Trapping (Anon 1981). On the initiative of the Canadian Government in 1987, the International Organisation for Standardisation (ISO) (Princen 2004) produced documents (developed by the Technical Committee - ISOTC191) to assess the safety and capture efficacy of traps (ISO 1999a; 1999b) and standards for the efficacy of killing traps (ISO 1999b). No consensus emerged for determining an acceptable level of injury for restraining traps (Harrop 2000, Princen 2004, Iossa *et al.* 2007), largely because the trapping industry and animal welfare organisations were divergent when defining a *humane trap* and it was agreed that the ISO standards would produce testing methodology standards only (Harrop 2000). In 1991 regulations arising from the European Parliament (EEC 1771/94) banned the use of leg-hold traps in the European Community and foresaw a ban on 13 species used for fur products from countries that had not initiated bans on the use of leg-hold traps (Princen 2004). In 1993, Canada proposed that the scope of a Humane Animal Traps Project to be 'standardisation' and in 1996 the USA introduced voluntary 'Best Management Practice' (BMP) for traps (Princen 2004) under the aegis of the International Association of Fish and Wildlife Services (Anon 2003). Both leg-hold traps and snares have become illegal in certain states of the USA (Way *et al.* 2002) and by 1999 the European Council prohibited the use of leg-hold traps in 15 member countries (Andelt *et al.* 1999). Due to a dispute arising with the World Trade Organisation, delays in the implementation of bans led to the establishment of another working group, comprising the USA, Canada (and later Russia) to develop standards to facilitate fur trade (Harrop 2000) and resulted in statements about a range of traps in 1996 for the EC, Canada and Russia (Princen 2004). Although legally non-binding, the parties agreed to develop a set of BMP guidelines for trapping, developed by scientific studies in order to reduce pain and discomfort in target furbearers (Andelt *et al.* 1999).

2.4 Limitations of trapping as a control technique

Populations of wild dogs that have been subjected to recurrent trapping may become increasingly difficult to capture and trapping effectiveness may diminish over time. In northern California, after sustained trapping for many decades, the trapping effort to capture a single coyote was 10 times that required in southern Texas and this was believed to be the consequence of trap shyness (Sacks *et al.* 1999). It is difficult to measure the degree of trap shyness without an independent means to assess the number of animals that have avoided trap sets.

Large-scale lethal control of dingoes may not always reduce calf losses as livestock loss is not always obviously related to the abundance of dingoes on a property (Allen *et al.* 1998) and may be unrelated to the density of wild dogs in an area overall (Fleming *et al.* 2006). In Victoria, the primary method used to reduce wild dog attacks on livestock is trapping within 3-5 km external to private land boundaries with government land and on private properties.

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[6] The UK regulations, similar to those in Victoria, appear to make no distinction between 'leg-hold' and 'foot-hold' traps.

The effectiveness of this approach remains largely untested (Fleming *et al.* 2006) and departs from the strategy used in most other states where aerial baiting is the predominant control technique. Trapping is not generally considered to be a control technique that can be used cost-effectively and unilaterally to suppress populations or maintain low population abundance of canids (Fleming *et al.* 1998). It was recommended that buffer control zones for baiting in the semi-arid Pilbara district of Western Australia should be 15-20 km wide, although the results from the study by (McIlroy *et al.* 1986) and (Harden 1985) indicate that wild dogs living more than 12-20 km inside National Parks in south-eastern Australia are unlikely to move out onto adjacent private land. Newsome *et al.* (1983) suggest that a zone 3 km wide is probably adequate for SE Australia although trapping is primarily limited to areas within properties in other parts of Australia (Fleming *et al.* 1998, Fleming *et al.* 2006).

Allen *et al.* (1998) suggest that the disruption of stable dingo packs causes a reduction in the size of packs and the number of experienced hunters that kill larger, more difficult prey. By sharing the cost of chasing, attacking and killing prey, dingoes increase their hunting efficiency (Allen *et al.* 1998, Allen *et al.* 2001) and group size increases hunting efficiency by sharing the physiological costs of chasing and attacking prey. Dingoes are known to switch between prey species and may alter their social structure in doing so. For instance, in smaller packs or as solitary hunters, dingoes switch from group hunting to hunt smaller mammals (Corbett 1995). Areas subject to lethal control are typically re-invaded with low ranked members of packs with reduced hunting ability that are more likely to target livestock. In the USA, breeding coyotes were most likely to kill sheep, yet trapping efforts appeared to be least effective at targeting them compared to non-breeding animals that caused the least damage (Sacks *et al.* 1999). Diminished dingo populations may also permit the invasion or expansion of red fox, feral cat (*Felis catus*) and European rabbit (*Oryctolagus cuniculus*) populations (Glen *et al.* 2007), although the magnitude and importance of such impacts are as yet not fully established. However, it may become increasingly necessary to assess the short-term and localised gains of wild dog control in context with wider ecological impacts that may have more significance to agricultural industries.

3.0 DEFINING WELFARE OBECTIVES

3.1 What is 'good welfare' and can we recognise it?

If an animal is having difficulty coping with its environment its welfare can be regarded as being poor (Broom *et al.* 1993). The 'magnitude' of an animal's welfare is generally associated with the incidence, severity and duration of a negative state (Webster 1998) and the capacity of the species to suffer (Littin *et al.* 2005). Good animal welfare can be described in terms of physical health and positive emotions, such as pleasure and contentment, while poor welfare comes from ill-health, injury, disease and negative emotions such as frustration or fear, which may be described as 'suffering' (Dawkins 2006). When assessing the welfare needs of a species it is inappropriate for a label of a pest to automatically imply that poor welfare outcomes are justified (Marks 1999, Morris *et al.* 2003, Jordan 2005, Littin *et al.* 2005). The suffering of wildlife is a relevant concern to wildlife managers and the community (Schmidt *et al.* 1981), although the term *animal welfare* is frequently confused with a political movement and not as a discipline that attempts to reduce suffering in animals and investigate their welfare states (Schmidt *et al.* 1981). A range of authors outline the need to reduce suffering inflicted on animals by trapping (Payne 1980, Schmidt *et al.* 1981) and to ensure that wildlife management practices are not insensitive to animal welfare concerns (Schmidt *et al.* 1981, Decker *et al.* 1987, Andelt *et al.* 1999).

If animals have a conscious experience of negative states (Mendl *et al.* 2004) they have the capacity to perceive poor welfare states by awareness of feelings, sensations and thoughts (Block 1998). However, the existence of cognitive capabilities that humans identify with is not a reliable indicator of conscious experience in non-human animals (Dawkins 2001b) and it may be easy to overlook suffering that is not relevant to human experience. As humans commonly equate 'intelligence' with the capacity to suffer we are generally more concerned about poor welfare in species such as primates and cetaceans (Marino 2002). However, even when other species such as corvids (eg. ravens and crows etc) show high levels of complex cognition which demonstrate: reasoning, flexibility, imagination, prospection and use of tools (Emery *et al.* 2004) there is usually much less concern for their welfare.

The adaptive benefits of the potential to suffer has a probable evolutionary significance in promoting avoidance of dangerous environments and circumstances that may produce trauma (Dawkins 1998). 'Human-like' consciousness is not necessary for the experience of both the sensory and emotional components of pain (Jordan 2005). It is generally accepted that all classes of vertebrates (with the possible exception of fish) perceive pain (Bateson 1991). The relevance of various stressors and the behaviours that they elicit in non-human animals are not directly apparent to humans, nor can we directly perceive poor welfare states in non-human animals or have insight into their mental state or perception from direct observation alone (Rushen 1996). Even in human patients it is difficult to interpret the significance of behaviour associated with the perception of pain and other forms of suffering, especially if that patient cannot communicate (Hackman 1996). Pain perception and suffering in non-human animals may be influenced by different mental states (Nagal 1974, Harrison 1991, House 1991) that are related to divergent brain function (Bermond 1997). While there may be a range of complex behavioural differences between species in the display of 'pain behaviours', it is thought that many species perceive threshold and tolerance limits of pain in a similar way to humans (Cooper *et al.* 1986), though our ability to easily recognise this and other forms of suffering in non-human animals makes the assessment of welfare states challenging.

3.2 Humane vertebrate pest control

Humane vertebrate pest control requires the selection of feasible control programs and techniques that avoid or minimise pain, suffering and distress to target and non-target animals (RSPCA 2004) and is based upon a simple precept that an animal's welfare is good in the absence of suffering (Littin *et al.* 2004). Until comparatively recently, the humaneness of control techniques used for vertebrate pests has received little attention in Australia (Jones 2003, Marks 2003). Increasingly it is accepted that no technique used to kill or manage pest species should cause unnecessary suffering (Scott 1976, Payne 1980, Schmidt *et al.* 1981, Ross 1986, Fisher *et al.* 1996, Marks 1999, Jones 2003, Marks 2003, Littin *et al.* 2004, Littin *et al.* 2005). Ideally, pest control methods should be effective and easy to use, safe for humans, humane, target-specific, cost effective and environmentally friendly (Marks 1999). There are few examples of pest control methods that achieve this ideal and the selection of pest control agents often require that a compromise be made.

An ethical basis for pest control firstly requires that control is necessary and can be justified, and that the aims can realistically be achieved and measured (Putman 1995, Marks 1999, Jones 2003, Littin *et al.* 2004, Littin *et al.* 2005). In Victoria, wild dog trapping is undertaken to manage livestock predation and the welfare implications of stock predation are significant (Allen *et al.* 2001, Fleming *et al.* 2001, Allen *et al.* 2004), yet the most humane control techniques possible should be used to minimise suffering and balance the harms and benefits of such control (Putman 1995, Marks 1999, Marks *et al.* 2000, Morris *et al.* 2003, Littin *et al.* 2005). In other areas of animal use, clear guidelines promote a reduction in animal suffering. Regulation of animal experimentation demands that if the existence or nature of pain or distress experienced by an animal is unknown, or conclusive evidence does not exist to the contrary, an assumption must be made that pain and distress could be perceived (Anon 2007). Moreover, investigators should assume that procedures that could cause pain and distress in humans are likely to cause pain and distress in other animals (Stafleu 2000). In addition, actions should be governed by an assumption of the worst possible outcome, and the cause of the suffering experienced (eg. as one of or a combination of pain, illness or stress) should be given equal weight (Stafleu 2000).

3.3 What is a humane trap?

Very few restraining traps that are used for wildlife species have been tested against agreed standards for animal welfare (Powell 2005) and there remains widespread confusion about what constitutes a 'humane trap' and how it should be defined (Harrop 2000). Traps may be *more humane* than other devices or *acceptably humane*, yet a *humane* trap would be one that avoids subjecting an animal to appreciable stress and avoids compromising its welfare in a significant way. Given the significant stress associated with the capture or restraint of wild animals using any known technique, it is unlikely that the development of a truly humane trap will be realistic objective using contemporary technologies.

In North America, humane trap standards are subject to commercial considerations of harvesting fur and the need to conform to restrictions imposed by fur importing countries. Where traps are set for the purpose of wild dog control in Victoria, trapping is conducted to protect the welfare and viability of livestock. The purpose of a restraining trap (or snare) in this instance is to hold the animal unharmed with the minimum of stress until the trap is checked and the animal can be euthanased or released (Iossa *et al.* 2007). The overall welfare of the target and non-target species from the moment of capture until intervention due to euthanasia or debilitation or death after release from the trap is relevant to deciding the overall relative humaneness of traps. Proulx *et al.* (1994b) suggested that the definition of a humane live-trap for furbearers should be a trap that is capable with 95% confidence of holding ≥ 70% of animals for 24 hours without serious injury. In North America, benchmarks or thresholds proposed to certify traps as acceptably humane, typically define a proportion of animals (ie. 20-30%) where poor welfare outcomes are acceptable and the welfare of non-target animals is not considered (Harrop 2000, Princen 2004, Harris *et al.* 2007, Iossa *et al.* 2007). Accordingly, traps can be deemed acceptable irrespective of a potential to capture and injure a large proportion of non-target species. Australian guidelines for acceptable welfare outcomes and humane treatment of animals do not ascribe thresholds that accept poor welfare outcomes for a proportion of a specified population in experimentation, agriculture, wildlife or companion animal regulations (eg. Anon 2007).

In this review the trap that has the best relative humaneness will be one that minimises suffering and permits a balance of the harms associated with trapping against the benefits of effective trapping of wild dogs.

4.0 IDENTIFICATION OF TARGET AND NON-TARGET SPECIES

4.1 Defining target and non-target species

Animals that are captured unintentionally by traps are commonly referred to as 'non-target' species. A trap is considered to be more selective if it captures a higher proportion of 'target' species rather than wildlife species or domestic animals. Trap selectivity (TS) is a measure of the number of non-target animals captured relative to the number of target animals (Newsome *et al.* 1983) or the number of non-target animals captured relative to a set number of trap nights (Fleming *et al.* 1998) where a relatively higher value for TS indicates lower selectivity.

Reducing the number of non-target animals captured has two important benefits for a trapping programme. Firstly, if few traps are occupied by non-target species, there is a greater potential for the capture of target species and a reduction in unproductive maintenance of traps. Secondly, if trap selectivity can be increased, a reduction in the capture of non-target species implies a corresponding reduction in negative welfare impacts that have no beneficial outcome. These benefits are complementary and suggest that trap selectivity is a key component in fostering an efficient trapping programme with optimised welfare outcomes.

Incidental capture of exotic pest species (eg. feral cats, European rabbits, and hares) is sometimes reported to contribute to a tally of target captures (Stevens *et al.* 1987, Murphy *et al.* 1990, Fleming *et al.* 1998). Best practice management of vertebrate pests stipulates the importance of defining clear management objectives, options and strategies that focus upon the mitigation of the impact of particular pests upon stated values (Braysher *et al.* 1998, Fleming *et al.* 2001). Stating the target animals sought is an important part of defining the aims and objectives for a control programme. Unintentional capture of exotic or feral species not regarded to be primary targets should be identified as 'exotic' or 'feral' non-target species, although there may be instances where more than one target species is sought (eg. Meek *et al.* 1995). Liberal definition of target species as the sum of all pest or exotic species will overstate the specificity and effectiveness of a trap and will not assist in the selection of the most appropriate trapping device or technique for specific objective.

4.2 Common non-target species in south-eastern Australia

In a review of trapping records in six locations in eastern Australia, Fleming *et al.* (1998) listed a range of non-target species including echidnas (*Tachyglossus aculeatus*), goannas (*Varanus* spp), wombats (*Vombatus ursinus*), possums and sheep. Captured birds included ravens (*Corvus* spp.), magpies (*Gymnorhina tibicen*) and pied currawongs (*Strepera graculina*). Newsome *et al.* (1983) listed many of the above non-target species during the capture of dingoes in north-eastern NSW with the addition of feral pigs (*Sus scrofa*), red-necked wallabies (*Macropus rufogriseus*), cattle (*Bos taurus*), farm dogs (*Canis lupus familiaris*), emus (*Dromaius novaehollandiae*), wedge-tailed eagle (*Aquila audax*), hawks (family Accipitridae), wonga pigeons (*Leucosarcia melanoleuca*), tawny frogmouth (*Podargus strigoides*), superb lyrebird (*Menura novaehollandiae*), spotted quail-thrush (*Cinclasoma punctatum*), white-winged chough (*Corcorax melanorhamphos*) and blue tongued lizard (*Tiliqua* spp.). Corbett (1974) reported that between 1966 – 71, in 4796 trap nights (80% set without lures or baits), Victorian government trappers using steel-jawed (Lane's) traps recovered 13 dingoes and 261 non-target species. Mammalian species caught included the common ring-tail possum (*Pseudocheirus peregrinus*), the sugar glider (*Petaurus breviceps*), the greater glider (*Petauroides volans*), koala (*Phascolarctos cinereus*), long-nosed potoroo (*Potorous tridactylus*), deer (*Cervus* sp) and a marsupial carnivore (probably a spot-tailed quoll [*Dasyurus maculatus*]) although specific numbers of each species captured were not reported. In another study, nine dingoes were captured using padded Lane's traps, along with 11 mammals, 7 birds and one reptile (Harden 1985). Meek *et al.* (1995) captured a total of 54 animals with Victor Soft-Catch #3 traps and treadle-snares in coastal NSW. Non-target species caught in 'Victor' traps comprised Australian raven (*Corvus coronoides*), magpie, swamp wallaby (*Wallabia bicolor*), long-nose bandicoot (*Peremeles nasuta*) and brushtail possums. Non-target species caught in treadle-snares were Australian ravens, pied currawong and an eastern grey kangaroo (*Macropus giganteus*). Using treadle-snares in sub-alpine NSW, Bubella *et al.* (1998) captured Australian ravens, a feral cat (*Felis catus*) and common wombats. Sharp *et al.* (2005a; 2005b) list ravens, pied currawongs, magpies, kangaroos, wallabies, rabbits, hares, echidnas, goannas, wombats, possums, bandicoots, quolls and sheep as potential non-target species.

Non-target capture records have often used local names or generic descriptions for animals that do not permit identification to the species level. 'Wallabies' are likely to include both swamp and red-necked wallabies in south-eastern Australia, and possibly other smaller macropods. Similarly, 'bandicoot' are likely be either the southern brown bandicoot (*Isoodon obesulus*) or long-nosed bandicoot (Strahan 1984) in Victorian studies. Brushtail possums could be the common brushtail or mountain brushtail possum (Strahan 1984). There are three species of crows and three ravens in Australia and these are difficult to tell apart, although reports of crow and raven captures are likely to be little Australian ravens, given their wide distribution and abundance (Pizzey *et al.* 1997).

In trapping data accumulated during wild dog control programs from November 1986 to December 1987, a total of 1189 animals were captured with steel-jawed (Lane's) traps and treadle-snares in Victoria. Native animals accounted for 34% (n=397) with 7.4% (n=88) of all non-target species being common wombats (Murphy *et al.* 1990). When target species were defined as wild dogs only, 62% of trapped animals were non-target species. Overall, the diversity of non-target species captured reflected those reported in other trapping studies in south-eastern Australia (Table 1).

Newsome *et al.* (1983) found that large jawed Lane's traps had far less target specificity (TS [non-target:target] = 4.79) than smaller Oneida #14 traps (TS = 0.92). The reduction in brushtail possum, wallaby and common wombat captures for the Oneida trap was also a strong indication of different device specificity. Newsome *et al.* (1983) reported that 'Oneida' traps were unlikely to catch large-footed animals such as wallabies and emus. 'Oneida' traps did not catch kangaroos and wombats although some were sprung by these species. Trapping was conducted at the same site and during the same season, although it was possible that more care was taken in setting Oneida traps to avoid non-target species (Fleming *et al.* 1998). In other studies, estimates of TS range from 4.79 – 0.13, but this measure is biased given the use of various setting techniques conducted in different habitats and seasons and different degrees of trapping effort and correspondingly variable sample sizes of target and non-target species (Table 1).

The proportion of non-target:target species recovered in all studies indicates a ratio of (rounded to the nearest whole number) 96:100 for the red fox, 58:100 for common wombats, 49:100 for wallabies (swamp and red-necked combined), 26:100 for feral cats, 19:100 for brushtail and mountain possums combined, and 10:100 for eastern-grey kangaroos. Species that were represented < 10:100 wild dog captures, but ≥ 1:100 included the European rabbit (9:100), superb lyrebird (3:100), raven (2:100), goanna (2:100), emu (2:100) and echidna (1:100). A range of other species was represented in < 1:100 wild dog captures (Table 1).

Table 1. Capture records for exotic mammals and non-target mammals, birds and reptiles from studies (1-7) conducted in south-eastern Australia using Lane's (L), Oneida #14 (O), treadle-snares (T), Victor Soft-Catch #3 (V) traps or a combination of trap types (C), where wild dogs (D) or foxes (F) were the target species. The non-target species (NT) and target species (T) captured are expressed as a ratio: (NT:T) is the number of non-target mammals, birds and reptiles (non-target exotics included) captured for every 100 target species or their reported occurrence (Y). (1 = Newsome *et al.* 1983, 2 = Stevens and Brown 1987, 3 = Bubela *et al.* 1998, 4 = Meek *et al.* 1995, 5 = Murphy *et al.* 1990, 6 = Fleming *et al.* 1998, 7 = Corbett 1974).

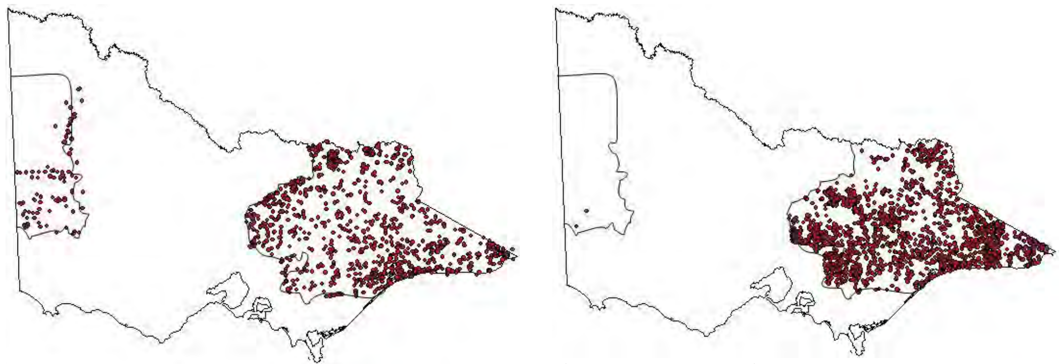
SPECIES		**TRAP TYPE**										
		L	O	T	L	T	V	T	L,T	C	L	NT:100T
	Authority	1	1	2	2	3	4	4	5	6	7	
	Target species sought	D	D	D	D	F	D/F	D/F	D	D	D	
EXOTIC AND FERAL MAMMALS												
Wild dog	*Canis lupus dingo*	95	51	17	22		11	7	920			-
Red fox	*Vulpes vulpes*	118	25	23	17	71	28	7	791	Y	Y	96.2
Feral cat	*Felis catus*	36	4	4	4	1			240	Y	Y	25.7
Feral pig	*Sus scrofa*	6	1									0.62
European rabbit	*Oryctolagus cuniculus*	21	1						77		Y	8.82
European hare	*Lepus europaeus*								1			0.1
NATIVE MAMMALS												
Echidna	*Tachyglossus aculeatus*	1	-						13	Y	Y	1.25
Bandicoot	*P. nasuta or I. obesulus*	3	-				1			Y	Y	0.36
Brushtail or mountain possum	*Trichosurus sp*	49	1	2	9		1		151	Y	Y	18.97
Common wombat	*Vombatus ursinus*	69		4	2	3			571		Y	57.79
Wallaby	*Wallabia bicolor or Macropus rufogriseus*	92	2	10	13		1		434		Y	49.15
Eastern grey kangaroo	*Macropus giganteus*	8						1	100		Y	9.71
Cattle	*Bos taurus*	1									Y	0.09
Farm dog	*Canis lupus familiaris*	1										0.09
Sheep	*Ovis aries*								6	Y	Y	0.53
Koala	*Phascolarctos cinereus*									Y	Y	
Quoll	*Dasyurus maculatus*								1		Y	0.09
NON-TARGET BIRDS												
Emu	*Dromaius novaehollandiae*	9							14		Y	2.05
Whistling kite	*Haliastur sphenurus*	0	1									0.09
Wedge-tailed eagle	*Aquila audax*	1	1						1		Y	0.27
Hawk	*Accipitridae*	0	3						1		Y	0.36
Wonga pigeon	*Leucosarcia melanoleuca*	7							3		Y	0.89
Tawny frogmouth	*Podargus strigoides*	1										0.09
Superb lyrebird	*Menura novaehollandiae*	16		1					21		Y	3.38
Spotted quail-thrush	*Cinclostoma punctatum*	1										0.09
White-winged chough	*Corcorax melanorhamphus*	4										0.36
Australian magpie	*Gymnorhina tibicen*	1							5	Y		0.53
Pied currawongs	*Strepera graculina*						1	1	1	Y		0.27
Raven	*Corvus sp.*	7	6			5	4	2	2	Y		2.32
NATIVE REPTILES												
Goanna	*Varanus varius*	2	2						19	Y	Y	2.05
Blue-tongue lizard	*Tiliqua sp*	1										0.09
NT:T RATIO		4.79	0.92	2.59	2.05	0.13	0.21	0.29	2.67			

Table 2. Major non-target (Status as 'E' = exotic or 'N' = native) and record of presence in either the eastern (E) or western (W) trap exemption zone (Zone) with body weight (kg) and subjective frequency of occurrence (*** = very common, ** = common, * = uncommon [see methods for explanation]) in combined trapping records (NT_f), comparative activity substrates (AS) (T = terrestrial, SC = scansorial, A = arboreal), activity rhythms (AR) (N = nocturnal, C = crepuscular, D = diurnal) and feeding category (FC) (C = carnivorous, I = insectivore, O = omnivore, BH = browsing herbivore, GH = grazing herbivore) and if a meat diet has been confirmed (Y/N) (Strahan 1984, Lee *et al.* 1985).

Common name	**Species**	**Status**	**Zone**	**Weight**			**Activity**		**Diet**		**Authority**
				kg	NT_f	**C**	**AS**	**AR**	**FC**	**Meat?**	
Bobuck	*Trichosurus cainus*	N	E	1.5-3.7	***	N	A	N	BH	Y	Menkhorst *et al.* 2004
Brushtail possum	*Trichosurus vulpecula*	N	E/W	1.5-4.0	***	N	A/T	N	BH	Y?	How 1988, Marks 2001a
Common wombat	*Vombatus ursinus*	N	E/W	20-35	***	M	T	N	GH	N	Menkhorst *et al.* 2004
Eastern grey kangaroo	*Macropus giganteus*	N	E/W	< 66	***	N	T	N/CR	GH	N	Menkhorst *et al.* 2004
Echidna	*Tachyglossus aculeatus*	N	E/W	2-7	*	N	T	D	I	N	Menkhorst *et al.* 2004
Emu	*Dromaius novaehollandiae*	N	E/W	30-45	*	N	T	D	O	Y	Schodde *et al.* 1990
European rabbit	*Oryctolagus cuniculus*	E	E/W	1-2.4	***	E	T	N/CR	GH	N	Menkhorst *et al.* 2004
Feral cat	*Felis cattus*	E	E/W	2.5-6.5	***	E	T	N	C	Y	Menkhorst *et al.* 2004
Goanna	*Varanus varius*	N	E/W	< 20	*	N	T/SC	D	C/O	Y	Cogger 2000
Little Australian raven	*Corvus coronoides*	N	E/W	0.5-0.82	*	N	T	D	O	Y	Schodde *et al.* 1990
Long-nosed bandicoot	*Perameles nasuta*	N	E	0.85-1.1	*	N	T	N	IO	Y	Lyne 1971, McIlroy 1981, Fairbridge *et al.* 2001
Red fox[1]	*Vulpes vulpes*	E	E/W	3.5-8.0	***	E	T	N	C/O	Y	Menkhorst *et al.* 2004
Southern brown bandicoot	*Isoodon obesulus*	N	E/W?	0.4-1.0	*	N	T	N	IO	Y	Fairbridge 2000, Fairbridge *et al.* 2001, Menkhorst *et al.* 2004
Spot-tailed quoll	*Dasyurus maculatus*	N	E	< 7.0	*	N	T/ SC	N	C/, IO	Y	McIlroy 1981, Belcher 1998, Menkhorst *et al.* 2004
Superb lyrebird	*Menura novaehollandiae*	N	E	< 1.5	*	N	T	D	I	N	Schodde *et al.* 1990
Swamp and/or red-necked wallaby	*Wallabia bicolour* *M. rufogriseus*	N	E./W	< 27	***	N	T	N	BH	Y	Edwards *et al.* 1975, Menkhorst *et al.* 2004

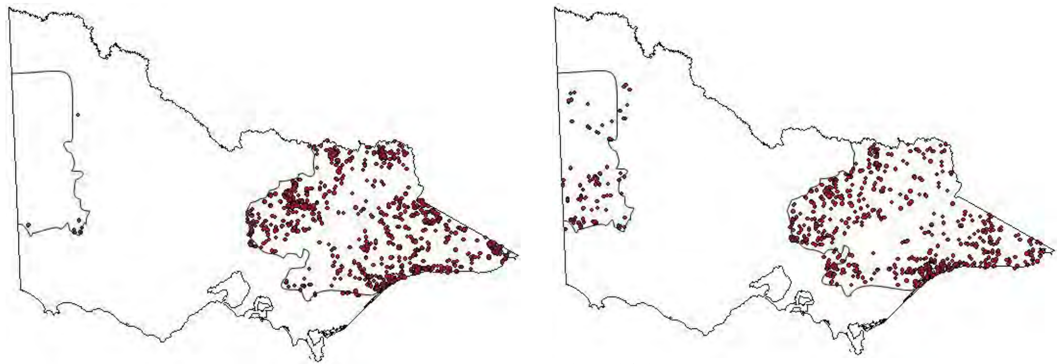
[1] Identification of bobuck and brushtail possums are likely to be easily confused

[2] Considered exotic non-target species in some wild dog control programmes



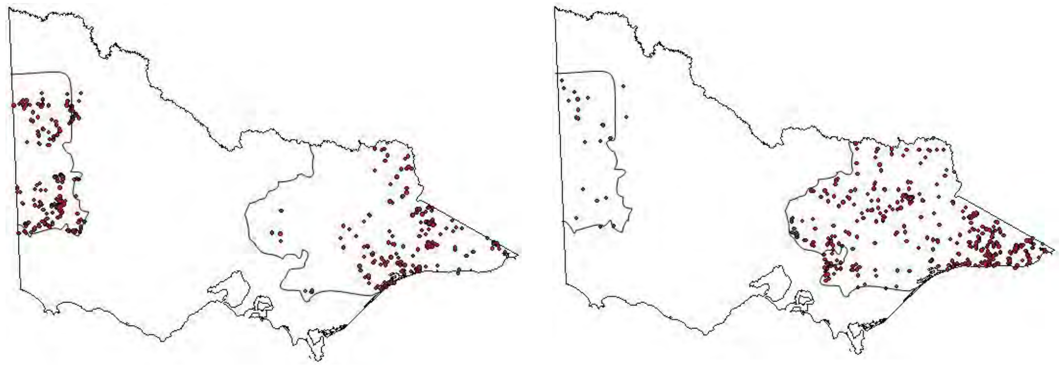
(a) brushtail possum

(b) common wombat



(c) eastern grey kangaroo

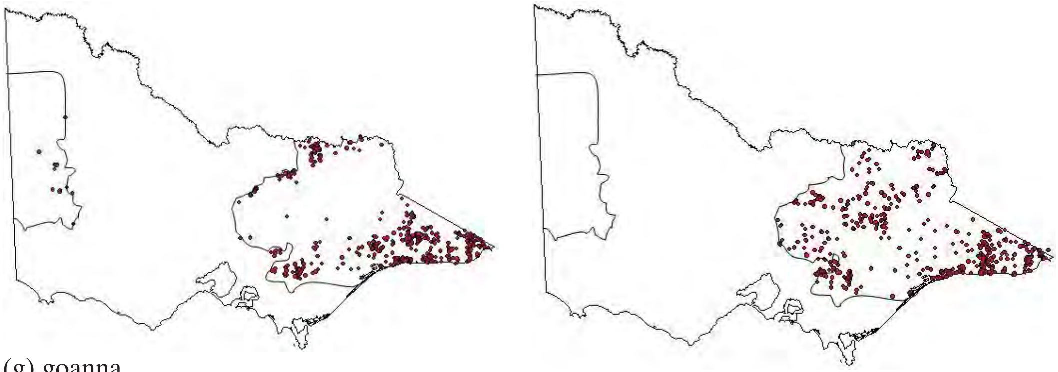
(d) echidna



(e) emu

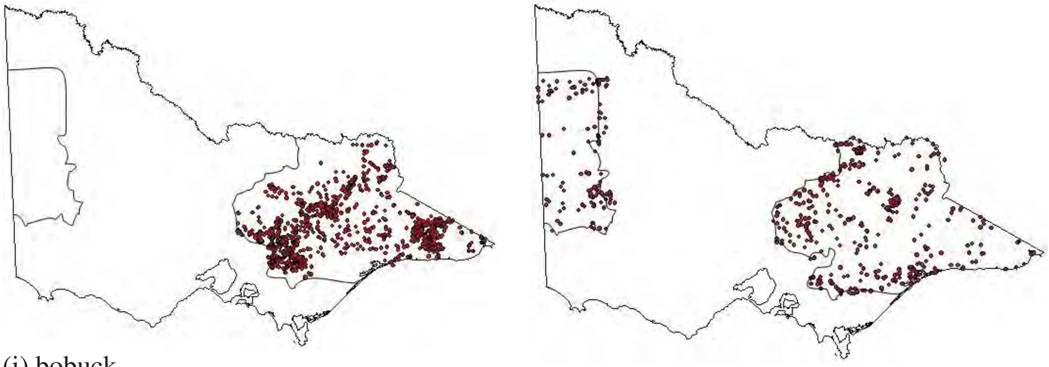
(f) feral cat

Figure 2. Distribution of major non-target species within the east and west trapping exemption zones in Victoria: (a) brushtail possum, (b) common wombat, (c) eastern grey kangaroo, (d) echidna, (e) emu, (f) feral cat, (g) goanna, (h) long-nosed bandicoot, (i) bobuck, (j) little Australian raven, (k) red fox, (l) swamp wallaby, (m) red-necked wallaby, (n) southern brown bandicoot, (o) spot-tailed quoll, (p) superb lyrebird and (q) European rabbit.



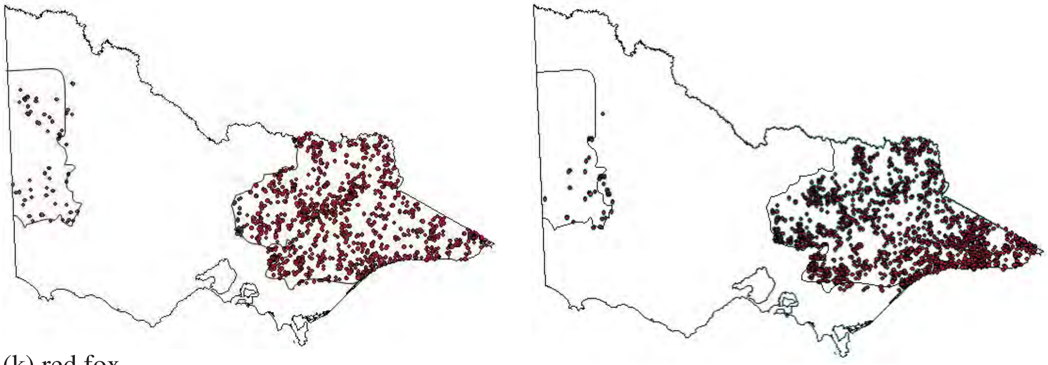
(g) goanna

(h) long-nosed bandicoot



(i) bobuck

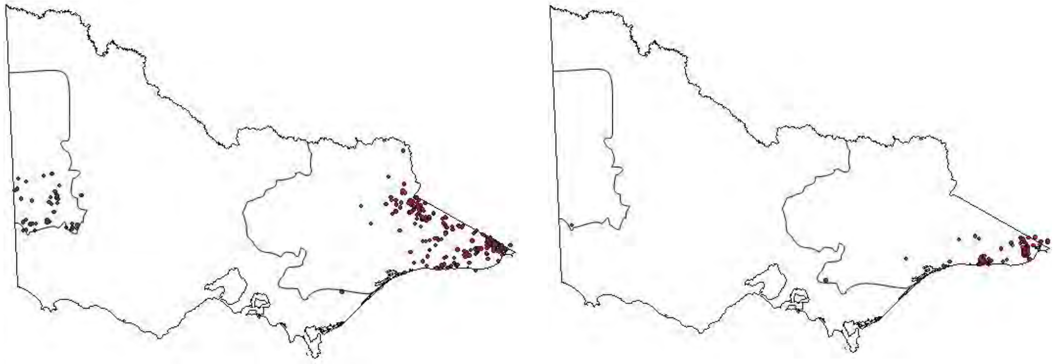
(j) little Australian raven



(k) red fox

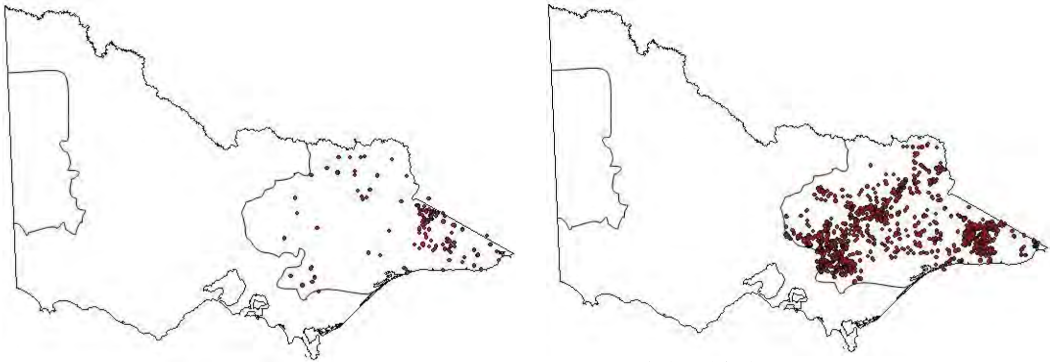
(l) swamp wallaby

Figure 2. (cont.) Distribution of major non-target species within the east and west trapping exemption zones in Victoria: (a) brushtail possum, (b) common wombat, (c) eastern grey kangaroo, (d) echidna, (e) emu, (f) feral cat, (g) goanna, (h) long-nosed bandicoot, (i) bobuck, (j) little Australian raven, (k) red fox, (l) swamp wallaby, (m) red-necked wallaby, (n) southern brown bandicoot, (o) spot-tailed quoll, (p) superb lyrebird and (q) European rabbit.



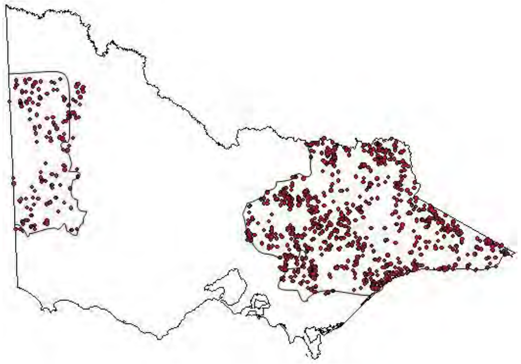
(m) red necked wallaby

(n) southern brown bandicoot



(o) spot-tailed quoll

(p) superb lyrebird



(q) European rabbit

Figure 2. (cont.) Distribution of major non-target species within the east and west trapping exemption zones in Victoria: (a) brushtail possum, (b) common wombat, (c) eastern grey kangaroo, (d) echidna, (e) emu, (f) feral cat, (g) goanna, (h) long-nosed bandicoot, (i) bobuck, (j) little Australian raven, (k) red fox, (l) swamp wallaby, (m) red-necked wallaby, (n) southern brown bandicoot, (o) spot-tailed quoll, (p) superb lyrebird and (q) European rabbit.

4.3 Discussion and conclusions

The wide range of non-target species reported for studies using leg-hold traps and snares in south-eastern Australia supports previous conclusions that trapping with leg-hold devices is not highly target-specific (Sharp *et al.* 2005a; 2005b). A wide range of native species can be considered as non-target species, with common wombats, wallabies (considered as both swamp and red-necked wallabies), brushtail (and bobuck) possums and eastern grey kangaroos appearing as very common non-target species in south-eastern Australia. Common exotic non-target species include the red fox, feral cat and European rabbit.

The capture of non-target species is highly dependent upon the geographical distribution of animals and their population abundance in particular environments (Shivik *et al.* 2002) and is subject to seasonal and long-term fluctuations. The habitats in which traps are used and the foraging behaviour of animals that bring them into contact with traps influences non-target captures. The manner in which the trap is set, its location (Powell *et al.* 2003), selectivity of the device used (eg. pan tension settings: see Turkowski *et al.* [1984]), trap size: see Newsome (1983) and the proportion of animals that are restrained by the trap without escape (Shivik *et al.* 2002) will determine the measured TS of the device.

Species with reduced distribution or low abundance could theoretically be highly susceptible to some traps, yet may not be well represented in capture records. A table of major non-target species was prepared with the emphasis upon species that were represented in more than 1:100 wild dog captures (Table 2). Although uncommonly represented in non-target capture records, bandicoots and spot-tailed quolls were included as potential non-targets as they are restricted or patchy in distribution and/or exist in low to moderate density in some locations (Figure 2). This could suggest the potential to be a more frequent non-target species in specific locations.

Corvids (eg. crows and ravens) are cosmopolitan and appear to be commonly represented in many trapping studies worldwide. American crows (*Corvus brachyrhynchus*), common ravens (*Corvus corax*), grey jays (*Perisoreus canadensis*) and blue jays (*Cyanocitta cristate*) were frequently captured in a range of leg-hold traps in Canada, while hawks, eagles and owls were captured less often and ducks (Anatidae) were captured rarely (Stocek *et al.* 1985). Notably, deer appear to be common non-target species in the United States (Pruss *et al.* 2002), yet although extensive exotic populations exists in Victoria (Strahan 1984), there was no enumeration of deer captures, other than an unspecified report by Corbett (1974).

There is a substantial overlap of the known distribution of the putative non-target species within the Victorian trap exemption zones where leg-hold traps and snares are used for wild dog control. In the western zone, some of the species most common to the highlands of eastern Victoria are absent (eg. superb lyrebird, spot-tailed quoll, long-nosed bandicoot and bobuck) or their distribution suggests much sparser or patchy populations overall (eg. common wombat, eastern-grey kangaroo, goanna) (Figures 2a – 2q), that may indicate a reduced potential for non-target captures. However, as distribution maps do not indicate population density, this conclusion would warrant further analysis.

5.0 IDENTIFYING INDICATORS OF TRAPPING STRESS

5.1 Stress and stressors

Stress is a response to a stressor and a means to adapt to it by reducing or eliminating its effects (Webster 1998). A state of stress occurs when an animal encounters adverse physiological or emotional conditions that cause a disturbance to its normal physiological or mental equilibrium by a stressor (Manser 1992). The general adaptation syndrome (Tolosa *et al.* 2007) suggests that there are three generalised responses to a stressor; *alarm* is an initial response, followed by *adaptation* to the stressor that reduce or eliminate its effects, while *exhaustion* may result if the capacity of the animal to adapt is exceeded (Seryle 1950).

Trapping activates predictable physiological responses as a reaction to a range of stressors during capture (Moberg 1985, Kreeger *et al.* 1990). Ongoing stressors may have a negative impact upon the welfare of animals (Jordan 2005) and attempts to understand their impact can be made by measuring the magnitude of the biological response, pre-pathological state and consequent pathology (Moberg 1985, Carstens *et al.* 2000). A stressor does not lead to suffering if the animal can act without difficulty to reduce its impact, but when stressors are prolonged, too severe or multiple stressors exist, suffering can be the consequence (Webster 1998). Pathological changes and disease may result if the stressor or a combination of several stressors require the diversion of resources from other biological activities that are critical to an animal's well being (Moberg 1985, Carstens *et al.* 2000). Where normal function is disrupted the potential for distress, suffering and a decline in welfare is possible (Moberg 1985, Carstens *et al.* 2000).

In order to make objective decisions and predictions concerning welfare states associated with trapping, the quantification of different types of stress arising from a range of stressors needs to be undertaken. Welfare science has a low level of precision when attempting to objectively measure stress, especially in a range of species, hence an assessment of an animal's welfare often requires the use of several different approaches (Webster 1998, Dawkins 2001a). Similarly, in attempting to describe pain experienced by animals, a range of physiological as well as behavioural indicators may be needed (Rutherford 2002). The presence or absence of behavioural, autonomic or endocrine stress responses can be used as indicators of welfare states in animals. Broom (1988) lists a range of indicators used in an attempt to objectively describe an animal's welfare; these are further summarised in four general categories:

Behavioural indicators: include indicators of pleasure and the extent to which strongly preferred behaviours can be shown. A variety of normal behaviours may be shown or suppressed or behavioral indicators of aversion (eg. avoidance) may be demonstrated;

Physiological indicators: include those that can indicate normal and abnormal physiological processes, coping mechanisms and anatomical development;

Pathological: changes such as trauma, changes in brain function, disease, immunosuppression and behavioural pathology;

Survival, growth and development: can be an indicator of welfare if it is possible to contrast normal versus reduced or abnormal life expectancy, growth or breeding.

5.2 Behavioural indicators

A wide range of common behaviours are used by animals in the expression of pain, including: escape reactions, vocalisation, aggression, withdrawing, recoiling, biting and chewing (Gregory 2005). A fearful and/or anxious domestic dogs may tuck its tail down, pin its ears against its head and display piloerection, lip licking and yawning (Neilson 2002). Vocalisation in dogs can occur due to play, excitement, communication, threat, attention seeking, defence, pain, anxiety or fear (Landsberg *et al.* 2003). Body posture tends to be lower with fear, anxiety or submission and common behaviours such as snout licking, body shaking, paw lifting and the amount of time that the tongue protruded were linked with increased heart rate and cortisol production in response to a stressor (Beerda *et al.* 1997). Certain aggressive behaviours in domestic dogs have been associated with the response to some painful stimuli (Borchelt 1983) and fear alone can release aggressive behaviours (Galac *et al.* 1997, King *et al.* 2003). In domestic dogs, the suddenness and intensity of a novel stimulus governs how effectively it will produce fear, as will a range of genetic and environmental factors (King *et al.* 2003). Studies of captive silver foxes showed that ear posture, activity and approach to the front of the cage could be used as indicators of welfare states, although they were not reliable in all cases (Moe *et al.* 2006). The absence of two behavioural indicators of poor welfare in trapped target species (self-mutilation and unresponsiveness) were used to indicate if a trap was acceptable (Harrop 2000).

An animal's general appearance or 'nocifensive' behaviour is one of the few ways available to interpret its perception of pain (Carstens *et al.* 2000). However, it is influenced by species-specific differences in response (Valverde 2005) and applies to behaviours in response to potential tissue injury (Mersky *et al.* 1994). Behavioural and endocrine indicators of pain in livestock have been applied to the development of standard pain assessment in agriculture (Mellor *et al.* 2000, Molony *et al.* 2002). Pain-specific behaviours include bucking in lambs in response to wound palpation after castration, escape behaviour of calves in hot-iron de-horning and increases in high frequency calls in piglets undergoing castration (Weary *et al.* 2006). Acute pain escape behaviours may be modified when pain persists and guarding behaviours may be observed where an animal protects or engages in a range of strategies to protect the sensitive area (Zimmerman 1986). There are few studies of behavioural indicators of distress in marsupial fauna. Tammar wallabies (*Macropus eugenii*) learned to be fearful and flee a model fox and then transferred this aversion to a model cat in a set of behaviours typical of predator avoidance (Griffin *et al.* 2002). However, there is no comprehensive and systematic study of the behaviours of endemic wildlife species that may be used to assess their stress response to traps.

Rather than interpretation of particular behaviours and their relevance to stress, testing the strength of an animal's motivation by measuring the sacrifice it is prepared to make to accommodate them may be an alternative approach (Dawkins 1980, Broom *et al.* 1993, Dawkins 1993), allowing a more objective assessment of an animal's choice (Dawkins 2001a). Aversive learning studies may assist in understanding what stressors have caused suffering that animals wish to avoid in the future (Rushen 1996).

Post-operative pain in domestic dogs has been investigated using subjective measures such as visual analogue and numerical scale ratings, pain threshold tests (Conzemius *et al.* 1997), response to palpation of wounds (Pascoe *et al.* 1993) and other behavioural indicators such as variations in greeting behaviours to owners (Hardy *et al.* 1997). The accuracy of assessments of pain by scoring is limited by their subjectivity, lack of contemporary controls (ie. a comparative group that experiences 'no pain') and lack of positive controls (ie. a comparative group where animals are subjected to a 'known amount' of pain). In experiments, behavioural changes caused by some analgesics independent of pain relief are possible, as are interactions of behaviours arising from fear and apprehension associated with pain (Flecknell *et al.* 2004). This suggests that it may not be possible to use analgesia in experimental groups to manipulate and identify behavious that are caused by pain alone.

Some behaviours or measures can be used as correlates of animal suffering or distress that are based upon indicators such as the intensity or response to stressors. Marks *et al.* (2004) used activity data loggers that measured the relative duration and activity of dingoes after capture to test the effectiveness of a drug to alleviate resistance to the trap and injury. While the degree of activity cannot be used as a direct measure of distress, the degree of resistance and escape behaviour in traps is believed to correlate with the type and extent of trauma sustained (Balser 1965) and trauma is commonly scored and used to determine the welfare impact of various traps (Tullar 1984, Van Ballenberghe 1984, Olsen *et al.* 1988, Onderka *et al.* 1990, Hubert *et al.* 1996, Phillips *et al.* 1996b, Iossa *et al.* 2007) (see chapter 5.4). Measuring simple indicators of activity of animals in traps may be a practical way to measure relative improvement in welfare even though it cannot be used to account for the specific nature of this improvement.

5.3 Physiological indicators

Animals subjected to a stressor will release a cascade of hormones as an adaptive, short-term response to a stressor (Baxter *et al.* 1987). There are two main physiological stress pathways that lead to the activation of the hypothalamic-pituitary-adrenal (HPA) axis and/or the sympathetic nervous system (SNS). Corticotrophin releasing hormone stimulates the secretion of adrenocorticotrophin hormone (ACTH) from the anterior pituitary and this influences the release of glucocorticoids from the adrenal cortex that play a major role in the conversion of protein and lipids to usable carbohydrates and the breakdown of body fats. This prepares an organism to deal with a perturbation and mobilises energy stores to meet short term requirements (Korte *et al.* 2005). The SNS can be activated by the HPA and in general prepares an animal for ‘fight or flight’ and in doing so it causes mobilisation of glycogen and free fatty acids, increased heart rate, vasoconstriction in body regions not directly involved in fight or flight and has effects on gut motility (Gregory 2005). If the animal is unable to escape from the stressor it may adopt a mode of ‘conservation-withdrawal’ with consequent increases in pituitary-adrenocortical activity (Moberg 1985). Endogenous opioids may initially be released in response to some painful noxious stimuli with resulting stress-induced analgesia. However, more prolonged stress produces hyperalgesia which contributes to aversive and guarding behaviours (Vidal *et al.* 1982, Kinga *et al.* 2007). Any stressor may elicit an increase in circulating steroids, but in contrast to early predictions, not all stressors produce an HPA response (Mason 1968).

The measurement of cortisol has been the most commonly used indicator of stress in most mammals and non-invasive sampling methods such as salivary sampling can be used to reduce restraint artefacts (Kirschbaum *et al.* 1989). Restraint and venipuncture can be a significant stressor and may be a confounding factor in the measurement of stress response (Beerda *et al.* 1996, Hennessy *et al.* 1998). Values of cortisol were measured in dogs subjected to stressful situations such as loud noises (20.4 nmol/L), falling bags (18.7 nmol/L) and electric shock (15.5 nmol/L). Peak cortisol concentrations were reached shortly after the acute stimuli (between 16 to 20 minutes) and declined thereafter usually within an hour (Beerda *et al.* 1998). However, cortisol concentrations may not always be a good indicator of how a dog perceives prolonged exposure to a stressor, or a continuous series of stressors. Animals that are regularly subjected to stressors or have stressful lives may have enlarged adrenal glands and secrete greater amounts of cortisol (Baxter *et al.* 1987). Moreover, there are a range of species-specific, individual, environmental, seasonal and circadian influences on cortisol concentrations identified in canids (De Villiers *et al.* 1995). Comparative interpretation of cortisol concentrations as an absolute and additive measure of stress must be undertaken cautiously and in context. Nonetheless, cortisol has been used in a wide range of species to

Table 3. Studies that used cortisol (CORT) and adrenocorticotrophic hormone (ACTH) to study stress in species responding to various stressors where the concentration were indicated as higher (H) relative to established normals, control or placebo populations.

SPECIES		STRESSOR	CORT	ACTH	AUTHORITY
African wild dog	*Lycaon pictus*	Handling	H		De Villiers *et al.* 1995
Blue fox	*Alopex lagopus*	Handling	H	H	Osadchuk *et al.* 2001
Domestic dog	*Canis familiaris*	Transport	H		Bergeron *et al.* 2002
Domestic dog	*Canis familiaris*	Transport	H		Frank *et al.* 2006
Domestic dog	*Canis familiaris*	Acoustic	H		Gue *et al.* 1989
Domestic dog	*Canis lupus*	Transport	H		Kuhn *et al.* 1991
European rabbit	*Oryctolagus cuniculus*	Predator odour	H		Monclus *et al.* 2006
Green monkeys	*Cercopithecus aethiops*	Capture	H		Suleman *et al.* 2000
Grizzly bear	*Ursus arctos*	Capture	H		Cattet *et al.* 2003
House sparrow	*Passer domesticus*	Capture and handling	H		Romero *et al.* 2002
Koala	*Phascolarctos cinereus*	Capture	E		Hajduk *et al.* 1992
Laboratory rat	*Rattus norvegicus*	Predator odour	H		Thomas *et al.* 2006
Lapland longspur	*Calcarius lapponicus*	Capture and handling	H		Romero *et al.* 2002
Red fox	*Vulpes vulpes*	Trapping	H	H	Kreeger *et al.* 1990
Silver fox	*Vulpes vulpes*	Handling	H		Moe *et al.* 1997
Silver fox	*Vulpes vulpes*	Blood sampling	H		Moe *et al.* 1997
Vicuna	*Vicugna vicugna*	Restraint	H		Bonacic *et al.* 2006
White crowned sparrow	*Zonotrichia leucophrys*	Capture and handling	H		Romero *et al.* 2002

investigate stressors such as restraint, capture, transport, handling and the response to sound and predator odours (Table 3). It is important to recognise that trapping may present an array of different stressors of varying intensity throughout the duration of captivity and this places a practical limitation on how and when cortisol concentrations can be used to measure welfare outcomes (Chapter 6.1).

There are a range of objective measurements considered to be associated with brain function during stress that have been proposed to assess welfare states. Changes in the hormone oxytocin and concentrations of neurotransmitters such as dopamine may be associated with the perception of pleasure. Event-related evoked potentials (ERPs) and the frequency spectrum of electroencephalographs (EEGs) have been found to be useful in assessing the perception of pain in humans (Bromm 1985, Chen *et al.* 1989) and in livestock (Barnett *et al.* 1996, Ong *et al.* 1996, Morris *et al.* 1997). These procedures are difficult to use in free-ranging and wild species as they cannot be used remotely and typically require surgical procedures. Increases in plasma oxytocin are associated with decreases in ACTH and glucocorticoids and proliferation of lymphocytes (Broom *et al.* 2004). The exposure of animals to psychological stressors or hostile environments initiates the secretion of a range of hormones that include cortisol, oxytocin, prolactin, catecholamines and renin (Van de Kar *et al.* 1999) and other factors such as nitric oxide (NO) modulate the immune system in response to stress (Lopez-Figueroa *et al.* 1998).

Measures of animal emotional responses are currently limited to a relatively simple range of physiological and behavioural responses where indicators such as stress hormones, elevation in heart rate or behaviours are attributable to fear or anxiety. These measures do not address the significance of the conscious experience, where the conscious awareness of sensations and emotions may be central to the capacity to suffer (Mendl *et al.* 2004). Heart rate has been used as an easily measured psychophysiological indicator of stress in dogs, yet increased heart rate may be associated with both positive and negative emotional states, and while it may be correlated with behaviours (Palestrini *et al.* 2005) it is difficult to use it as welfare indicator in isolation from other information to assist the interpretation of the emotional state.

In some species excitement and strenuous exercise can cause contraction of the spleen and expulsion of erythrocytes into circulation (Wintrobe 1976) that may alter normal erythrocyte numbers, haemoglobin concentrations, packed cell volume (PCV) and mean corpuscular volume (MCV) (Hajduk *et al.* 1992). Polymorphonuclear leucocytes include neutrophils which are the most abundant of the leucocytes. Neutrophils have the ability to migrate to the site of infection and inflammation and have a potent antimicrobial effect, but they have also been implicated in tissue damage (Schraufstatter *et al.* 1984, Ellard *et al.* 2001). Short-term mental stressors have been shown to cause a significant increase in neutrophil activation (Schraufstatter *et al.* 1984, Ellard *et al.* 2001) and this is confirmed in response to trapping stress in foxes (Kreeger *et al.* 1990). Neutrophil counts were significantly increased while lymphocytes decreased in dogs subsequent to air transport (Bergeron *et al.* 2002) and in coyotes following capture and restraint (Gates *et al.* 1976). Clomipramine, a tricyclic antidepressant, is used to treat anxiety disorders and aggression (Mills *et al.* 2002) and was supported as a treatment to mitigate transport stress in dogs as it reduced cortisol responses and neutrophil to lymphocyte (N:L) ratios compared to a placebo group (Frank *et al.* 2006). Neutrophil numbers increased and corresponded to an increase in the N:L ratio in koalas after capture (Hajduk *et al.* 1992). In vicuňa (*Vicugna vicugna*), animals that were restrained in enclosures showed a significant increase in N:L ratio (Bonacic *et al.* 2006). Similar changes in the N:L ratio have been found in pigs dosed with cortisol (Widowski *et al.* 1989). The injection of corticosteroids or adrenocorticotrophic hormones caused an increase in neutrophils and a decrease in lymphocytes within 2 – 4 hours in dogs (Jasper *et al.* 1965) and hence N:L ratios may be well associated with cortisol stress response, yet may show a delayed and flattened response. In macropods, haematological characteristics did not appear to be obvious markers of any of a range of clinical stressors including capture myopathy (Clark 2006). Variations in N:L ratios and haematological responses between species or animal groups may be unpredictable. Leukocyte counts are subject to diurnal variation, with neutrophils typically peaking in dogs during the day, corresponding to a decline in lymphocytes, which tend to peak during the mid evening (Lilliehöök 1997, Bergeron *et al.* 2002) and this is likely to be an important consideration if responses to less intense stressors are to be compared. In a range of studies that have sought haematological correlates with a range of stressors, N:L ratios appear to relate to capture, transport, trapping, housing and restraint stress, but appear to be less applicable to stressors that produce physical trauma (Table 4).

A range of biochemical indicators has been used to investigate a variety of stressors in different species (Table 5). Alsatian dogs that were subjected to exercise in hot temperatures showed an increase in glutamic oxalacetic transaminase (GOT), lactic dehydrogenase (LDH), phosphohexose isomerase (PHI), acid phosphatase (ACP), alkaline phosphatase (ALP), aldolase (ALD) and lipase (LIP) (Bedrak 1965). Alkaline phosphatase is found in most tissues and in high levels in bone and gut. Exercise and elevated corticosteroids can elevate ALP in dogs (Dorner *et al.* 1974). Conceivably, stress-induced increases in cortisols in trapped foxes could have caused the elevations of ALP (Kreeger *et al.* 1990). Restraint stress in mice has been shown to increase levels of LDH, creatine kinase (CK, formerly CPK), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) (Sanchez *et al.* 2002).

Creatine kinase concentrations are used for diagnosing skeletal muscle damage in animals and exertional myopathy which is a disease of the skeletal muscles and myocardium (Aktas *et al.* 1993). In rats the concentration of serum CK correlated strongly with the volume of muscle traumatised by crushing injury and LDH, AST and ALT concentrations increase in response to some crushing injuries (Akimau *et al.* 2005). Forced or mechanical restraint will cause an elevation of CK values in human patients (Goode *et al.* 1977). There are three isoenzymes that predominate in the skeletal muscle (MM) and myocardium (MM and MB), and intestine and

Table 4. Major haematological values measured in various species in response to stressors and their concentration as higher (H) or lower (L) relative to established normals, control or placebo groups (N:L = neutrophil to lymphocyte ratio, WCC = white cell count, RBC = red blood cell count, Hb = haemoglobin, PCV = packed cell volume, GRA = granulocytes, LYM = lymphocytes, EOS = eosinophils, NEU = neutrophils)

SPECIES		**STRESSOR**	**N:L**	**WCC**	**RBC**	**Hb**	**PCV**	**GRA**	**LYM**	**EOS**	**NEU**	**AUTHORITY**
Domestic dog	*Canis familiaris*	Transport	H						L		H	Bergeron *et al.* 2002
Domestic dog	*Canis familiaris*	Transport	H								H	Frank *et al.* 2003
Domestic dog	*Canis familiaris*	Transport		H	H	H						Kuhn *et al.* 1991
Eurasian otter	*Lutra lutra*	Capture		H	L	L					H	Fernandez-Moran *et al.* 2004
Flying fox	*Pteropus hypomelanus*	Restraint			L	L						Heard *et al.* 1998
Grizzly bear	*Ursus arctos*	Capture		H					L	L	H	Cattet *et al.* 2003
Human	*Homo sapian*	Mental stress	H								H	Ellard *et al.* 2001
Kit fox	*Vulpes macrotis mutica*	Capture	H						L			McCue *et al.* 1987
Koala	*Phascolarctos cinereus*	Capture	H	H	H	H	H		L		H	Hajduk *et al.* 1992
Laboratory dogs	*Canis familiaris*	Housing		H				H			H	Spangenburg *et al.* 2006
Red fox	*Vulpes vulpes*	Trapping	H	H							H	Kreeger *et al.* 1990
River otter	*Lontra canadensis*	Capture		H								Kimber *et al.* 2005
Silver fox	*Vulpes vulpes*	Handling		L				L	L			Moe *et al.* 1997
Silver fox	*Vulpes vulpes*	Blood sampling							L	L		Moe *et al.* 1997
Vicuna	*Vicugna vicugna*	Restraint	H								H	Bonacic *et al.* 2006

Table 5. Major blood biochemistry values measured in various species in response to stressors and their concentration as higher (H) or lower (L) relative to established normals, control or placebo populations (BR = bilirubin, UR = urea, Na = sodium, Gl = glucose, Ca = calcium, Glob. = globulin, Cr = creatinine, K = potassium, LDH = lactate dehydrogenase, CK = creatine kinase, AST = aspartate aminotransferase, ALT = alanine aminotransferase, ALP = alkaline phosphatase, Chl. = cholesterol).

SPECIES		**STRESSOR**	**BR**	**UR**	**Na**	**Gl**	**Ca**	**Glob**	**Cr**	**K**	**LDH**	**CK**	**AST**	**ALT**	**ALP**	**Chl**	**AUTHORITY**
American elk	*Cervus elaphus*	Capture	H							H	H	H	H				Millspaugh *et al.* 2000
Black bear	*Ursus americanus*	Capture				H					H	H	H	H	H		Powell 2005
Dog	*Canis familiaris*	Housing												H		L	Spangenburg *et al.* 2006
Eurasian otter	*Lutra lutra*	Capture		H							H		H	H	H		Fernandez-Moran *et al.* 2004
Flying fox	*Pteropus hypomelanus*	Restraint				H	L	L		H						L	Heard *et al.* 1998
Grizzly bear	*Ursus arctos*	Capture			H	H	L		L	L		H	H	H			Cattet *et al.* 2003
Human	*Homo sapian*	Restraint										H					Goode *et al.* 1977
Human	*Homo sapian*	Tourniquet										H					Rupiński 1989
Mice	*Mus musculus*	Restraint									H	H	H	H			Sanchez *et al.* 2002
Pig	*Sus scofa*	Limb gunshot										H					Münster *et al.* 2001
Rat	*Ratus*	Crush injury									H	H	H	H			Akimau *et al.* 2005
Red fox	*Vulpes vulpes*	Trapping	H									H	H	H			Kreeger *et al.* 1990
River otter	*Lutra canadensis*	Translocation										H	H				Hartup *et al.* 1999
River otter	*Lontra canadensis*	Capture					L					H	H	H	H		Kimber *et al.* 2005
Roe deer	*Capreolus capreolus*	Capture and transport		H					H	H		H					Montane *et al.* 2002
Silver fox	*Vulpes vulpes*	Handling				H											Moe *et al.* 1997
Silver fox	*Vulpes vulpes*	Blood sampling				H											Moe *et al.* 1997
Vicuna	*Vicugna vicugna*	Restraint										H	H				Bonacic *et al.* 2006
Vicuna	*Vicugna vicugna*	Capture										H					Bonacic *et al.* 2006

brain (BB) of dogs (reviewed in Aktas *et al.* 1993). Elevated CK-MM sub-fraction is typically associated with muscle trauma (rhabdomyolysis) through shock, surgery or disease affecting the skeletal muscles (Prudhomme *et al.* 1999). Experimental lower limb gunshot trauma in pigs also caused significant elevation of CK values (Münster *et al.* 2001). Shivering may induce elevation in creatine kinase (Wladis *et al.* 2002). Tourniquet ischemia of the arm produced with a pneumatic cuff for between 30 minutes to 80 minutes caused elevations in LDH, CK and total protein which could be detected when the cuff was applied for more than one hour and this response was detectable for three days after its removal (Rupiński 1989).

The use of CK is a specific marker for diagnosis of muscle disease (0.83 specificity) (Aktas *et al.* 1993), however its reliability is influenced by snake venom toxicosis, myocardial disease associated with parvovirus, dirofilariasis, haemolysis and venipuncture that penetrates muscle tissue and some therapeutic agents (reviewed in Aktas *et al.* 1993). In flying foxes (*Pteropus hypomelanus*) short-term restraint was associated with changes in haematology and blood biochemistry which were significantly reduced by anaesthesia with isoflurane (an anaesthetic) (Heard *et al.* 1998). The progressive evaluation of recently captured river otters (*Lontra canadensis*) showed that CK and AST/ALT were not good indicators of musculoskeletal injury owing to probable interactions with existing pathology due to infection, parasitism and other factors independent of capture injury (Kimber *et al.* 2005). Similarly, elevation of ALT in dogs has been shown to be associated with skeletal muscle degradation and not liver damage (Valentine *et al.* 1990). Some stressors may not be detected in some species or breeds given variation in response, genotypic difference or different context. For instance, in Alaskan sled dogs after long distance races there is little indication of increases in serum CK values as an indication of skeletal muscle damage after days of strenuous racing (Hinchcliff 1996), yet elevation of CK is associated with physical exertion in other domestic dogs (Aktas *et al.* 1993).

Overall, the most commonly used biochemical indicators of stress associated with capture, handling, injury and transport are CK, AST, ALT and ALP and changes in the values of these indicators have been successfully used to reveal stress responses in a wide range of animals (Table 5).

5.4 Visible pathological indicators

One criterion for the assessment of the humaneness of leg-hold traps has used the incidence and extent of physical injury as the primary indicator of trap welfare outcomes. In most studies the assumption is that the extent of trauma is inversely proportional to the relative humaneness of the device. Trauma scales have been used to assess injury produced by various traps and snares (Tullar 1984, Van Ballenberghe 1984, Olsen *et al.* 1988, Onderka *et al.* 1990, Hubert *et al.* 1996, Phillips *et al.* 1996a) and are reviewed by Iossa *et al.* (2007). Many studies have used damage scores based upon the extent of the visible trauma inflicted upon the captured limb only (eg. Olsen *et al.* 1986, Houben *et al.* 1993, Fleming 1998, Stevens and Brown 1987). Whole body necropsies attempt to fully account for the entire range of injuries, such as puncture wounds caused by vegetation (Hubert *et al.* 1997) that occur during trapping. Some authors have ignored mouth injuries (eg. chipped and broken teeth, lacerations and abrasions of the gums and lips), yet these are common injuries in carnivores caused by traps (Onderka *et al.* 1990). Bite wounding (Marks *et al.* 2004), predation and death of animals held in a trap have not always been regarded as relevant to the welfare outcomes and performance of particular devices (eg. Fleming *et al.* 1998). Many of the earlier scoring systems did not account for injury and debilitation associated with pathology such as capture myopathy (Tullar 1984, Van Ballenberghe 1984, Olsen *et al.* 1988, Onderka *et al.* 1990) and given the various manifestations and progression of this disease (Chapter 6.2.3), it is likely that gross observations would be inadequate to diagnose this condition.

Since the development of injury scoring, there has been an increase in the number of injury classes used in various studies (Onderka *et al.* 1990, Phillips *et al.* 1996a, Hubert *et al.* 1997) and altered weighting and scoring methods make comparisons between many studies difficult (Engeman 1997, Shivik *et al.* 2000, Iossa *et al.* 2007). Van Ballenberghe (1984) developed five classes of injury scores to assess trap injury (Table 6).

Table 6. Trap injury classification system developed by Van Ballenberghe (1984).

Injury class	Description
I	Slight foot/leg oedema, no lacerations or broken bones.
II	Moderate oedema, lacerations less than 2.5 cm long, no broken bones and joints.
III	Lacerations at least 2.5 cm long, visible tissue damage, no tendon damage, one metacarpal or phalanx bone broken.
IV	Combinations of deep, wide lacerations, severed tendons, broken metacarpals, broken radius or ulna bones and joint dislocations.

Stevens and Brown (1986) developed a rating system that was based upon that by Van Ballenberghe (1984) in order to investigate the humaneness of steel-jawed traps and treadle-snares to captive target and non-target vertebrates in Victoria. These authors modified some of the classification and added an additional one to assist in discerning between slight injuries and total absence of injury (Table 7).

Table 7. Trap injury classification system used by Stevens and Brown (1987) based upon that developed by (Van Ballenberghe 1984).

Injury class	Description
I	No visible trap-related injuries.
II	Foot swollen.
III	Skin broken.
IV	Bones disjointed or broken.
V	Foot amputated.
VI	Dead.

Using the criteria of Stevens and Brown (1987), Murphy *et al.* (1990) constructed two broad classifications of "major injury" which included ratings 4, 5 and 6 and "minor injury" for any of ratings 1, 2 and 3. It was assumed that animals with minor injuries would not be permanently debilitated upon release. Meek *et al.* (1995) and Fleming *et al.* (1998) used a scoring system following that of Van Ballenberghe (1984) in an Australia-wide analysis of trauma caused by a range of traps (Table 8).

Table 8. Injury classes attributed to target and non-target animals (after Van Ballenberghe 1984) with inclusion of Class V (Fleming *et al.* 1998).

Injury class	Description
I	No visible trap-related injuries or only slight foot and /or leg oedema with no lacerations and no evidence of broken bones or dislocated joints.
II	Moderate oedema with skin lacerations 2.5 cm or less, bones and joints as in Class I.
III	Skin lacerations greater than 2.5 cm long with visible damage to the underlying tissue, tendons intact, bone breakage limited to one phalanx or metacarpal / tarsal.
IV	Various combinations of deep and wide lacerations, severed tendons, broken metacarpal/tarsal, radius, tibia, fibula and ulna bones, joint dislocation of the legs, and/or amputation.
V	Dead in trap from hyperthermia/hypothermia, excessive blood loss, shock or capture myopathy.

The first widely used scoring systems for trapping trauma (Table 9) sought to weigh individual injuries in terms of their potential to cause incapacitation and impact upon the welfare of animals (Onderka *et al.* 1990). These systems were additive and allowed quantification and comparison of mean or median injury scoring developed for different devices. Given that they accommodated a wide range of specific injuries the resolution of this approach was greater and allowed researchers a greater ability to detect differences in injury outcomes from a range of devices.

Table 9. Trauma scoring system adopted by Onderka *et al.* (1990).

Score	**Injury**
0	Apparently normal.
1-5	Edematous swelling and/or hemorrhage.
1-5	Cutaneous laceration <2 cm long.
10	Cutaneous laceration >2 cm long.
10-20	Subcutaneous muscle laceration or maceration.
20-40	Tendon or ligament maceration with partial severance.
30	Partial fracture of metacarpi or metatarsi.
30-40	Fracture of digits.
30-40	Amputation of digits.
50	Joint luxation of digits.
50	Simple fracture below carpus or tarsus.
50	Severance of tendons below carpus or tarsus.
75	Compound fracture below carpus or tarsus.
100	Simple fracture above carpus or tarsus.
200	Compound fracture above carpus or tarsus.
200-300	Luxated elbow or hock joint.
400	Amputation of limb.

Table 10. Trauma scoring system (summarised) adopted by the International Organisation for Standardisation (ISO) and subject to threshold assessments (Harrop 2000).

Score	**Injury**
2	Claw loss.
5	Minor cutaneous laceration.
10	Major cutaneous laceration.
25	Severance of minor tendon or ligament.
25	Amputation of one digit.
30	Permanent tooth fracture exposing pulp cavity.
30	Simple rib fracture.
30	Eye lacerations.
50	Compression fracture.
50	Amputation of two digits.
100	Amputation of three or more digits.
100	Spinal chord injury.
100	Compound rib fractures.
100	Ocular injury resulting in blindness in an eye.
100	Death.

The ISO committee restricted definition of welfare impacts associated with trapping to purely pathological observations (Harrop 2000). Their trauma scores permitted an agreed level of trauma to be associated with an ‘unacceptable’ trap that would allow major debilitative injury in a majority of cases (Table 10). It was established that the acceptability of a trap would be contingent upon a 90% confidence that it would exceed a lower threshold score on 50% of occasions and an upper score for 20% of occasions (Harrop 2000).

Poor welfare outcomes arising from trapping have been defined by the existence of pathological signs that increase in their severity from the lowest to highest score (Anon 1997, Shivik *et al.* 2005) and this approach was useful in relating trauma that would be considered to be an unacceptable welfare outcome:

1. Fractures and/or joint luxation proximal to the carpus or tarsus;
2. Severance of a tendon or ligament;
3. Major periosteal abrasion;
4. Severe external haemorrhage into an internal cavity;
5. Major skeletal muscle degeneration;
6. Limb ischemia;
7. Fracture of a permanent tooth exposing the pulp cavity;
8. Ocular damage including corneal laceration;
9. Spinal cord injury;
10. Severe internal organ damage;
11. Myocardial degeneration
12. Amputation;
13. Death.

5.5 Survival, growth and development

Trapping studies usually assume that the probability of capture for all individuals in a population is equal. Trap related injuries and debilitation can reduce the chances of recovery from subsequent trapping (Earle *et al.* 2003). This permits trap-release-recapture studies to provide some insight into the relative impact of traps upon a population. Studies that use radio-collars to monitor the long-term fate of animals subsequent to capture and release are probably the most informative in allowing the fate of animals to be known. After trapping a population of Rüppels fox (*Vulpes rueppellii*) using padded leg-hold traps, the majority of individuals were given low injury scores but survival was reduced possibly due to higher levels of predation upon foxes as trapping could have caused limping or debilitation in other ways (Seddon *et al.* 1999, in Iossa *et al.* 2007). There is an absence of studies that record the survival, growth and development of animals after capture as a primary aim of the study. Such controlled studies are difficult to conduct, as good experimental design would ideally require a population of animals that have not been trapped to be similarly monitored.

5.6 Discussion and conclusions

The value of behavioural indicators of stress is probably limited in the comparative assessment of leg-hold traps. As behaviours can be variable and not specifically related to stress, they can be readily misinterpreted (Beerda *et al.* 2000). Wild animals may hide symptoms of pain and distress that might otherwise make them vulnerable to predators and they may display different signs and symptoms of pain (Jordan 2005). Moreover, the utility of human experience and direct observation to infer the suffering of animals is limited, as we often do not have the same perceptual abilities; eg. the absence of a vomeronasal organ; inability to detect infrared radiation, magnetic fields, specific pheromones and some sound frequency ranges (Gregory 2005).

Studies of the aversiveness of different trapping devices require ‘choices’ to be made between different traps. Trapping activities are not undertaken in a manner where a wild animal can be easily observed or be given multiple exposures to traps, and animals are usually unaware of the trap prior to capture. Further, it is likely that all trapping stressors are intense regardless of the device used. Discerning discrete differences in behaviour or preference could be difficult to interpret and may provide very limited information about welfare states. While the long-term control of coyote populations was found to reduce trapping success and may have suggested individual aversion (Sacks *et al.* 1999), problematically this may have been the consequence of selected neophobia at a population level, rather than individual preference based on prior experience. Repeated cage trapping did not affect the recapture rate of red foxes (Baker *et al.* 2001), yet other studies using endocrine, pathological, biochemical and haematological indicators suggest similar traps produce significant stress in foxes (White *et al.* 1991). It is possible that cage trapping did not produce recognisable aversive behaviour for a range of reasons, such as prior negative states not being intense enough to promote learning, rapid extinction of the memory of prior captures, and/or failure to differentiate the cage trap from other features in the environment upon recurrent capture. It is difficult to support an assumption that a lack of demonstrated learned aversive behaviour (perhaps from one or few experiences) equates to an overall lack of aversiveness and absence of trapping stress. Moreover, behavioural indicators of trapping stress may not provide sufficient sensitivity to discern between subtle differences in welfare outcomes from different trap devices.

Trauma scales and scores are limited in their ability to assess the overall welfare impact of trapping. The nature of suffering associated with injuries; long-term impacts of injury upon survival, resulting changes in fecundity and impacts upon dependent animals cannot be known (Iossa *et al.* 2007). Variation and lack of compatibility in various trauma scales and their application even within one species makes comparison of studies difficult (Engeman 1997). One key deficiency is that the amount of time that an animal spends in captivity is rarely known even with moderate accuracy. Monitoring trapping practices in the field must contend with a wide range of experimental variables such as heterogeneous habitat and age structure of the population; differences in light, temperature and precipitation; trapping protocols and variations in the performance of each trapping device. Under such conditions, subtle changes in welfare states may be difficult to detect. Trap injury categories and scoring systems may be capable of discerning differences in large magnitudes of gross physical injury associated with a range of traps, especially if they are tested contemporaneously, yet severe injury is an endpoint of poor welfare. Improvements in trapping practices that may incrementally improve a range of welfare outcomes may be difficult to demonstrate given the problems in controlling experiments, the high degree of experimental variance in such field assessments, and the fact that trauma is only one component of trapping stress that is relevant to assessing welfare impacts.

An ISO Technical Working Group rejected the adoption of hormone and blood analysis as indicators of welfare, although this was an approach favoured by European scientists (Harrop 2000). Monitoring the neuroendocrine systems is difficult to do without introducing stressors associated with blood sampling and restraint normally associated with such investigations, which may confound experimental results (Carstens *et al.* 2000). However, other physiological indicators such as N:L ratio, ALP, AST, ALT and CK appear to be useful indicators of stress that have been consistently associated with known stressors and pathology in a wide range of species. Creatine kinase appears to be one of the most useful indicators of trapping stress, given its potential sensitivity to skeletal muscle trauma, exertion and myopathy, which are key poor welfare outcomes. Stress leukograms may be useful if used appropriately in experiments to assess stress, and N:L ratios in particular have been used to assess a wide range of stressors (Marks, in review, Appendix 1). Unlike collection and measurement of cortisol, these indicators are comparatively slow to respond and are less likely to be affected by blood sampling and handling stress, although N:L ratios and ALP levels are probably correlated with the release of cortisol. A significant drawback is that not all species will respond to stress indicators in a uniform way and the most appropriate use of haematological and blood biochemistry indicators will depend upon an understanding of these species differences. Using data logger systems that reveal the capture period and relative activity of animals in conjunction with physiological indicators such as CK, AST, ALP, ALT and N:L ratios and detailed whole-body necropsies is likely to yield the most useful, practical and unequivocal insight into the relative welfare impacts of traps. Many of the haematological and biochemical indicators are standardised, cost-effective and widely available laboratory tests that, if properly applied, could provide sufficient information to monitor relative welfare states and promote adaptive management of trapping practices towards better welfare outcomes.

6.0 STRESSORS AND PATHOLOGY ASSOCIATED WITH LEG-HOLD TRAPPING

The stressors produced by trapping and the resulting stress and pathology that may arise is directly related to the potential negative welfare outcomes associated with trapping and snaring. Improving the welfare outcomes of trapping will require the removal or reduction in the intensity of various stressors. As species respond to various stressors in different ways, the contribution of each stressor towards the welfare state of each species should be considered independently. A model of an animal's response to stressors suggests that exposure to stressors can overwhelm an animal's defence of its normal biological functions and result in prepathological or pathological states (Figure 3).

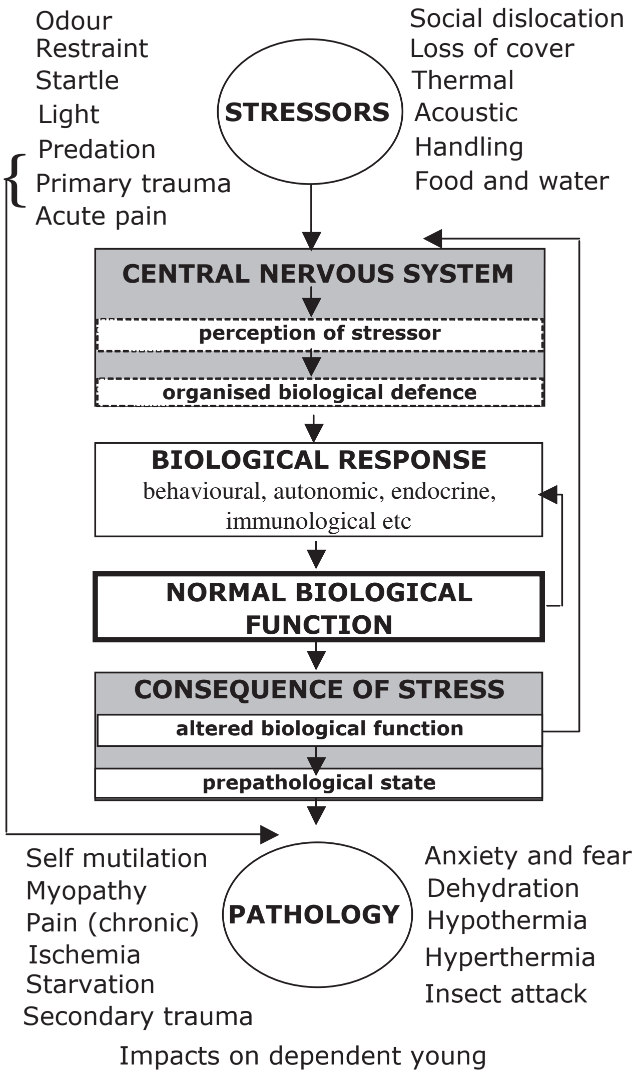


Figure 3. Model of the response of trapped animals to stressors and stress associated with leg-hold traps (Modified from Moberg 1999 and Carstens and Moberg 2000).

6.1 Trapping stressors

6.1.1 Startle

Startle response (often referred to as *fright*) occurs when an animal encounters a perceived danger without being prepared for it (Gregory 2005). Exposure of an animal to novelty is one of the most potent conditions that can lead to a negative emotional response (Dantzer *et al.* 1983, King *et al.* 2003) and the fearfulness that it produces will be influenced by the physical characteristics of its presentation, including its proximity, intensity, duration and how suddenly it appears (Russel 1979). Perception of sudden movement is believed to a potent stressor in provoking fear in domestic dogs, but its extent depends upon the nature of the stimulus (King *et al.* 2003). Leg-hold traps and most snares are hidden, and activation of some traps occurs within 18.52 -18.59 ms (Johnston *et al.* 1986) and correspond to velocities of between 5.38 - 6.83 m s^{-1} with an impact forces of 182.3 - 281 N in Victor Soft-Catch traps (Earle *et al.* 2003). The suddenness and forcefulness of the initial activation and restraint by a leg-hold trap is highly likely to be a potent cause of startle response.

6.1.2 Primary trauma and acute pain

Primary trauma caused by trapping occurs immediately upon capture or quickly thereafter. Trauma is defined as tissue injury that usually occurs suddenly as a result of a violent action that is responsible for the initiation of the HPA, metabolic and immunological responses (Muir 2006). Such events will usually generate pain, stress and fear. Collectively, these reactions normally benefit animals by enabling them to avoid situations that cause trauma and will prevent further injury and compensate to restore homeostatic function (Foex 1999). Pain is usually defined as an unpleasant subjective physical and emotional sensation (Bateson 1991). The International Association for the Study of Pain defines pain as “an unpleasant sensory and emotional experience associated with potential or actual tissue damage” (Mersky 1994). Pain has a unique status in that it is probably best thought of as a stressor as well as a form of stress associated with trauma in a feedback mechanism. Pain may exacerbate struggling and other behaviours that result in further trauma and pain.

Acute pain associated with trapping may be associated with primary trauma due to capture. ‘Nociceptors’ are nerve fibres specialised in the reception and transmission of noxious stimuli that elicit the release of neurotransmitters. They are located in the skin, viscera, muscles, fascia, vessels and joint capsules and respond to mechanical, thermal or chemical stimuli (Covington 2000). Pain signalling has been described as operating in several modes: *control state* (normal); *suppressed*; *sensitised*; or *reorganised* (pathologic) (Woolf 1994). Accordingly, pain is not a simple ‘hard-wired’ response that is experienced predictably and uniformly over time or between individuals. The perception of pain is modulated and attenuated by a wide range of physiological mechanisms that can enhance or reduce the experience of pain (Covington 2000).

A putative list of tissues that differ in their sensitivity to pain arranged from most to least sensitive include: cornea, dental pulp, testicles, nerves, spinal marrow, skin, serous membranes, periosteum and blood vessels, viscera, joints, bones and encephalic tissue (Baumans *et al.* 1994, Martini *et al.* 2000, Rutherford 2002). Pain from broken bones arises from distortion and pressure on receptors serving the intramedullary nerve fibres; stretching of the receptors in the periosteum, receptors in the muscle and soft tissue around the bone. The pressure resulting from haematoma triggers further pain from the soft tissues and bradykinin, histamine, potassium and peptide neurotransmitters accumulate and sensitise nociceptors and initiate tenderness (Gregory 2005). Some forms of environmental and physiological stress can modulate pain perception and are often referred to as "stress-induced analgesia" (Amit *et al.* 1986) and this is well documented in cases of severe trauma in humans who may not report pain for minutes to hours subsequent to injury, and is common with injuries such as fractures (5 min), cuts (13 min) and lacerations (21 min) (Melzack *et al.* 1982). However, the relevance or extent to which stress-induced-analgesia has a role in the mitigation of pain associated with trapping injury is so poorly known that it could not be relied upon to de-emphasise the likelihood that pain is a consistent outcome of trauma caused by leg-hold traps in all vertebrates.

6.1.3 Restraint and handling

Where species are unable to control or escape from a stressor or trauma, they may show enhanced emotional stress and responses (Seligman 1972). Restraint is one of the most common stressors experienced by animals and is a problem associated with a wide range of agricultural practices where animals are handled (Gregory 2005). Large flight distances and extreme wariness of humans is a common characteristic of wild mammals that have not been tamed or domesticated (Price 1984), and handling to euthanase or release animals from a trap can be a major stressor. Trap escapes have been recorded when traps that have held red foxes for many hours are approached by trappers, and this may suggest that greater struggling is produced by this stressor (C.A. Marks, personal observations). It is possible that the additional motivation that intensified escape behaviour is associated with a fear of humans that might produce significantly greater motivation than the combined stressors encountered prior to human contact. Selective breeding of confidence traits produces a reduction in stress associated with human contact in foxes and other species (Kenttämines *et al.* 2002, Trut *et al.* 2004). This implies that in the absence of domestication to reduce stress associated with innate avoidance of humans (Price 1984), approach and handling of wild species by humans can be expected to be more stressful than for domestic animals.

6.1.4 Behavioural, social and spatial dislocation

'Behavioural needs' are activities that an animal is compelled to perform such that its welfare is diminished when it is deterred from doing so (Friend 1999). Behavioural deprivation is often referred to in terms of the denial of behavioural needs (Morgan *et al.* 2007). The spatial requirements of an animal are normally determined by a range of factors such as the need to seek food and water, social interactions, shelter and other resources, and the home range used may vary due to season, status or other requirements in the pursuit of these needs (Price 1984). Captivity prevents the pursuit of normal behavioural needs, social interactions with con-specifics and patterns of established range and use of resources.

6.1.5 Loss of cover

Shelter and hiding is a common defensive behaviour for concealment and protection (Blanchard *et al.* 2001) and as a means of escape from predators and aggressive social partners (Price 1984). Trapping and restraint of animals reduces the ability of animals to retreat to cover in response to the stress it produces. Prepared diurnal shelter sites may be used during the day for nocturnal species such as foxes (Marks *et al.* 2006) and wombats (McIlroy 1977). Larger macropods such as eastern grey kangaroos and red-necked wallabies select open shelter sites to ensure early detection of predators in order to promote escape (Jarman 1991, Le Mar *et al.* 2005) while smaller macropods such as swamp wallabies rely upon cryptic shelter places to avoid detection and predation during the day (Jarman 1991, Le Mar *et al.* 2005). A wide range of anti-predator behavioural adaptations have evolved

(Kavaliers *et al.* 2001) and animals respond to avoid aversive stimuli using a narrow array of ‘species-specific defence reactions’ (Bolles 1970). For instance, the defensive reactions of wild species that receive an unexpected shock from an electric fence are predominantly flight or withdrawal to a prepared retreat (McKillop *et al.* 1988). Common wombats were observed to immediately retreat towards their burrow system in response to aversive stimuli such as shock from an electric fence (Marks 1998a) as do swamp wallabies (C.A. Marks, unpublished data) and kangaroos (McCutchan 1980). Trapping stressors are likely to trigger species-specific defence reactions in a wide range of animals, but restraint prevents the performance of behaviours that are typically used to mitigate such stressors.

6.1.6 Light

Circadian rhythms adopted by animals use light as the primary source of temporal information that is often the key cue for tightly regulated physiological and behavioural functions (Mohawk *et al.* 2005). The exposure of captured animals to abnormal light intensity or the disruption of their usual dial rhythms is an important stressor. Light intensity influences the activity patterns of a range of carnivores in a species-specific manner. While red foxes were found to be nocturnal 90% of the time, other carnivores are most active during the day and increased light intensity can either inhibit or promote activity (Kavanau *et al.* 1975). Dingoes in the NSW highlands were found to be active throughout the day, with activity peaks at dawn and dusk (Harden 1985), but in SW Queensland capture times appeared to suggest predominant nocturnal activity (Marks *et al.* 2004) (see Chapter 8.4). Increasing light intensity when rats lack cover increases the level of threat (Tachibana 1982) and stress can alter the use of photonic regulation for their circadian rhythms (Mohawk *et al.* 2005). The increase of startle response in rats tested in bright light has an evolutionary basis as rats are generally nocturnal and are more vulnerable to predators in the light (Walker *et al.* 2002). Nocturnal or diurnal habits of species can be typically identified by the characteristics of the photoreceptors in their retina and the predominance of rods, while diurnal species typically have higher densities of cones (Peichl 2005). Most Australian mammals are nocturnal in habit and seek shelter during daylight hours; the numbat (*Myrmecobius fasciatus*) is the only truly diurnal marsupial (Strahan 1984). Nocturnal activity is argued to be a primary anti-predator mechanism for many arboreal species (Goldingay 1984). Brushtail possums alter the intensity of their foraging activity in response to moonlight (Coulson 1996) and most birds (with the exception of owls, nightjars, night herons etc) are diurnal species that roost or shelter during the evening (Schodde *et al.* 1990). Recommendations for live trapping of nocturnal animals require that traps are set before dusk and inspected as soon as possible after dawn in order to reduce stress associated with subjecting nocturnal animals to direct light (Sharp *et al.* 2005a; 2005b, Anon 2007). Trapping protocols that extend the period between trap setting and daytime inspection can be assumed to increase the significance of light exposure as a stressor.

6.1.7 Acoustic

Sounds may be a powerful stressor for captive animals that cannot retreat from them. Sound stressors associated with predators can cause stress and myocardial necrosis due to insufficient perfusion of the heart muscle that can lead to death. This has been demonstrated to occur in species such as ground squirrels and rats that were made to listen to recordings of cat-rat fighting (Gregory 2005). Traps have a wide range of moving parts with attachments, chains and mechanisms that produce a varying amount of sound when activated and resisted by captive animals. Loud noises were shown to be aversive to domestic dogs and affected gastric motility and hormone release (Gue *et al.* 1989), activity and behaviour (King *et al.* 2003). Noise is an important stressor that affects the welfare of captive laboratory animals

(Jain *et al.* 2003). In a forest habitat, ambient noise levels ranged from 40 – 70 dB while in savannah habitats it was 20 – 36 dB (Waser *et al.* 1986). The sound of metal on metal during cage cleaning in a laboratory was measured to be 80 dB and had a wide spectrum of harmonics that were rich in different frequencies (Morgan *et al.* 2007). Noise made by the capture device may compound stress experienced by the captured animal and contribute to the initial startle responses. When inspecting fox trap lines that also used Victor Soft-Catch #3 traps, treadle-snares holding foxes were heard up to 50 m away by a characteristic 'metal against metal' sound of the treadle plate, the chain moving through the eye of the main spring and the sound of the device hitting hard surfaces. In contrast, Victor Soft-Catch #3 traps appeared to make far less sound if they were tethered on a short chain and fox captures could not be heard until a close approach was made to the trap site (C.A. Marks, personal observations). Post-capture noise could be hypothesised as a possible contributing reason why comparative blood biochemistry values for foxes trapped in treadle-snares and Victor Soft-Catch traps differed significantly (Marks, in review, Appendix 1).

6.1.8 Food and water

No organism has a uniformly available food source and periods of negative energy balance will be normally encountered (Millar *et al.* 1990). Long-term captivity and restraint will not allow animals to pursue their normal foraging activities in order to meet metabolic requirements that may be exacerbated by trapping stress and mobilisation and use of energy stores. The inability to use behavioural strategies to avoid heat loss may further produce a negative energy balance. Confinement by a trap device is likely to produce a degree of food and water stress, depending upon the duration, environmental conditions, activity of the trapped animal and its nutrition and hydration upon capture. In many terrestrial vertebrates, the majority of fluids are ingested as part of the food they consume and an inability to forage for food will compromise hydration and induce thirst (Gregory 2005). In dogs, evaporative loss from cutaneous surfaces or by panting, salivation or urination (Ramsay *et al.* 1991) may be influenced by temperature and stressors. In laboratory conditions, at room temperature after radiant heating raised the dorsal skin temperature up to 45°C, evaporative loss was the equivalent of running 7-10 km h^{-1}. When dogs ran under heat their water loss increased to 85-150 g hr^{-1} (O'Connor 1977). Dogs tend to drink water voluntarily once water loss is ≈ 0.6% of body mass (O'Connor 1977). In a hot and exposed environment, it is likely that water loss during a period of many hours resisting a trap will be significant.

The field metabolic rate (FMR) and water turnover of various animals has been calculated using a range of methods including a 'doubly labelled' water method (Nagy 2005). The relationship between the body mass of various vertebrate groups and FMR has been investigated by allometric scaling to describe their energetics (Nagy 2005), although the precise relationship between body mass and energy metabolism is a complex multivariate relationship (Heusner 1985). In NSW, the influx of water for adult foxes was found to be 577 mL day^{-1} and 444 mL day^{-1} for males and females respectively in November and decreased to a mean of 314 mL day^{-1} and 251 mL day^{-1} for males and females in April. Higher water intake in November may have been due to supplementation of water by drinking (Winstanley *et al.* 2003). As foxes obtain most of their water requirement from prey, a water intake of 314 mL day^{-1} corresponds to 370 g of mammalian prey ingested per day (Saunders *et al.* 1993). Common wombats were found to require 694 g day^{-1} and 1450 g day^{-1} of dry matter to meet their energy requirements in the dry and growing seasons respectively (Evans *et al.* 2003). Birds have to relatively use approximately 20 times more energy each day to live in contrast to a lizard, while mammals require 12 times more (Nagy *et al.* 1999). While it has been assumed that animals increase their energy expenditure in winter to meet the higher cost of thermoregulation, this has not been supported by studies that suggest that seasonal variations in metabolic rate is marginal (Nagy *et al.* 1999). However, given that the stress of capture will have significant metabolic costs, trapping stress is likely to be high and compounded by a need to defend body temperature if exposed to unfavourable climatic conditions.

6.1.9 Odour

Avoidance of predators by their detection by odour (olfaction) is a commonly used strategy in animals. Captured animals are unable to escape or avoid odour stressors. Components of fox urine have been shown to elicit endocrine and stress responses in rodents (Soares *et al.* 2003) and predator odours can in general produce powerful avoidance behaviour (McGregor *et al.* 2002). Rats avoided ferret odours and developed a sensitised stress response after the first exposure (Masini *et al.* 2006) and mongoose (*Herpestes auropunctatus*) odour was found to be repellent to rats (*Rattus* sp.) (Tobin *et al.* 1995). The sensitivity of canine scent identification is well recognised, as is their ability to detect and discern human scents at low concentrations (Lorenzo *et al.* 2003), and it is likely that odour detection will be a significant stressor associated with detection, avoidance, fear and anxiety associated with interactions with humans.

6.1.10 Thermal

Some animals are strongly dependent upon behavioural thermoregulation to regulate their body temperature (Brown 1984, Brice *et al.* 2002) and nocturnal activity rhythms are common in order to minimise water loss and avoid high temperatures. The denial of shelter through trapping and captivity and alteration of normal activity rhythms that assist behavioural thermoregulation may cause thermal stress in unfavourable environments. The capacity for trapping to expose animals to thermal stressors will be largely dependent upon the climate, degree of shelter, season, period of captivity and species-specific attributes that determine susceptibility to thermal stress.

6.2 Trapping pathology

6.2.1 Secondary trauma and pain

Post-capture activity and secondary trauma
Balser (1965) observed that injuries caused to coyotes by steel-jawed traps were largely produced by their struggle to escape the trap and chewing of the restrained appendage. Van Ballenberghe (1984) noted that 41% of 109 wolves captured in leg-hold traps incurred severe injuries to their feet and legs. Injury sustained by wolves was thought to be directly related to the degree of struggling after capture (Frame *et al.* 2007). The ‘aggressiveness’ of coyotes measured by their degree of vocalisation and lunging on removal from neck snares was positively related to the degree of injury that they had sustained (Pruss *et al.* 2002). Much of the trauma produced from trapping is unlikely to be visible immediately or even within some hours of capture and may take many days to develop into recognisable pathology. The relationship between initial trauma and the development of secondary trauma is unclear, yet may include a wide range of physical injuries that have been documented to be caused by different trapping devices including: oedematous swelling; haemorrhage; lacerations or maceration of skin and muscle; laceration, maceration or severance of tendons and ligaments; fracture of metacarpi, metatarsi, digits and other bones; luxation of joints; compound fractures and amputation (Van Ballenberghe 1984, Linhart *et al.* 1986, Olsen *et al.* 1986, Linhart *et al.* 1988, Olsen *et al.* 1988, Fleming *et al.* 1998, Pruss *et al.* 2002, Frame and Meier 2007).

In red foxes trapped in padded and unpadded leg-hold traps, physical activity due to struggling was intense following capture, but decreased rapidly during the first two hours of capture after which struggling was intermittent (Kreeger *et al.* 1990). In box traps, foxes were found to be active for 35.7 ± 8.8 (SE) % of the time overall, although activity was most intense immediately after capture (White *et al.* 1991). A similar activity pattern was observed in dingoes that had been captured in padded Victor Soft-Catch traps, where activity was most intense during the first hour of capture, yet progressively declined to half the value in the second hour and almost a quarter by the fifth hour of captivity. Dingoes that had been captured with a trap fitted with a tranquilliser trap device (TTD) containing diazepam had significantly lower activity, especially from the second hour of capture, corresponding to the onset of the sedative/anxiolytic used (Figure 4) (Marks *et al.* 2004).

As bone strength increases during maturation until approximately 30 weeks of age in domestic dogs (Jonsson *et al.* 1984), the bones of young canids may be more susceptible to breakage. Most studies identify the swelling of the foot to be associated with foot-snares and traps, yet tend not to indicate that this is a serious injury (Logan *et al.* 1999, Frank *et al.* 2003, Iossa *et al.* 2007). Trap injury scoring that focuses only upon the limbs of trapped coyotes was found to be 15% lower than injuries scored when the entire body was necropsied (Hubert *et al.* 1997) and this suggests the need for whole body examination of trapped animals (Onderka *et al.* 1990) as surrounding vegetation can cause entanglement, trauma and puncture wounding (Logan *et al.* 1999, Powell 2005) and other trauma independent of the trap.

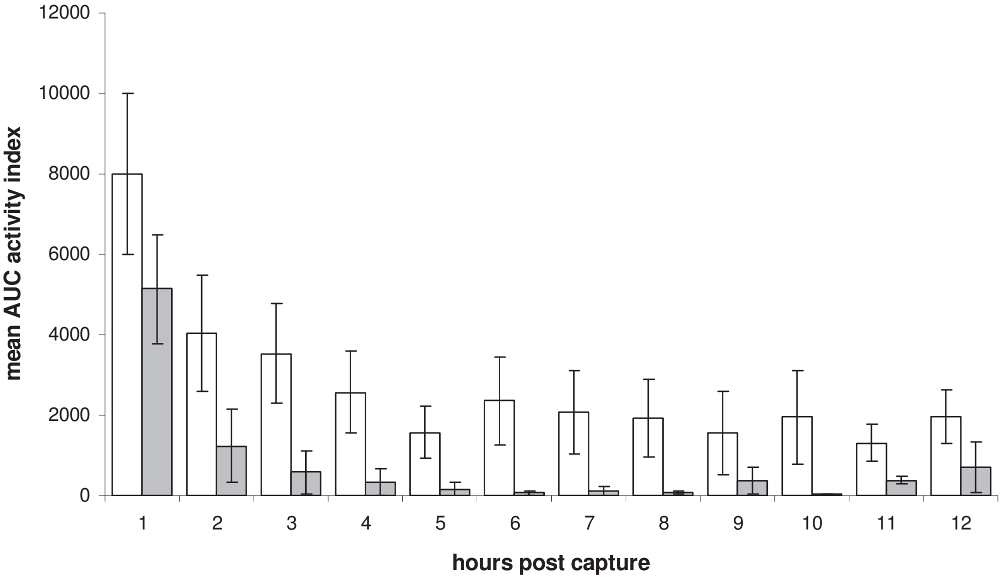


Figure 4. Mean hourly activity measure, AUC (Area Under Curve), for dingoes captured in Victor Soft-Catch #3 traps with a tranquilliser trap device (TTD – grey shading) (n = 19) or a placebo TTD (open bars) (n = 20) ($P < 0.05$) (after Marks *et al.* 2004).

Dental injury

The welfare implications of dental injures that expose the pulp cavity are highly significant as this is proposed to be the second most sensitive tissue that can produce intense pain (Baumans *et al.* 1994, Martini *et al.* 2000, Rutherford 2002). Van Ballenberghe (1984) observed that 44% of 109 wolves captured in steel-jawed traps had serious foot injuries, while 46% broke teeth. Broken, chipped or dislodged teeth occurred in 44% of adults (n=202) and 14% of juveniles (n=104) captured in steel-jawed traps (Kuehn *et al.* 1986). Mouth-injuries, such as chipped and broken teeth, and lacerations and abrasions of the gums and lips occur as a result of the trapped animal biting at the trap and are more prevalent in carnivores. The biting of traps is believed to be a common initial response to capture in wolves (Sahr *et al.* 2000) and is common in dingoes captured with Victor Soft-Catch #3 traps due to the chewing and biting of traps, probably in the initial period after capture (Marks *et al.* 2004). This can result in damage to metal parts of the trap (Figure 5). Englund (1982) found that 19% of juvenile foxes captured in Victor #2 and #3 long-spring traps suffered severe dental injuries by chewing traps, while 58% of adults were affected. Severe dental injury and jaw breakage may render animals unable to continue with a normal diet that requires a 'killing bite'. The predation of livestock by larger carnivores may be associated with a need to seek alternative food after damage to dentition and such infirmity was proposed to account for lion attacks upon humans (Patterson *et al.* 2003) and jaguar (*Panthera onca*) attacks upon livestock (Rabinowitz 1986). However, injuries are also observed in the mouths of untrapped animals and some authors ignored the assessment of tooth damage due to difficulties in determining if these injuries were related to trapping alone (eg. Fleming *et al.* 1998).

Figure 5. Damage to 'Paws-I-Trip®' pan tension device 'dogs' caused by chewing (indicated by arrows) of the Victor Soft-Catch #3 traps after capture of dingoes (after Marks *et al.* 2004).

Predation and insect attack

The predation and death of non-target animals trapped in leg-hold traps is well documented and the confinement of individuals in leg-hold traps is a major disadvantage to animals that may need to defend themselves against aggressive interactions with competitors, predators or insects. Bite wounding among domestic dogs is a well recognised cause of trauma that results in severe bruising and crushing injuries (Shamir *et al.* 2002). A fresh bite wound to the scrotum of a trapped dingo was apparently inflicted by a con-specific (Marks *et al.* 2004). The predation of non-target species by wild dogs or foxes while they are held in leg-hold traps and snares has been reported in Australia (Bubela *et al.* 1998, Fleming *et al.* 1998). Over 121 March flies (Family Tabanidae) and blowflies were found in the stomach of a trapped dingo (even though flies are not regarded as food) and were observed to pester trapped dingoes (Newsome *et al.* 1983).

Ischemia

Oedema is a common indication of potential ischemia and is frequently observed after trapping in padded leg-hold traps (Andelt *et al.* 1999), yet in some cases animals recover after release in a few days with no further indications of injury (Saunders *et al.* 1984). Oedema of varying degrees is seen in foxes captured with treadle-snares (Figure 6a) and Victor Soft-Catch traps (Figure 6b).

During the obstruction of blood flow, cellular production of ATP may use glycogen metabolism and creatine phosphate until depleted. Glycogen is broken down to yield pyruvate and lactate and causes a decline in pH, which will then limit phosphofructokinase activity and further reduce the potential to develop ATP stores (Harris *et al.* 1986). There is a good relationship between the depletion of skeletal muscle ATP stores and the extent of ultimate muscle necrosis (Walker 1991). Using laboratory rodents subjected to periods of ischemia, reflow of blood into capillaries was inhibited after two hours and upon release of the tourniquet declined for a further 90 minutes (Forbes *et al.* 1995). Restricted blood flow to limbs will not return to levels seen before ischemia and tissue damage continues for a period thereafter. The mechanism responsible may relate to the obstruction of capillaries with leukocytes (Schmid-Schönbein 1987), neutrophil mediated injury in tissue (Schraufstatter *et al.* 1984, Ellard *et al.* 2001), the swelling of endothelial cells (Harris *et al.* 1993) or free-radical mediated damage (Walker 1991).

The sudden return of circulation initiates the conversion of injured tissue that may have shown superficial oedema to necrotic tissue over a few days and may take a protracted period to develop completely (Walker 1991). Tissue pressure of 50 mm Hg represented a critical threshold for human peripheral nerves at which there will be acute damage (Gelberman *et al.* 1983). Pressures of 300 mm Hg cause almost total occlusion of blood flow in the limbs of monkeys (Klennerman *et al.* 1977). The application of tourniquet cuffs was shown to damage the sciatic nerve of dogs and although the degree of impairment differed between individuals, full recovery was shown to take up to 6 months (Rorabeck *et al.* 1980). Using lower pressures of 200 mm Hg for two hours, temporary peripheral nerve conduction and blood flow was occluded and a degree of nerve injury was most pronounced a week after treatment and diminished in severity over a six week period (Nitz *et al.* 1986). An important implication for welfare outcomes from trapping is that after a period of ischemia, gross pathology will be visible only well after blood flow is restored (Walker 1991). The incidence of debilitation cannot be known unless the fate of animal is followed subsequent to release or detailed veterinary investigations are made of affected tissues prior to release.

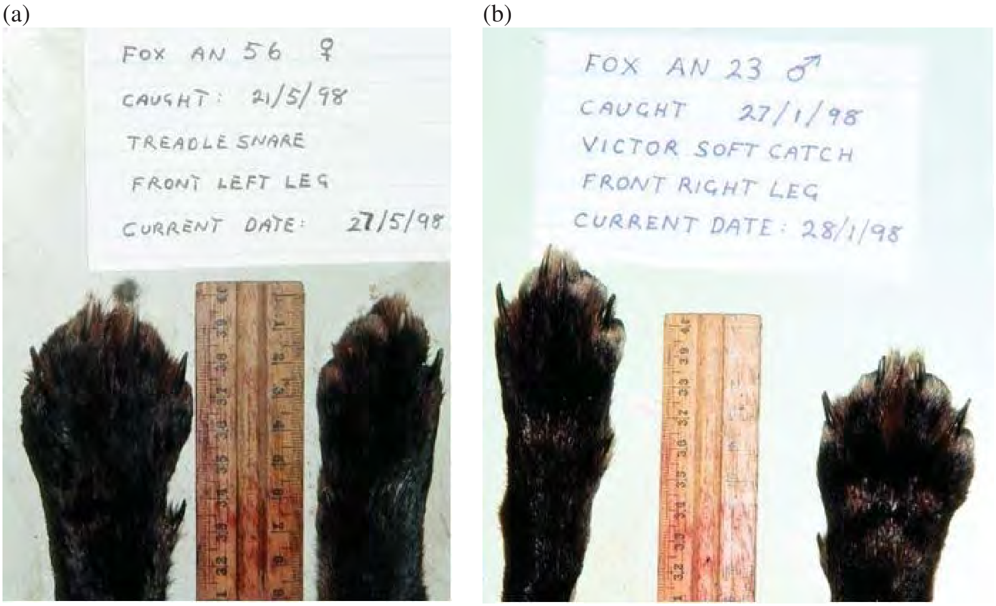


Figure 6. Typical oedematous swelling in the paws of foxes restrained by a treadle snare (on the left front leg) (a) and the Victor Soft-Catch #3 trap (on the right front leg) (b) for unknown durations.

Secondary, chronic and pathological pain

When an animal is trapped there may be pain associated with the initial closure of the trap and ongoing pain from the trap mechanism (eg. clamping pressure). Pain may arise from injury due to struggling and continue subsequent to an animal's release, as it does not necessarily abate upon the removal of a painful stimulus. Pain is probably best considered to be both a stressor and a form of a variable pathology that may have a complex feedback mechanism. Chronic pain may be variously defined as pain that is perceived subsequent to healing or pain that has no useful purpose (discussed by Rutherford 2002). Chronic pain is not an extension of acute nociceptive pain, but may be an evolving process where injuries produce a chain of pathogenic mechanisms that initiates another (Covington 2000). Pain may not arise immediately, but may follow some time after trauma and exertion (Marchettini 1993). For example, muscle pain may arise from a state of nociceptor sensitisation and be associated with strenuous muscle activity (eg. post-exercise muscle pain) and associated with myopathic weakness and an increase in serum muscle enzymes. Pain that arises after neurological damage (neuropathic pain) after trauma and the development of inflammation (Carstens *et al.* 2000) can be chronic and associated with abnormal nociception and amplification of pain.

After nerve damage associated with trap injury, the cessation of physical trauma cannot be assumed to eliminate pain as acute pain may sensitise and/or facilitate the development of chronic pain mechanisms (Covington 2000). Pain can become more intense due to restricted venous return as the wound area becomes engorged with blood and the veins are occluded. The pressure from this swelling may directly activate pain receptors and the stimulus producing the pain cannot be removed by restoring blood flow (Gregory 2005). Animal models of neuropathic pain have been developed in rats by the placement of loose ligatures around the sciatic nerve or dorsal roots. When the limb becomes oedematous it is often held in the air and animals develop long lasting and extreme sensitivity to heat and mechanical stimulus beyond the area of nerve damage (Bennett *et al.* 1988, Kim *et al.* 1992).

Self mutilation

Kuehn *et al.* (1986) recorded that up to 3% of grey wolves chewed at their trapped limbs irrespective of whether traps were toothed or offset. Self-mutilation is frequent in raccoons (*Procyon lotor*) captured in padded and unpadded leg-hold traps (Berchielli *et al.* 1980). Dingoes were observed to gnaw at their trapped leg, sometimes biting off extremities (Newsome *et al.* 1983) and this is common in coyotes (Balser 1965). In other studies, injury sustained by the trapped limb was possibly produced as the animal gnawed at the device, implying that it may not always be self-directed (Stevens *et al.* 1987). A fox cub was found to mutilate its digits below the point at which it was held by a Victor #3 Soft-Catch trap (C.A. Marks, unpublished data). Self-mutilation of trapped feet was observed in 2/10 coyotes trapped in modified Victor Soft-Catch traps (Houben *et al.* 1993). Using off-set and laminated Bridger #3 traps to capture coyotes, 2/27 were also found to have chewed their foot pads (Hubert *et al.* 1997). Self mutilation was observed in 2/107 pumas captured in leg-hold snares after lower leg bones had been broken (Logan *et al.* 1999). Raptors were found to self-mutilate following traumatic nerve injury (Holland *et al.* 1997), yet their propensity to do this in traps is unknown.

The relationship between nerve damage and self-mutilation is still unclear and previously some authors proposed that it occurs as a way for animals to shed impaired and insensitive appendages (autotomy) (Rodin *et al.* 1984), although this explanation has not found wide support. It has also been suggested that the reasons for self-mutilation of animals trapped in leg-hold traps may be because of progressive limb desensitisation (Gregory 2005) and may imply that injury is not self-directed. However it appears likely that pain and nerve damage is most likely the primary stimulus that directs self-mutilation. When the sciatic nerves of rats were severed, 80% were observed to self-mutilate the desensitised area (Blumenkopf *et al.* 1991) and this was also observed in 91% of subjects in another study (Wall *et al.* 1979)
There is evidence that genetically determined variation in rates of autotomy/self-mutilation

occurs within some species (Coderre *et al.* 1986). Self-mutilation has become an important marker of pain in the assessment of analgesics (Willenbring *et al.* 1994). In mice, self-mutilation begins at the toes, after which biting progresses further up the limb. Anaesthetic applied to the limb before nerve damage prevents the onset of self-mutilation and this implies that pain perception is important in the initiation of this behaviour. In chronic post-traumatic situations in humans, most commonly following traumatic brachial plexus avulsion, patients have attempted to persuade others to amputate the limb in the hope of relieving unremitting neuropathic pain. In these cases the prime motivation is almost always relief of pain rather than merely the removal of dysfunctional anatomy (Bonney 1959).

6.2.2 Anxiety and fear

Fear is an emotional response to a potentially harmful stimulus and is sometimes separated from *anxiety* which is defined as an emotional response to a stimulus that predicts a potentially harmful or unpredictable environment (Casey 2002). In this definition, fear is elicited by an explicit, threatening stimulus and subsides shortly after offset of that stimulus (Davis *et al.* 1997). Anxiety may be a more generalised and may last for a long period once activated (Davis *et al.* 1997). It is a different state to that of fear as it is mostly related to anticipation or dread in the absence of external triggers (Gregory 2005). Gregory (2005) lists a range of situations that produce fear, including capture, exposure to unfamiliar objects and odours, sudden movement, separation from companions, aggressive encounters, exposure to predators and predator related cues. This emphasises that fear and anxiety are probably experienced in response to a broad range of stressors encountered during trapping. Sudden and violent alarm (eg. startle response), apprehension and frustration may be states related to fear and anxiety and are deemed to be psychological stressors (Jordan 2005) (Figure 7). They are motivators induced by the perception of danger and each has survival value if life expectancy of animals can be increased if danger is avoided (Boissy 1995). In monitoring the environment for threats, an animal will respond with fear if there is a large discrepancy between observed and expected stimuli (Archer 1979). Fear in animals is believed to give way to either defensive or avoidance behaviours as a way to protect them from potentially harmful situations (McFarland 1981).

Fear and anxiety can become pathologic when the stressors are intense or prolonged. Tissues can be damaged by short-term immobilisation and even emotional or social stress. Immobilisation or restraint in the absence of other stressors can induce myocardial lesions and affect tissue integrity in vital organs (Sanchez *et al.* 2002). This finding challenges previous beliefs that stress operates over longer periods to cause pathology; short-term restraint may have greater implications for the welfare of animals than previously thought. When in contact with humans, Arctic foxes express fear that is well known to be associated with an increase in stress hormones (Kenttämines *et al.* 2002). Domesticated animals have a reduced functional activity of the pituitary-adrenal system, a decreased total glucocorticoid level in blood and, from *in vitro* studies, appear to produce less adrenal hormones and basal levels of ACTH (Trut *et al.* 2004), yet silver foxes that have been bred to be resistant to stress (Belyaev 1978; 1979) will display rapid stress-induced hyperthermia (SIH) when in close proximity to humans (Moe and Bakken 1997; 1998, Trut *et al.* 2004). This has also been observed in laboratory rodents. In each species, it has been related to the induction of the HPA and sympathetic adrenal-medullary system (Moe *et al.* 1997); there is little increase in physical activity associated with SIH in foxes (Moe and Bakken 1997 and rodents (Kluger *et al.* 1987). All vertebrate species probably possess specific receptor sites for benzodiazepine drugs, which influence states of anxiety (Rowan 1988), and diazepam has been used successfully to manage SIH in laboratory rodents and foxes (Moe *et al.* 1998), reinforcing that anxiety or fearful states initiated solely by the presence of humans are probably responsible for SIH.

Figure 7. Anxiety, fear or frustration? A dingo captured with a Victor Soft-Catch #3 trap instrumented with an activity monitoring data logger (metal box fixed to chain) after approximately 10 hours of confinement (after Marks *et al.* 2004).

6.2.3 Capture myopathy and exhaustion

Capture myopathy is an acute degeneration of muscle tissue that may arise from capture and restraint, especially when associated with intense muscular exertion (Hulland 1993). It is a condition variously named as *transport stress*, *capture stress*, *degenerative myopathy*, *white muscle disease* or *exertional rhabdomyolysis*. It is primarily a disease of wild and domestic animals and is most commonly reported in birds and mammalian taxa such as macropods, deer, cetaceans, seals, rodents and primates (Williams *et al.* 1996). Trauma or compression of muscles due to physical injury, long-term confinement in the same position, strenuous activity and constriction of blood flow or hyperthermia are among a number of stressors that can lead to muscle damage (Vanholder *et al.* 2000). The disease is initiated when exertion during anaerobic glycolysis produces low muscle pH associated with the accumulation of lactic acid in muscle cells. Cellular enzymes such as CK, AST, and LDH are released into the blood stream along with free radicals that can overwhelm the protective and corrective antioxidant defence mechanisms (Viña *et al.* 2000). Diagnosis of exertional myopathy is usually based upon history of susceptibility, clinical signs and elevation in AST, CK and LDH (Dabbert *et al.* 1993). Upon the death and disintegration of muscle tissues, myoglobins (that resemble haemoglobin) are released and can damage the kidney and the lungs (Wallace *et al.* 1987, Vanholder *et al.* 2000) and when severe, urine may be discoloured dark brown. Acute renal failure may result from a combination of acidosis and ischemia in concert with myoglobin deposition in the glomeruli (Wallace *et al.* 1987). Normally, free myoglobin is bound to plasma globulins, but massive release of myoglobins will exceed the capacity of plasma proteins to bind them. Short and intensive bursts of activity may contribute more to the onset of capture myopathy than prolonged but less intense activity (Beringer *et al.* 1996).

There are four general appearances of the disease that have been best described in livestock:

1. **Hyperacute (peracute) capture myopathy** – associated with very sudden onset and death due to shock and vascular collapse;
2. **Acute capture myopathy** – where animals survive for hours or days;
3. **Sub-acute capture myopathy** - Ruptured muscle syndrome occurs within days to weeks and the animals develop painful movement due to muscle rupture;
4. **Chronic** – associated with death that supervenes after a second capture attempt due to predisposition to cardiac arrest and arrhythmias due to capture myopathy or pathogen and parasite related diseases (Spraker 1993, Rendle 2006).

While not normally a disease commonly associated with carnivores and dogs in general (Aktas *et al.* 1993), capture myopathy was described in a red fox (Little *et al.* 1998) and in river otters (*Lutra canadensis*), where clinical signs included depression, anorexia and shock, although it was not the sole cause of death (Hartup *et al.* 1999). Capture myopathy has been reported for 11 species of macropods in Australia with either debilitation or death being the outcome (Shepherd *et al.* 1988). No evidence of cardiac necrosis or renal damage was found in a study on red kangaroos (*Macropus rufus*) although skeletal muscle necrosis and myoglobinuria was found in many (Shepherd 1983, in Shepherd 1988). An attempt to capture macropods in Australia has been documented to result in 37% (Keep *et al.* 1971) and 100% (Shepherd *et al.* 1988) mortality due to capture myopathy. This has lead to the development of trapping and immobilisation techniques for small macropods that are specifically designed to avoid injury and capture myopathy (Coulson 1996, Lentle *et al.* 1997). It has been suggested that long-legged birds are more susceptible (Hanley *et al.* 2005) and appears to be the case with emus (Tully *et al.* 1996). The presentation and clinical signs of the disease appear to vary and may be species-specific. Three roe deer were captured in drive nets, restrained and placed in transport boxes and then translocated to an enclosure where they were observed to die 48 hours, 72 hours and 8 days after capture, possibly due to a second stress episode (Montane *et al.* 2002). When using ‘drop nets’ it was estimated that between 6-16% of white-tailed deer (*Odocoileus virginianus*) suffered capture myopathy. Sedating and blindfolding animals and limiting the noise associated with handling was shown to reduce capture myopathy by 50% (Connor *et al.* 1987) and probably demonstrates the importance of handling, light and acoustic stressors in managing this disease. The use of traps that reduce handling and processing times and overall exertion were found to significantly decrease the incidence of capture myopathy compared to the use of net guns (Beringer *et al.* 1996).

Animals suffering from capture myopathy may be debilitated by scarring of skeletal or cardiac muscles, which may cause them to appear slower or less alert after release. This may make animals more susceptible to predation or to other stressors that can cause their death weeks or months after capture (Hulland 1993). The prognosis is poor for animals that have clinical signs of capture myopathy, especially if released immediately (Rogers *et al.* 2004, Hanley *et al.* 2005). In whooping cranes (*Grus americana*), routine capture and handling caused exertional myopathy and treatment was unsuccessful (Hanley *et al.* 2004). Some success has been reported in a range of shorebirds that were rendered unable to stand, walk or fly, yet this took up to 14 days of intensive supportive care (Rogers *et al.* 2004). Similarly, muscle tissue killed by myopathy in quokkas (*Setonyx brachyurus*) was found to regenerate after 5-8 weeks (Kakulas 1966). Selenium (0.06 mg kg^{-1} as sodium selenite) and vitamin E (0.45 mg kg^{-1} as d-α tocopherol acetate) was shown to be beneficial in protecting and assisting recovery of myopathy conditions in livestock (Viña *et al.* 2000). Treatment of northern bobwhites (*Colinus virginianus*) significantly increased the survival of birds compared to a placebo and this was attributed to a reduction in pathology associated with capture myopathy (Abbott *et al.* 2005). Given that many wildlife species will be intractable to long-term captivity, the practicality of providing supportive care in the field to non-target species suspected of suffering myopathy is questionable.

Exertion until exhaustion will have species-specific consequences; dogs appear to be able to endure exercise stress until exhaustion without severe metabolic acidosis and were found to have a resting cardiac output 30% greater than pigs, which increases to 60% greater during steady-state exercise (Hastings *et al.* 1982). Wombats caught in steel-jawed traps that are tethered to solid objects will often respond by continuous digging with their unrestrained limb until physical exhaustion characterised by lethargy and unresponsiveness is seen (C.A. Marks, personal observations), which is clearly associated with poor welfare (Anon 2007). Unfortunately, there are few data available concerning the susceptibility of many wildlife species to capture myopathy and their fate subsequent to release.

6.2.4 Hyperthermia and hypothermia

Heatstroke (hyperthermia) occurs when the mechanisms responsible for heat loss are overwhelmed, particularly in the absence of freely available water in species such as domestic dogs. In dogs the disease is characterised by marked elevation in core body temperature resulting in widespread hepatic and gastrointestinal cellular damage as body temperature approaches 42°C with vascular collapse, shock and death (Bosak 2004). At body temperatures in excess of 41°C, domestic dogs are unable to maintain thermal equilibrium and collapse, and neurological symptoms are evident above 42.5°C (Andersson 1972). After 30-60 min of moderate exercise on a treadmill (4 km h^{-1} at an 8% gradient) at air temperatures between 37-42°C, Alsatian dogs became distressed and attempted to escape (Bedrak 1965).

The early stages of heatstroke in dogs are characterised by hyperthermia, tachycardia, depression, vomiting, diarrhoea and dehydration (Krum *et al.* 1977). Independent of thermal stressors, anxiety and stress can induce hyperthermia in silver foxes within 5 minutes (Moe *et al.* 1997). Heat stress was associated with the death of animals in traps despite the use of the TTD containing diazepam (Balser 1965). Elevated body temperature was associated with capture deaths in black bears caught with foot-snares (Balser 1965).

Most small vertebrate species, including arid adapted mammals and reptiles, will become thermally stressed when ambient temperatures exceed 40-45°C in traps and prolonged exposure may result in death (Hobbs *et al.* 1999). Some bandicoots that are found in mesic environments such as the eastern barred-bandicoot (*Perameles gunnii*) are similarly unable to tolerate ambient temperatures > 35°C (Larcombe *et al.* 2006). Common wombats reduce heat loss during winter by active periods of feeding followed by refuge in a burrow where their heat loss is reduced. They have difficulty in maintaining a constant body temperature when ambient temperatures exceed 25°C and show severe thermal stress when exposed to temperatures above 30°C (Brown 1984). Arid adapted wombats such as the southern hairy-nosed wombat avoid high temperatures in summer by selecting cooler parts of the evening to forage, and they appear to be poor at regulating their body temperature (Wells 1978). The echidna is unable to manage ambient temperatures > 35°C and relies upon shelter in burrows to maintain a body temperature below a fatal body temperature of 38°C (Brice *et al.* 2002).

Hypothermia is a condition where the animal's body temperature drops below that required for normal metabolism. Signs of hypothermia include shivering, lethargy, muscle weakness, stupor, coma and death if severe (Kayser 1957). Rapid chilling is associated with pain and discomfort, especially to the extremities, and reperfusion pain when full circulation is restored (Gregory 2005). Some trapped species have been recorded to die as a result of hypothermia in North America (Mowat *et al.* 1994) and it has been listed as a possible cause of death for trapped Australian species (Fleming *et al.* 1998). Overnight temperatures < - 8 °C were found to be associated with risk of freezing injury in lynx (Mowat *et al.* 1994). In sub-zero temperatures the common wombat appears to be dependent on access to burrows in order to avoid hypothermia (Brown 1984), although southern hairy-nosed wombats may be mildly tolerant to hypothermia (Wells 1978). Poorly insulated shelters can cause death through hypothermia in common wombats housed in zoos (Marks 1998b).

6.2.5 Impact on dependent young and reproduction

The welfare, growth and reproductive performance of agricultural, laboratory and zoo animals can be negatively affected by fear and anxiety (Boissy 1995). Trapping stress, injury and death may cause: 1. ejection of pouch young; 2. abortion; 3. the death of dependent offspring and; 4. welfare impacts that arise from prenatal stress altering HPA responsiveness *in utero* and consequent effects upon the behaviour of offspring. The period of reproductive activity corresponding to gestation, birthing period and maintenance of target and non-target young gives some indication of the periods that correspond to possible impacts of trapping upon reproduction and offspring (Figure 8).

Dependent young
The trapping of animals with offspring that are dependent upon lactation, food and maternal or paternal care is a possible outcome when traps are used during times corresponding to breeding, birth and care of target and non-target young (Sharp *et al.* 2005a; 2005b). In dogs and foxes, lactation is vital to the survival of cubs maintained within the natal den before they begin to accept prey (Tembrock 1957). The care of dependent young is also highly dependent upon a wide range of roles fulfilled by the adults of different species, such as egg incubation, provision of shelter, protection from predation, provision of body heat and potentially the maintenance and protection of young past early dependence (Clutton-Brock 1991).

Dingoes appear to breed only once each year in the wild, yet births in the eastern highlands of Victoria were estimated to occur over a seven month period from March to September with a breeding peak from June to August (Jones *et al.* 1988). Male dingoes were found to have either a low intensity testicular cycle (Jones *et al.* 1988) or none at all (Catling 1979). Breeding in domestic dogs is variable in timing and can occur more than once each year (Christie *et al.* 1971), with males being fertile throughout the year (Kirk 1970, in Jones and Stevens 1988). The red fox will produce a single litter each year after a 52-53 day gestation period (Lloyd *et al.* 1973, Ryan 1976, Coman 1983). In Australia, pregnancies in the fox have been reported to range from June to October in foxes taken from a range of habitats across New South Wales (Ryan 1976) and from July to October in Canberra (35^{o}S) (McIntosh 1963). In a study in western New South Wales (32-33^{o}S), the timing of mating and births varied from 7 weeks in 1995 to 3-3.5 weeks in 1996, and the earliest evidence of oestrus was detected on the 14th June (McIlroy *et al.* 2001).

The bandicoot genera, *Isoodon* and *Perameles,* contain highly fecund species, with multiple births each year with short inter-litter intervals. The macropods (*Macropus* and *Wallabia*) breed year round (Menkhorst 1995). Along with brushtail possums, they have a much larger inter-litter period (> 200 days) and while brushtail possums have a major autumn and minor spring breeding season, breeding may occur year round (How 1988). Wombats have been shown to breed throughout the year, although in Victoria there appears to be a cluster of births in summer (Skerratt *et al.* 2004). Lyrebirds and emus breed from May through to October and ravens between July and September. The period of care provided by the male emu for chicks has been recorded to last as long as 18 months and may be a period of three to four months for ravens (Schodde *et al.* 1990). Although seasonal breeders can have more predictable reproductive cycles, the period of maternal care necessary to ensure the survival of juvenile offspring is difficult to define with any precision.

Ejection of young and abortion
In macropods, the ejection of pouch young due to stress or predator avoidance is a unique strategy to assist in the survival of the mother when stressed (Coulson 1996). The ejection of

pouch young in response to stress has been observed in eastern-grey kangaroos (in Coulson 1996) and swamp wallabies (Robertshaw *et al.* 1985). Stress-induced inhibition of prolactin secretion, resulting in diminished progesterone concentrations, might be the chief cause of reproductive failure and abortion in red foxes (Hartley *et al.* 1994). Stress induced abortions have been noted as a consequence of trapping stress, yet may not occur immediately. For instance, a puma injured during trapping with a leg-hold snare aborted 3-4 days after capture but was only recorded because it was closely monitored (Logan *et al.* 1999).

Prenatal stress

Prenatal stress in the last third of pregnancy induced by brief handling affected adrenal weight and adrenocortical function in blue fox offspring (*A. lagopus*) (Braastad 1998). This follows a general observation that anxiety during pregnancy can affect the corticosterone response to stress (Vallee *et al.* 1997), although the welfare implications of this finding are not clear.

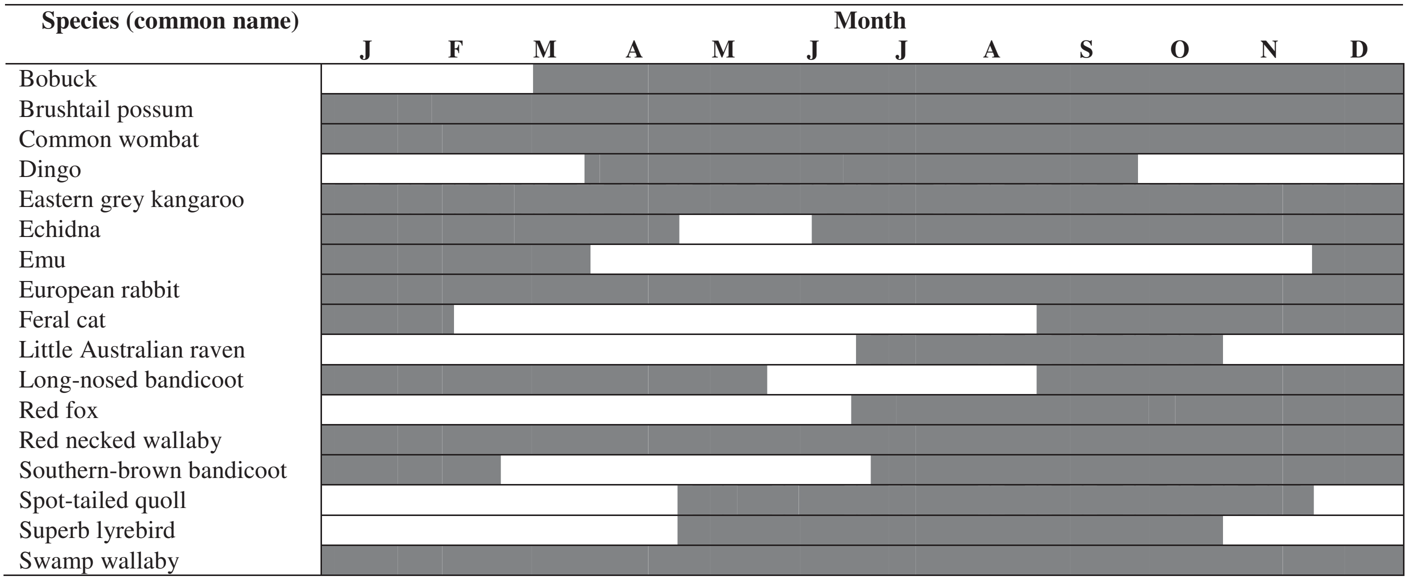


Figure 8. Period of gestation following mating and potential birth season and period of care for dependent young (lactation and maternal care) for target and non-target species (Strahan 1984, Lee *et al.* 1985, Tyndale-Biscoe *et al.* 1987, Hayssen *et al.* 1993, Menkhorst 1995, Temple-Smith *et al.* 2001, Menkhorst *et al.* 2004).

6.2.6 Dehydration and starvation

If obligatory loss of water (eg. panting, salivation, urination etc) is not replaced by water ingestion, raised extracellular fluid osmolarity and reduced extracellular fluid volume will rapidly cause a state of cellular and extracellular dehydration (Ramsay *et al.* 1991) and may contribute significantly towards the onset of hyperthermia in hot environments. In dogs, 24 hour water deprivation results in a steady rise in plasma osmolarity and an increase in plasma vasopressin without a decline in urine volume because water excretion is required to eliminate sodium (Thrasher *et al.* 1984). Black bears captured in Aldridge snares had blood biochemistry profiles attributed to greater exertion, muscle damage and dehydration compared to individuals captured by remote activated tranquilising collars (Powell 2005). Grizzly bears had higher N:L ratios, as well as increased concentrations of Na and Cl that were attributed to dehydration due to water deprivation during 2-23 hours of captivity, which was probably aggravated by intense activity (Cattet *et al.* 2003). Increased CK, PCV, ALB, Na, TP, Gl and Cl in foxes captured in treadle-snares are suggestive of dehydration due to intense activity (Marks, in review, Appendix 1).

Large body size appears to assist animals endure fasting better than smaller animals. For instance, wolves can survive 18-45 days between kills (de Bruijne *et al.* 1983, Millar *et al.* 1990), yet much smaller (shrew sized) mammals may need to eat more than their body weight each day to survive (Chapman *et al.* 1999). Consequently, the period of time that an animal is held and its endurance to fasting will determine the extent to which pathology results. In fasting dogs, liver glycogen was depleted in the second and third days and glycogenesis was slower than seen in humans or pigs (de Bruijne *et al.* 1983). Ketone bodies were generated by carbohydrate-sparing energy production from fat metabolism to assist in energy requirements after a single day of fasting (de Bruijne *et al.* 1983). Yet an increase in muscle carnitine, probably associated with a decrease in metabolic rate associated with prolonged starvation, was detected between day 5 to 8 in the dog (Rodriguez *et al.* 1986). It would appear that in favourable environmental conditions starvation is an unlikely outcome over one day in canids and larger mammals. In unfavourable conditions of prolonged food stress, disease or other energy demands that have caused a negative energy balance, a relatively brief period of fasting and additional stress may have greater welfare consequences.

6.3 Discussion and conclusions

Physical trauma, self-mutilation, myopathy, starvation, dehydration, hypothermia, hyperthermia, anxiety and fear and ultimately death are endpoints of trapping stress and the consequence of exposure to intense stressors or a combination of stressors. Good welfare outcomes of trapping should seek to prevent or mitigate such consequences (Carstens *et al.* 2000). Identifying stressors and their association with observed pathology is a useful model for developing methods to prevent, improve and understand welfare states associated with trapping. The degree to which each stressor may produce stress or pathological responses may vary due to environmental conditions and the relevance of the stressor to each species.

Fear, anxiety, social and spatial dislocation, starvation, dehydration, hyperthermia, hypothermia and impacts upon dependent young cannot be accurately accounted for by assessing trauma alone. Unless detailed necropsies are conducted, capture myopathy and ischemia are also likely to be undetected in most instances where the focus of assessing trapping stress is upon recording gross trauma.

Some stressors have different relevance to a range of species and a variable potential to produce negative welfare outcomes. For instance, the impact of loss of cover and periods of confinement in light may be extremely stressful for a nocturnal herbivore, yet may not have the same significance for diurnal species. The placement of traps close to cover may reduce stressors associated with loss of cover, yet aggravate entanglement and injury due to vegetation.

There may be a wide range of stressors associated with physical trauma that are not directly related to the trap mechanism. Acoustic and light stressors, loss of cover, social dislocation and associated states of fear and anxiety may contribute substantially towards the degree to which certain animals resist trap devices and sustain or aggravate injuries. Reduction of the specific stressors that potentiate trauma will guide development of trapping systems with improved welfare outcomes.

7.0 COMPARISION OF DEVICES

7.1 Welfare outcomes

7.1.1 Steel-jawed leg-hold traps

Toothed, steel-jawed leg-hold traps cause serious injuries, including compound fractures, dislocations and amputations of limbs. Not all animals caught in toothed Lane's traps sustained injuries that were considered debilitating, but in a comparative assessment of four other devices, they were the only device where animals were found dead in the trap (Fleming *et al.* 1998). Unpadded traps such as the Victor #3 NM, Victor #3NR, Victor #3 coil springs and Newhouse #4 produce major injuries to coyotes (Phillips 1996b). Of 196 red and grey foxes trapped with #1 to #3 long-spring type traps (#1 ½ being the most common), 26% were believed to have been crippled through self mutilation or escaping with traps attached to limbs. The potential for survival was considered to be low, although survival with the loss of one or two toes is common and these animals have been reported to be re-trapped (Atkeson 1956). Over two years the survival rate of marked and released nutria (*Myocastor coypus*) previously trapped in leg-hold traps (Victor #11 long spring, Victor #1½ coil spring, Victor #2 long spring or Victor #2 coil spring traps) or cage traps was compared. Released nutria that had been captured in a leg-hold traps experienced a significantly greater mortality rate (74% compared to 53% for those cage trapped). In this study, it was unknown if the type of leg-hold trap used influenced survival (Chapman *et al.* 1978). Subsequent to capture by steel-jawed 'Lane's' traps, 14% of common wombats were shown to have major injuries and the remaining 86% displayed minor wounds. Wallabies and kangaroos received major wounds on 61% and 83% of occasions, respectively. Major wounding occurred in 65% of foxes, 69% of possums and 84% of birds (Murphy *et al.* 1990) (Table 11)

7.1.2 Modified steel-jawed leg-hold traps

Modifications were made to # 2 double coil spring traps by removing one spring and padding the jaws with adhesive tape after the sharp edges were filed blunt. Of 86 adult foxes captured, four broke legs and 7/65 cubs broke legs in similarly modified # 1 ½ traps (Sheldon 1949). Based upon a comparison of injuries sustained by grey wolves in toothed or smooth jawed traps with either off-set or fully closing jaws, Van Ballenberghe (1984) observed that #14 toothed traps off-set by 1.8 cm appeared to produce less cuts and major injuries (trap inspection time unstated). Lane's traps were modified with padding and offsetting the jaws of the trap so that they did not fully close (Harden 1985) and this reduced the injuries produced compared with unpadded Lane's traps (Fleming *et al.* 1998). Thompson (1992) used padded Lane's leg-hold traps (trap inspection time unstated) and 21/205 (10.2%) dingoes died directly as a result of trapping believed to be caused by a combination of exposure, exhaustion and shock. Most trapped dingoes sustained minor cuts or oedema of the trapped leg or foot and their gait appeared normal within days of capture. Although 33/205 (16.1%) were released with more serious injuries such as missing toes, 19/33 of these were believed to suffer from no long lasting ill-effects, while 12/33 exhibited abnormal gait and 2/33 became dissociated from the social group and eventually died. In all, 27.3% of dingoes captured in this manner sustained major injuries and 23/205 (11.2%) died either directly as a result of trapping or in the period afterwards (Table 11).

7.1.3 Padded leg-hold traps

Kreeger *et al.* (1990) studied the behavioural, physiological, biochemical and pathological response of captive and free ranging red foxes to padded Victor Soft-Catch #3 and unpadded steel-jaw traps. Foxes caught in both types of leg-hold traps developed typical stress responses characterised by elevated heart rate, HPA hormones, CK, AST, LDH and neutrophilia. Foxes spent far les time physically resisting padded traps, and recurrent peaks of struggling were restricted to unpadded traps. Unpadded traps appeared less humane on the basis that, among other indicators, foxes had significantly higher levels of blood cortisol, ALP, AST and gamma-glutamyl trans-peptidase (GGT) and greater limb injury damage scores compared to padded traps.

Earlier designs of the Victor #3 Soft-Catch traps were shown to cause minor foot injuries to coyotes (Olsen *et al.* 1986, Linhart *et al.* 1988) and had lower capture success than the unpadded Victor #3 NM trap (Linhart *et al.* 1986, Linhart *et al.* 1988, Linscombe *et al.* 1988, Linhart *et al.* 1992, Houben *et al.* 1993, Hubert *et al.* 1997). Progressive modifications to the trap appear to have overcome earlier problems over a number of generations of development and testing (Skinner *et al.* 1990, Linhart *et al.* 1992, Phillips *et al.* 1992, Phillips *et al.* 1996a). Soft-Catch traps caused the least visible injury to coyotes and 50% (n=10) had no visible injury while the remainder (n=10) had a swollen foot, small cuts or abrasions. This contrasted with the Victor #3 NM trap that caused moderate to severe injuries in 80% of coyotes and the #4 Newhouse traps that caused moderate to severe injuries in 45% (Phillips *et al.* 1992). The use of #3 Montgomery music wire springs increased the pressure needed to depress the spring levers from 110 kg in the supplied traps to 154 kg (Houben *et al.* 1993) and appeared to reduce the mean injury score by 7 – 14 points in coyotes (Houben *et al.* 1993). In comparison to unpadded trap types (Victor #3 NM longspring, unpadded #4 Newhouse and Sterling MJ600) the Victor Soft-Catch #3 was found to have comparable capture rates and efficacy to the other trap devices under a range of trapping conditions. There was no difference among the four traps for capturing the paw below or across the pads, although the Sterling MJ600 had significantly fewer toe captures (Phillips *et al.* 1996c) (Table 11).

In a comparison of eight capture devices for coyote by the Denver Wildlife Research Centre (USA), the Victor Soft-Catch #3 modified with four coil springs and increased clamping force (3.6 kg cm^2, compared to 2.1 kg cm^2 for the standard model) produced less than half the mean injury score and higher capture rate (see Chapter 7.3) (CR = 0.97) compared to a laminated Northwoods #3 trap and was the most successful of all devices compared. While the EZ Grip trap and Belisle foot-snare appeared to produce marginally lower median injury scores, they had lower capture rates (CR = 0.88 and 0.64) respectively) (Andelt *et al.* 1999) and the WS-T snare produced more injury (Shivik *et al.* 2005). The # 3 ½ EZ Grip was compared with unpadded Stirling MJ600 and the unpadded Northwoods #3 with rolled steel laminations for the capture of coyotes. Trauma scores were based upon those proposed by Jotham *et al.* (1994) and the ISO trauma scales (Jotham *et al.* 1994) and median injury scores for the EZ Grip traps were significantly lower than for the other devices. Frame and Meier (2007) found that the EZ Grip trap cased no injury in 74% and 77% of adult and juvenile wolves. Using Victor Soft-Catch #2 and #3 traps, 61% of red foxes were found to have no injury (Englund 1982) (Table 11).

Australian studies that compared a range of devices designed to capture wild dogs and foxes revealed that Victor Soft-Catch traps seriously injured 28.3% of non-target animals and treadle-snares caused serious injuries to 17.1%. The severity of injuries experienced by animals caught in Soft-Catch traps varied between species, with wallabies (mostly *Macropus dorsalis* and *M. rufogriseus*) suffering either minor injuries, broken limb bones or dislocations (Fleming *et al.* 1998). Molsher (2001) used Victor #1 ½ Soft-Catch traps to target feral cats and observed that a non-target fox broke its leg. A cat was captured repeatedly within a relatively short period

(10 times in total): its left front leg was swollen and it limped on release. It was found dead two months later. Some foxes caught in 'Victor' traps sustained serious tissue damage and exposure of the metacarpal bone. Meek *et al.* (1995) found that animals dislocated their legs by entangling themselves and the trap in understorey vegetation while trying to escape, and the shock-absorbing effect of the spring and the swivel were rendered ineffective. Non-target birds were released with the loss of some leg scales after capture in Victor Soft-Catch traps (Meek *et al.* 1995). An adult fox was euthanased after capture by the scrotum in a Victor Soft-Catch trap (C.A. Marks, unpublished data). Marks *et al.* (2004) used fourth generation Victor Soft-Catch #3 fitted with a diazepam or placebo TTD to trap dingoes and assessed damage to soft tissue, bone, tendon, and cartilage, consistent with the scoring method described by Onderka *et al.* (1990). Chipped or broken teeth and total tooth damage scores were similar for the drug TTD and placebo TTD fitted traps. Limb damage was limited in both groups with 13/20 and 16/19 dingo limbs having no visible injury in the placebo and drug groups respectively. Compound fractures and bone damage was limited to a single case of a bone chip on a digit. Superficial damage was generally limited to small cutaneous lacerations and subcutaneous haemorrhage however there was no significant difference in the median limb damage scores for both groups (Marks *et al.* 2004). Research into the injury sustained by brushtail possums in New Zealand using Lane's-Ace and padded and unpadded Victor #1 and #1½ traps indicated that serious injuries were caused by traps without padding modifications (Warburton *et al.* 2004) (Table 11). Recent authors have encouraged further research with padded leg-hold traps as they appear to minimise injuries more than other models or modifications (Hubert *et al.* 1997) and are the thought to be a significant advance in preventing capture trauma (Phillips 1996).

Pressure necrosis and ischemia may arise from the use of traps or leg-hold snares that restrict blood flow to tissues for prolonged periods, and this may also be at least partly responsible for the initiation of self-mutilation (see Chapter 6.2.1). Ischemia has been described in wolves captured with leg-hold traps (Frame *et al.* 2007) but the degree to which this occurs in a range of traps is unknown. Dingoes trapped in Victor Soft-Catch #3 traps with modified springs showed signs of necrotic injury upon recapture and this was hypothesised to be a result of constriction caused by the rubber pads (Byrne and Allen 2008). Foxes housed in a research facility were originally trapped with the Victor Soft-Catch #3 trap and showed indications of mild to moderate oedema after removal from the trap and no other trauma. When held in captivity for approximately one week, some were found to develop tissue necrosis and erosions that caused the exposure of tendons (Figure 9d and 9e) (C.A. Marks and F. Busana, unpublished data). The incidence of this trauma in non-target species is not known, nor is the welfare implications of such injury in target species, as most are either euthanased or released before visible pathology develops. Self-mutilation of feet was observed in 2/10 coyotes trapped in Victor Soft-Catch traps that were modified for 40% greater spring tension and a 15 cm chain that restricted activity and movement (Houben *et al.* 1993). It was suggested that this may have been due to the Soft-Catch trap being more capable of numbing the coyote's foot (Houben *et al.* 1993), however the small sample (n=10) of animals taken with the alternative trap (modified Northwoods #3 coil spring) precludes any firm conclusions.

7.1.4 Laminated leg-hold traps

The #3 Northwoods offset jawed, coil-springed traps (Glen Sterling: Faith, South Dakota) were modified with 6.35 mm lamination strips and the average pressure required to depress the jaws was 198 kg. Coyotes captured in unpadded Victor #3 coil spring traps and Victor #3 long-spring traps had an incidence of injury 5-7.5 times greater than those captured in the modified Northwoods traps (Houben *et al.* 1993). The combination of doubling the width of the jaw area and offsetting jaws, strong springs and improved swivelling system were believed to be responsible for this, however there was no significant reduction in injury scores when compared to the Victor Soft-Catch trap, although these data were based upon small samples (n=10) (Houben *et al.* 1993). Injuries to coyotes using Northwoods #3 traps modified with unpadded, offset, wide-laminated jaws (12.8 mm) and centre mounted anchor chains where significantly higher than for padded #3 ½ EZ Grip long-spring traps (Phillips *et al.* 1996b).

Trap related injuries in red foxes using # 1 ½ coil spring traps were less serious when jaws were offset and laminated (Kern *et al.* 1994, in Hubert *et al.* 1997). However, no statistically significant reduction in injury was detected when larger Bridger #3 traps were modified with similar lamination (total width = 9.5 mm) and offset, although some reduction in mean injury scores (28% reduction in whole body injury) was implied (Hubert *et al.* 1997). In contrast, between 48-85% reductions in injury have been documented for coyote capture using the #3 Victor Soft-Catch trap (Olsen *et al.* 1986, Olsen *et al.* 1988, Onderka *et al.* 1990, Hubert *et al.* 1997) (Table 11).

7.1.5 Leg-hold snares

Iossa *et al.* (2007) reviewed the welfare performance of leg-hold snares and found that they are generally associated with less mortality than leg-hold traps. Approximately 51% of foxes captured with foot-snares (Nordic Sports AB: Kellefteå: Sweden) were found to have dental injury compared to 94% and 75% captured in Victor long-spring traps (Englund 1982). Cable restraints used in trials with the Belisle and WS-T snare caused swelling and lacerations as well as fractured and chipped teeth, probably from chewing the cable. When compared to the Collarum neck snare, both produced far greater injury scores (Shivik *et al.* 2000). The 'Rose Leg Cuff' uses a Kevlar band that encloses the trapped leg and has been used with success to restrain foxes and badgers in the UK, where the only trauma reported was temporary swelling of the trapped paw (Kirkwood 2005). In Australia, visible trauma associated with the treadle-snare was significantly reduced compared to large (Lane's) steel-jawed traps (Stevens and Brown 1987, Murphy *et al.* 1990, Fleming *et al.* 1998) and was believed to be similar to trauma caused by Victor Soft-Catch #3 traps (Meek *et al.* 1995). Meek *et al.* (1995) indicated that the most serious injuries sustained by foxes caught in treadle-snares were lacerations caused by the edges of the snare-locking bracket rubbing on the skin. Bubella *et al.* (1998) captured 71 red foxes with treadle-snares and three suffered broken legs and were shot. Most individuals showed swelling of the lower foreleg due to loss of circulation and skin abrasions, depending on the length of time spent in the trap. Forty red foxes that were radio-tracked and observed for up to two years following trapping showed no apparent long-term adverse effects such as visible deformation of limbs or limping. The nine individuals that were recaptured showed no sign of having been trapped previously as no scarring or thickening of the limb was seen. Fleming *et al.* (1998) indicated that approximately 55% of dogs, foxes and cats received no injury as a consequence of capture in the treadle-snare (Table 11).

The behaviour of different species when snared will greatly influence the amount of trauma sustained. For instance, after capture with a snare based upon the Aldridge snare throwing arm, lions (*Panthera leo*) appear to resist little and had no broken skin or injury (Frank *et al.* 2003). Snares used to capture black bears can cause swelling and lacerations around the restrained area and constant tugging can cause fractures, muscle, tendon, nerve and joint injury (Lemieux *et al.* 2006). In a study by Powell (2005), black bears were captured with Aldridge-type foot-snares and capture injury and blood biochemistry was compared with bears captured in their dens and those recovered with immobilising dart collars. Snaring resulted in less than 70% of the population incurring damages consistent with a score of ≤ 50 points according to the scoring system used by Powell and Proulx (2003). Blood biochemistry parameters corresponding to higher levels of exertion in snared adult bears in comparison with those recovered by dart collars and included elevated Gl, ALB, AP, ALT, LDH and CK. Dehydration was indicated by changes in Gl, ALB, ALB:globulin ratio and TP. Elevated CK and LDH were indicative of high levels of exertion during snaring relative to other recovery techniques (Powell 2005). Spring activated leg-hold snares (Margo Supplies: Alberta, Canada) used to capture grizzly bears caused elevated CK, AST and ALT which was suggestive of muscle damage following capture, related to tightening of the cable on the forelimb and excessive strain on the muscles and joints. A higher N:L ratio was typical of a stress leukogram as well as increased concentrations of Na and Cl^- that indicated dehydration as a result of being deprived of water for 2-23 hours aggravated by intense activity (Cattet *et al.* 2003). Elevation of muscle enzymes has also been reported for black bears (*Ursus americanus*) and polar bears (*Ursus maritimus*) captured by leg-hold snares (Lee *et al.* 1977, Schroeder 1987, Huber *et al.* 1997).

Compared to other recovery methods (cage traps, netting and Victor Soft-Catch #3 traps), foxes captured in treadle-snares had significantly higher mean ALB, CK, RCC, N:L ratio, Na, TP and white cell counts (WCC). Treadle-snares were also associated with higher Cl^-, Hb and packed cell volume (PCV) than cage trapping and netting. These were indicators of greater muscle damage, exertion and dehydration (Marks, in review, Appendix 1) similar to that reported in snared black bears (Powell 2005) and grizzly bears (Cattet *et al.* 2003). Treadle-snares were tethered to a solid fixture by a length of snare cable and chain that was 2 m in length, in contrast to 0.5 – 0.75 m chains that were used to anchor the Victor Soft-Catch traps (Marks, in review, Appendix 1). Foxes have the ability to run or leap to the end of the snare tether where they are brought to a sudden stop, while their coordinated movement appears to be impaired when caught in a leg-hold trap (C.A. Marks, personal observations). Longer tethers and an ability to develop large momentum before being pulled to a sudden stop may be associated with greater activity and muscle damage (Chapter 8.3). The apparently greater metallic noise associated with activated treadle-snares (Chapter 6.1.7 and Chapter 8.5) may be an additional stressor that promotes increased activity in comparison to that associated with the Victor Soft-Catch trap.

Limb oedema was an almost universal observation of red foxes that had been recovered by treadle-snares (Figure 6a and 6b) and Victor Soft-Catch traps (Figure 6c and 6d) and this was photo-documented in trapped foxes received by the Victorian Institute of Animal Science (Frankston, Victoria, Australia) and housed in the institute's fox facility (C.A. Marks and F. Busana, unpublished data). Some foxes captured with treadle-snares were found to have trauma typical of deep, compressive wounds, and lacerations caused by the locking bracket and cable. Oedematous swelling, which appeared to worsen within the first day after capture, was consistent with observations of ischemia and reperfusion injury (Chapter 6.2.1). In some animals, skin and muscle necrosis became apparent within 3-5 days of trapping and extensive erosion of the injury site was exacerbated by foxes licking and debriding the wound (F. Busana, personal observations). Tendon and bone was exposed and muscle tissue had a purple to crimson appearance typical of necrotic tissue (Figure 9a-9c). The progression of this pathology was believed to be consistent with that described for ischemic conditions leading to outcomes of long-term or permanent debilitation (Chapter 6.2.1). The time period that the foxes had been captive in the snare prior to recovery was unclear.

7.1.6 Neck snares

When set correctly, serious injury was reported to be relatively uncommon from non-lethal neck snares used in the UK, although mortality may be higher than for foot-snares due to their frequent misuse (Kirkwood 2005, Iossa *et al.* 2007). The welfare outcomes from neck snaring of foxes in the UK can be variable as the methods used to manufacture, set and monitor neck snares differ and the proportion of non-target species captured can range from 21-69% (Kirkwood 2005). The Collarum neck snare appears to be more target-specific than many leg-hold traps and snares as it uses a baited lure to trigger it and it is set above ground level, which may allow more selectivity for capturing coyotes (Shivik *et al.* 2000). The Collarum appears to causes few cases of major injury, with the most conspicuous trauma being tooth damage, probably from chewing on the cable (Shivik *et al.* 2000). While cases of deaths have been recorded due to the failure of the system to trigger correctly, this is relatively rare (Shivik *et al.* 2005). The ISO injury scores for two versions of the Collarum neck snare (2.5 and 5.4) were far lower than for the WS-T (12.3) and Belisle snare (22.5) (Shivik *et al.* 2000). When the Collarum was compared to the WS-T and Victor Soft-Catch in another study, damage scores were 2.5, 30.7 and 21.7 (scoring system after Phillips *et al.* 1996) respectively (Shivik *et al.* 2005). Neck snares equipped with diazepam tabs reduced the number of coyotes with oral lacerations and facial injuries (Pruss *et al.* 2002) and the potential to incorporate this approach with the Collarum snare may reduce injuries further (Table 11). Lethal wire neck snares were assessed in the field and of 65 coyotes recovered, only 59% were captured by the neck. Of the remainder, 20% were captured by the flank, 11% by the front legs and neck and 10% by the foot. Of these, 48% were found to be alive by morning although a proportion were moribund (Guthery *et al.* 1978). Using power neck snares, foxes could be rendered unconscious in a minimum of six minutes but the device also tended to capture some individuals around the body or head (Proulx *et al.* 1990).

Figure 9. Appearance of lower limb of foxes restrained by the treadle snare (a,b,c) and Victor Soft-Catch #3 trap (d,e) 6-11 days after capture showing various degrees of tissue necrosis and erosion exposing tendon and bone. Upon capture these foxes were all observed with oedematous swelling, but no other obvious trauma. Capture duration is unknown.

Table 11. Trap and snare type used to capture canids (wild dogs, dingo, wolf, coyote and red fox) and non-target species and the percentage with no injury (NIL), minor injury (MIN), major injury (MAJ) and those that were dead upon recovery (DEAD). (Minor injury = swelling, cutaneous, tendon or ligament lacerations corresponding to up to 20 points of trauma scale proposed by Tullar 1984, Olsen 1988, Onderka *et al.* 1990, Hubert *et al.* 1996. Major injury = trauma > 20 points corresponding to degrees of joint luxation, fractures or amputation. Minor injury corresponds to class I and II (Van Ballenberghe 1984, Kuehn *et al.* 1986, Frame and Meier 2007), < class III with class I corresponding to no injury (Fleming *et al.* 1998), class I, II and III (Stevens and Brown). Cause of death is inclusive of trauma from trap related injury or predation of captive animal.

TRAP AND SNARE TYPE	TARGET	N	% NIL	% MIN	% MAJ	% DEAD	AUTHORITY
Belisle foot snare	Coyote	16	1			0	Shivik *et al.* 2000
Bridger #3	Coyote	19	-	21	79	-	Hubert *et al.* 1997[1]
Bridger #3 (laminated-offset)	Coyote	29	-	28	72	-	Hubert *et al.* 1997[1]
Collarum neck snare (1998 version)	Coyote	16	0			0	Shivik *et al.* 2000
Collarum neck snare (1999 version)	Coyote	24	4			1	Shivik *et al.* 2000
Collarum neck snare	Coyote	13	30	62	0	7	Shivik *et al.* 2005
EZ Grip #7	Wolf (adult)	70	74.3	17.1	8.6	0.0	Frame *et al.* 2007
EZ Grip #7	Wolf (juv)	26	76.9	11.5	11.5	0.0	Frame *et al.* 2007
Lane's (large steel-jawed)	Dog, fox and cat	73	5.5	63.0	26.0	5.5	Fleming *et al.* 1998
Lane's (large steel-jawed)	Dog, fox and cat	123	3.3	65.9	27.6	3.3	Stevens *et al.* 1987
Lane's (large steel-jawed)	Non-target	56	8.9	32.1	46.4	12.5	Stevens *et al.* 1987
Lane's (large steel-jawed)	All	179	5.0	55.3	33.5	6.1	Stevens *et al.* 1987
Lane's (large steel-jawed)	Fox	268	-	35.4	64.6	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Rabbit	63	-	19	81	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Cat	114	-	54.4	45.6	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Wombat	88	-	86	14	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Possum	72	-	31	69	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Kangaroo	36	-	17	83	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Wallaby	153	-	38.6	61.4	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Bird	25	-	16	84	-	Murphy *et al.* 1990
Lane's (large steel-jawed)	Dingo	205	0?	-	16.1?	10.2	Thomson 1992
Lane's (padded)	Dog, fox and cat	313	33.6	50.5	15.9	0.0	Fleming *et al.* 1998
Lane's-Ace	Brushtail possum	78	-	71	30	-	Warburton 1992[1]
LPC #4	Wolf (adult)	38	13.2	31.6	55.3	0.0	Sahr *et al.* 2000
LPC #4	Wolf (juv)	47	44.7	48.9	6.4	0.0	Sahr *et al.* 2000
Newhouse #14	Wolf (adult)	91	5.5	61.5	33.0	0.0	Kuehn *et al.* 1986
Newhouse #14	Wolf (juv)	38	21.1	63.2	15.8	0.0	Kuehn *et al.* 1986
Newhouse #14	Wolf (adult)	21	4.8	95.2	0.0	0.0	Kuehn *et al.* 1986
Newhouse #14	Wolf (juv)	19	0.0	100.0	0.0	0.0	Kuehn *et al.* 1986
Newhouse #4	Wolf (adult)	182	7.1	52.2	41.2	0.0	Kuehn *et al.* 1986
Newhouse #4	Wolf (juv)	87	36.8	46.0	17.2	0.0	Kuehn *et al.* 1986
Newhouse #4	Wolf (adult)	81	9.9	51.9	38.3	0.0	Kuehn *et al.* 1986
Newhouse #4	Wolf (juv)	35	31.4	40.0	28.6	0.0	Kuehn *et al.* 1986
Nordic sport foot-snare	Red fox	115	83	15	3		Englund 1982
Smooth steel-jawed	Dog, fox and cat	20	40.0	50.0	10.0	0.0	Fleming *et al.* 1998
Steel-jawed (various)	Wolves	106			44		Van Ballenberghe 1984
Tomahawk snare	Coyote	7	14	43	29	14	Shivik *et al.* 2005
Treadle-snare	Dog, fox and cat	80	33.8	60.0	5.0	1.3	Stevens *et al.* 1987
Treadle-snare	Non-target	32	43.8	40.6	12.5	3.1	Stevens *et al.* 1987
Treadle-snare	All	112	36.6	54.5	7.1	1.8	Stevens *et al.* 1987
Treadle-snare	Dog, fox and cat	117	54.7	41.0	4.3	0.0	Fleming *et al.* 1998
Treadle-snare	Fox	71	-	-	4.2	-	Bubela *et al.* 1998
Treadle-snare	Fox	523	-	81.3	18.7	-	Murphy *et al.* 1990
Treadle-snare	Rabbit	14	-	79	21	-	Murphy *et al.* 1990
Treadle-snare	Cat	126	-	93.7	6.3	-	Murphy *et al.* 1990
Treadle-snare	Wombat	483	-	91.5	8.5	-	Murphy *et al.* 1990
Treadle-snare	Possum	79	-	73	27	-	Murphy *et al.* 1990

[1] Indicates scoring category may have some minor overlap or inconsistency when compressed into current injury category.

Table 11 (cont). Trap and snare type used to capture canids (wild dogs, dingo, wolf, coyote and red fox) and non-target species and the percentage with no injury (NIL), minor injury (MIN), major injury (MAJ) and those that were dead upon recovery (DEAD). (Minor injury = swelling, cutaneous, tendon or ligament lacerations corresponding to up to 20 points of trauma scale proposed by Tullar 1984, Olsen 1988, Onderka *et al.* 1990, Hubert *et al.* 1996. Major injury = trauma > 20 points corresponding to degrees of joint luxation, fractures or amputation. Minor injury corresponds to class I and II (Van Ballenberghe 1984, Kuehn *et al.* 1986, Frame and Meier 2007), < class III with class I corresponding to no injury (Fleming *et al.* 1998), class I, II and III (Stevens and Brown). Cause of death is inclusive of trauma from trap related injury or predation of captive animal.

			%	%	%	%	
TRAP TYPE	**TARGET**	**N**	**NIL**	**MIN**	**MAJ**	**DEAD**	**AUTHORITY**
Treadle-snare	Kangaroo	64	-	50	50	-	Murphy *et al.* 1990
Treadle-snare	Wallaby	281	-	64.8	35.2	-	Murphy *et al.* 1990
Treadle-snare	Bird	23	-	39	61	-	Murphy *et al.* 1990
Victor # 1½ unpadded	Brushtail possum	74	-	81	10	-	Warburton 1992[1]
Victor # 1 unpadded	Brushtail possum	72	-	87	12	-	Warburton 1992[1]
Victor #2 & #3 LS (coated)	Red fox	28	36	21	43		Englund 1982
Victor #2 and #3 LS	Red fox	117	61	9	30		Englund 1982
Victor Soft-Catch # 1	Brushtail possum	63	-	99	2	-	Warburton 1992[1]
Victor Soft-Catch # 1½	Foxes	48	-	62.5	37.5	-	Olsen *et al.* 1988
Victor Soft-Catch # 1½	Brushtail possum	82	-	93	7	-	Warburton 1992[1]
Victor Soft-Catch #1½	Foxes	30	-	93.3	6.7	-	Olsen *et al.* 1988
Victor Soft-Catch #3	Coyote	36	-	47.2	52.8	-	Olsen *et al.* 1988
Victor Soft-Catch #3	Wild dog	13	7.7	76.9	15.4	0.0	Stevens *et al.* 1987
Victor Soft-Catch #3	Wild dog	170	60.0	20.6	19.4	0.0	Fleming *et al.* 1998
Victor Soft-Catch #3	Red fox	75	46.7	30.7	22.6	0.0	Fleming *et al.* 1998
Victor Soft-Catch #3	Feral cat	35	68.6	28.6	2.8	0.0	Fleming *et al.* 1998
Victor Soft-Catch #3	Dog, fox and cat	280	55.7	24.3	18.2	0.0	Fleming *et al.* 1998
Victor Soft-Catch #3	Birds	45	10.2	28.6	46.8	14.3	Fleming *et al.* 1998
Victor Soft-Catch #3	Lagomorphs	32	25.0	21.9	28.1	21.9	Fleming *et al.* 1998
Victor Soft-Catch #3	Macropods	29	3.5	17.2	62.1	17.2	Fleming *et al.* 1998
Victor Soft-Catch #3	Sheep	12	91.7	0.0	0.0	8.3	Fleming *et al.* 1998
Victor Soft-Catch #3	Possums	11	54.6	27.2	0.0	18.2	Fleming *et al.* 1998
Victor Soft-Catch #3	Varanids	11	27.3	0.0	45.5	27.2	Fleming *et al.* 1998
Victor Soft-Catch #3	Rufous bettong	9	44.4	22.2	22.2	11.1	Fleming *et al.* 1998
Victor Soft-Catch #3	Dingo	20	65.0	30.0	5.0	0.0	Marks *et al.* 2004
Victor Soft-Catch #3	Coyote	31	-	83.9	16.1	-	Olsen *et al.* 1988
Victor Soft-Catch #3	Coyote	24	4	88	8	0	Shivik *et al.* 2005
Victor Soft-Catch #3/TTD	Dingo	19	84.2	15.8	0.0	0.0	Marks *et al.* 2004
WS-T leg snare	Coyote	20	0			0	Shivik *et al.* 2000

[1] Indicates scoring category may have some minor overlap or inconsistency when compressed into current injury category.

7.2 Comparative capture rate

Capture rate (CR) is the ability of the trap to catch and hold an animal, which has sprung the trap. Linscombe and Wright (1988) defined CR as the number of animals captured divided by the potential captures. Potential captures include those animals that have escaped, or if known, those that failed to trigger the trap mechanism that were at the trap site. Under Australian conditions, the CR of Victor Soft-Catch traps (CR = 0.75) were shown to be significantly higher than those for the toothed Lane's traps (CR = 0.54). No significant difference in CR was found between Lane's traps and treadle-snares for dogs, foxes and feral cats combined (CR = 0.46) (Fleming *et al.* 1998). The capture rate for the Novak and Freemont snares did not differ in the capture of coyotes, yet was approximately three times less than for leg-hold traps, and Novak snares missed potential captures more frequently (Skinner *et al.* 1990). In general, the CR of snares appears to be lower for leg-hold traps and the Belisle (CR = 0.64, 0.78), Panda (CR = 0.08) and WS-T snares (CR = 0.66, 0.88) mostly under-perform contemporary Victor Soft-Catch devices. Although earlier versions of the Collarum neck snare appeared to have less efficacy (CR=0.41) (Shivik *et al.* 2000), later versions may have improved this (CR=0.87) (Shivik *et al.* 2005). It is notable that earlier studies using the first generations of Victor Soft-Catch #3 traps reported reduced CR (eg. CR = 0.32, 0.66, 0.49, 0.95), yet all studies conducted after 1996 with coyotes indicate improved results (CR = 0.82, 0.97, 0.95, 0.95, 0.91, 1.0). This suggests superior performance to past versions and comparable performance to unpadded leg-hold devices of the same size. It is unlikely that few (if any) of the Australian Victor Soft-Catch #3 trap data used in the study by Fleming *et al.* (1998) related to fourth generation traps, since this study collated data from the late 1980's to early 1990s that was in part reported by Stevens and Brown (1987), and pre-dated these trap modifications (Table 12).

Linhart and Dasch (1992) indicated that coyote capture rates for modified ('fourth generation') Soft-Catch traps were comparable with the unpadded leg-hold trap models which are favoured by trappers (CR = 0.79). In one study much lower CR has been reported for Victor Soft-Catch traps during wet conditions (Kern 1994, in Andelt *et al.* 1999) and when light soils are used for trap placement for coyotes (CR = 0.32) and bobcats (CR = 0.66) (Holt and Connor 1992, in Houben *et al.* 1993) while the Victor # 1.75 q-coiled off-set jawed trap had a superior CR for coyotes (CR = 0.92) and bobcats (CR = 1.0). However, under a range of operational conditions there was no indication of reduced performance from the Victor Soft-Catch trap in operational studies when trappers closely followed setting instructions (Phillips *et al.* 1996c). The fourth generation of the #3 Victor Soft-Catch that was re-engineered to have a faster closure was found to be equal in its performance to unpadded traps (Skinner and Todd 1990, Linhart and Dasch 1992, Phillips *et al.* 1992). When compared to the #4 Newhouse (CR = 1) Victor NM long-spring trap (CR = 1), the high capture rate (CR = 0.95) was similarly attributed to users closely following the manufacturer's setting instructions (Phillips *et al.* 1992). Coyotes were taken more effectively with M-44 cyanide ejectors than with the Oneida-Victor No 3 and No 4 traps in a trial of various control devices in Texas (Beasom 1974), although other studies found a similar level of success (Windberg *et al.* 1990).

Table 12. Trap type and target species and capture rate (CR) measured as the number of animals captured / potential captures for target species in each region.

TRAP AND SNARE TYPE	SPECIES	CR	REGION	AUTHORITY
Belisle foot snare	Coyote	0.78	rural USA	Shivik *et al.* 2000
Belisle foot snare	Coyote	0.64	rural USA	Andelt *et al.* 1999
Collarum neck snare	Coyote	0.87	rural USA	Shivik *et al.* 2005
Collarum neck snare	Coyote	0.41	rural USA	Shivik *et al.* 2000
EZ Grip #3 padded	Coyote	0.88	rural USA	Andelt *et al.* 1999
Heimbrock Special	Coyote	0.94	rural USA	Andelt *et al.* 1999
Newhouse #4	Coyotes	1	rural USA	Phillips *et al.* 1992
Newhouse #4	Coyote	0.89	rural USA	Phillips *et al.* 1996c
Newhouse #4	Coyote	0.83	rural USA	Phillips *et al.* 1996c
Newhouse #4 pan tension	Coyote	0.87	rural USA	Phillips *et al.* 1996a
Northwoods #3 laminated	Coyote	0.95	rural USA	Andelt *et al.* 1999
Lane’s padded	Dogs and foxes	0.83	rural Australian	Fleming *et al.* 1998
Panda foot snare	Coyote	0.083	rural USA	Shivik *et al.* 2000
Lane’s toothed	Dogs and foxes	0.54	rural Australian	Fleming *et al.* 1998
Sterling MJ 600	Coyote	1	rural USA	Phillips *et al.* 1996c
Sterling MJ 600	Coyote	1	rural USA	Phillips *et al.* 1996c
Sterling MJ 600	Coyote	0.94	rural USA	Andelt *et al.* 1999
Treadle-snare	Dogs and foxes	0.46	rural Australian	Fleming *et al.* 1998
Victor #1.75 coiled off-set jaw	Coyotes	0.92	rural USA	Houben *et al.* 1993
Victor #1.75 coiled off-set jaw	Bobcats	1	rural USA	Houben *et al.* 1993
Victor #3 coil spring	Coyote	0.91	rural USA	Linhart *et al.* 1992
Victor #3 NM long-spring	Coyotes	1	rural USA	Phillips *et al.* 1992
Victor #3 NM long-spring	Coyote	0.95	rural USA	Phillips *et al.* 1996c
Victor #3 NM long-spring	Coyote	0.91	rural USA	Phillips *et al.* 1996c
Victor #3 NM long-spring	Coyote	0.95	rural USA	Andelt *et al.* 1999
Victor #3 NM long-spring pan tension	Coyote	0.91	rural USA	Phillips *et al.* 1996a
Victor #3 NR and OS offset	Coyote	0.73	rural USA	Linhart *et al.* 1986
Victor #3 NR padded	Coyote	0.51	rural USA	Linhart *et al.* 1986
Victor 3NM long-spring off-set jaws	Coyote	0.83	rural USA	Linhart *et al.* 1992
Victor Soft-Catch #3	Dogs and foxes	0.75	rural Australian	Fleming *et al.* 1998
Victor Soft-Catch #3	Coyotes	0.32	rural USA	Houben *et al.* 1993
Victor Soft-Catch #3	Bobcats	0.66	rural USA	Houben *et al.* 1993
Victor Soft-Catch #3	Coyotes	0.95	rural USA	Phillips *et al.* 1992
Victor Soft-Catch #3	Coyote	1	rural USA	Shivik *et al.* 2005
Victor Soft-Catch #3	Coyote	0.95	rural USA	Phillips *et al.* 1996c
Victor Soft-Catch #3	Coyote	0.91	rural USA	Phillips *et al.* 1996c
Victor Soft-Catch #3	Coyote	0.95	rural USA	Andelt *et al.* 1999
Victor Soft-Catch #3	Coyote	0.49	rural USA	Linhart *et al.* 1986
Victor Soft-Catch #3	Coyote	0.79	rural USA	Linhart *et al.* 1992
Victor Soft-Catch #3 modified	Coyote	0.97	rural USA	Andelt *et al.* 1999
Victor Soft-Catch #3 pan tension	Coyote	0.818	rural USA	Phillips *et al.* 1996a
WS-T snare	Coyote	0.66	rural USA	Shivik *et al.* 2000
WS-T snare	Coyote	0.88	rural USA	Shivik *et al.* 2005

7.3 Comparative capture efficacy

Capture efficiency (CE) is usually defined as the number of target captures per trap set standardised as captures per 100 or 1000 trap-nights (Boggess 1990). The CE measure is affected by the expertise of the trapper, population density of the target and non-target animals, previous exposure of the targeted population to trapping, the sex and age structure of the targeted population, seasonal and site characteristics, baits and lures used and the pre-baiting period (Novak 1987). Given the difficulty in controlling for these variables, CE is a highly biased measure and comparative assessments between sites using different techniques should be done cautiously (Fleming *et al.* 1998). Minor variations in trap setting practices may have major implications for CE. For example, coyotes were found to be more susceptible to capture outside or on the edge of their normal range, if they were between 1-2 years old and when olfactory attractants were used to enhance trapping success (Windberg *et al.* 1990). McIlroy *et al.* (1986) used modified Oneida leg-hold traps to capture wild dogs in south-eastern Australia and the CE obtained (CE = 1.56) was similar to that obtained for toothed Lane's traps and treadle-snares but smaller than CEs obtained for padded Lane's and Soft-Catch traps (Fleming *et al.* 1998). Data from Newsome *et al.* (1983) revealed a CE = 0.58 and 1.72 for toothed Lane's and Oneida traps respectively. Although highly biased, these data imply that padding modifications and use of smaller traps did not reduce capture of dingoes and foxes under Australian conditions.

7.4 Practicality

Meek *et al.* (1995) reports that the treadle-snare was effective for capturing foxes under ideal conditions but was bulky, prone to malfunctions and difficult to transport. The Freemont foot-snare also requires more time to set and more regular maintenance than leg-hold traps, and a new snare noose is required after each capture (Mowat *et al.* 1994), as is the case with the treadle-snare (Meek *et al.* 1995). Treadle-snares were used to capture 40 individual foxes in Kosciusko National Park and of 136 snares that were sprung, 71 foxes were captured overall (ie. some more than once). Approximately 50% of sprung snares were thought to be related to missed foxes and associated with the difficulty in reliably setting treadle-snares (Bubela *et al.* 1998). Treadle-snares were used to capture feral cats but in comparison to Victor Soft-Catch traps they were considered expensive, bulky to transport and difficult and time consuming to set (Short *et al.* 2002).

7.5 Discussion and Conclusions

Padding of trap jaws has been attempted with cloth, plastic or rubber tubing in a number of Australian studies, however no comprehensive assessment of the welfare benefits from this approach can be found. Such modifications probably result in less injury than produced by unmodified devices, yet are unlikely to produce outcomes comparable to commercially available devices that have undergone progressive testing and modification. Devices that have been altered without regard for a stated specification or standard do not permit comparative welfare benefits to be known. A large range of modifications have been made to existing leg-hold trap devices in an attempt to meet injury threshold limits in North America.

There is no compelling evidence to suggest that trap lamination delivers welfare outcomes superior or comparable to those associated with commercially available padded leg-hold traps. Increasing the spring energies and closing velocity of padded traps reduces the number of captures at the extreme ends of the paw that are often implicated in higher rates of injury. As this modification also increases the impact force of the jaws upon capture, the use of materials such as rubberised padding may be necessary to dissipate forces that could otherwise produce acute trauma upon trap closure. There is some data that suggests that this may enhance ischemia, however there is no clear indication as yet that this is significantly greater than for other devices that have similar closing and clamping forces. It is difficult to compare the potential for different traps to cause ischemic injury without reference to their relative closure speeds, clamping forces and jaw characteristics, and the outcomes that these imply. As prolonged ischemia may produce necrotic injury only after many days, the most significant potential welfare impact could be for non-target animals that are released from traps.

The Victor Soft-Catch #3 trap has been extensively field tested in North America and has received some assessment in Australia. The device has undergone at least four ‘generations’ of modification and while earlier versions of the trap were found to be less efficient and reliable than unpadded traps, current versions appear to be at least equivalent in performance. Studies in New Zealand have shown that smaller versions of the Victor Soft-Catch trap produce comparatively better welfare outcomes for brushtail possums which are an important non-target species in south-eastern Australia. The Victor Soft-Catch devices (and possibly the EZ Grip traps that are the subject of much fewer published studies) probably differ from other leg-hold traps in that they are new designs conceived for reducing trap trauma, rather than developed through adaptation of existing devices.

It has been noted that in general, leg-hold snares appear to produce far less trauma than a wide range of leg-hold traps (Iossa *et al.* 2007). The treadle-snare produced comparable injury scores to the Victor Soft-Catch trap (Meek *et al.* 1995, Fleming *et al.* 1998). Biochemical indicators of stress in red foxes captured by treadle-snares suggest higher levels of muscle damage, activity and dehydration (Marks, in review, Appendix 1). Given relatively low levels of impairment in locomotion using snares, a greater degree of activity may be possible, allowing greater acceleration and momentum and this could be implicated in trauma and stress (see Chapter 8.3). It is likely that the greater skill and familiarity required to use the treadle-snare effectively will result in outcomes that are less predictable than those from a simpler leg-hold trap mechanism.

The period of time that the animal spends in the trap is related to the injury and stress it sustains but the majority of studies fail to account for capture duration. Disregarding the influence of capture duration during trap studies often implies that a trap is expected to produce similar injury scores irrespective of the period of captivity. However, greater periods spent resisting the traps are known to contribute to overall trauma and are strongly linked to welfare outcomes. Stress such as anxiety, fear and a range of other pathologies cannot be measured by injury scores alone (see Chapter 5) and quantification of observed trauma as the primary welfare indicator has not fostered wider consideration of overall stress and welfare impacts. For example, tooth injury that exposes the pulp cavity has the capacity to inflict severe pain and debilitation in carnivores (see Chapter 6.2.1) and probably occurs relatively soon after capture. Rapid euthanasia of an animal that has suffered painful injury will deliver the best welfare outcome as this reduces the time period it remains in the trap and the potential suffering.

Trappers may be reluctant to adopt new trap designs that reduce injury unless they can be shown to have comparable efficacy to those in present use (Warburton 1982, Novak 1987). Although padded traps have been shown to be efficacious and humane relative to commonly used devices in North America, voluntary use of padded traps was reported to be low and the standard trap in use (in 1997) was the unpadded #3 coil spring trap (Hubert *et al.* 1997). Despite being available in the United States since 1984, padded traps in 1992 comprised only 3% of leg-hold traps owned by trappers (in Aldelt *et al.* 1999). Scepticism about research results and the increased cost of trap replacement (Phillips 1996), together with reports of lower capture efficacies associated with earlier models (Linscombe *et al.* 1988, Andelt *et al.* 1999) may account for poor adoption of padded traps in North America (Phillips 1996).

There is sufficient evidence to conclude the fourth generation Victor Soft-Catch traps (and possibly other devices such as the EZ Grip trap) have equivalent performance for the capture of canids with better welfare outcomes than unpadded traps.

8.0 METHODS TO IMPROVE WELFARE OUTCOMES

A range of modifications has been made to trapping devices and field practices to promote better welfare outcomes and target-specificity and these are summarised in Table 13. Major categories of modifications are discussed in this chapter with reference to the potential scope for improving the welfare outcomes of leg-hold trapping in Victoria.

8.1 Assessing trap performance

Evaluation of trap performance and routine testing of traps will reduce the likelihood of trap failure and poor welfare outcomes (Iossa *et al.* 2007). Closure speeds of traps will affect capture rates as some species are capable of recoiling rapidly (Johnson *et al.* 1986). The accumulation of surface soil and rust during the life of a trap increases the amount of friction that its springs need to overcome when triggered and indicates poor trap maintenance[7]. The mean trap closure speed of Victor #3 double coil and 3N long-spring traps was measured at between 18.59-18.52 mS (Johnston *et al.* 1986) and mechanical testing revealed that some Victor Soft-Catch #3 traps had insufficient clamping force to be effective (Earle *et al.* 2003). Replacement of springs in Victor Soft-Catch #3 traps or the use of additional springs was found to be necessary maintenance for traps used for dingo control (Lee Allen, personal communications). Excessive trap closure times increased trap injury scores and was associated with a greater number of bobcats being held by their toes rather than higher on their paw (Earle *et al.* 2003). Given the variability in testing conditions encountered in the field, standardisation of mechanical trap testing is required (Linhart *et al.* 1986).

Figure 10. Injury resulting from restraint by the digital pads from a padded steel-jawed (Lane's) trap set in eastern Victoria in 2006. Trap closure speed will influence the position on the limb that animals will be held and slower closing devices are typically associated with capture by the digits and higher injury scores.

The performance of kill traps can be assessed in order to ensure their ability to cause rapid death for target species and the impact energy, trap closing time and clamping force are commonly assessed (Gilbert 1976, Zelin *et al.* 1983, Johnston *et al.* 1986). The development of performance criteria for kill traps for racoons, mink, muskrats, beaver (Gilbert 1976) and brushtail possums (Warburton *et al.* 1995, Warburton *et al.* 2000) enabled the development of traps that would produce rapid unconsciousness and death. The use of anaesthetised animals has been a standard practice in conducting these trials, yet it is probable that in some species

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[7] Standard operating procedures used for trap maintenance should include regular cleaning, boiling in dye and waxing before being reset in a new location. This procedure replaces human and/or canid odours with neutral odours and lubricates and protects traps from corrosion (Lee Allen, personal communication).

these data may not reflect realistic times for loss of sensibility (Hiltz *et al.* 2001). Assessment of trap performance in an artificial setting cannot fully mimic the conditions and animal behaviours encountered in field situations. Kreeger *et al.* (1990) found that haematological, endocrine and biochemical indicators in wild caught red foxes varied significantly from those habituated and used in captive trials.

8.2 Trap inspection times

Increased periods of confinement in leg-hold traps are associated with correspondingly larger exertion, struggling and injury (Powell *et al.* 2003). Daily inspection of traps set for exotic brushtail possums in New Zealand is mandatory (Warburton 1992, Morris *et al.* 2003) under the Animal Welfare Act (NZ). In Sweden, trap inspection times must not be less than twice per day and this may account for the relatively low injury scores for foxes trapped in leg-hold traps and snares in the trial reported by Englund (1982). In the United States (in 1995), 33 states required that traps must be inspected every 24 hours. Early morning trap checking reduces the level of injury sustained by many trapped animals (Novak 1987, Proulx *et al.* 1994b, Andelt *et al.* 1999). Some researchers inspect traps twice each day in times of excessive heat (Logan *et al.* 1999) or early the following morning (Powell 2005). Trapping of species with high conservation value will often result in more attentive trap inspections such as the setting of traps at dusk and inspection and clearance at dawn (McCue *et al.* 1987).

During the harvesting of Arctic foxes using # 1½ steel-jawed traps, daily inspection was associated with 2/97 (2%) trap deaths compared with 14/58 (24%) deaths where foxes had been held longer (Proulx *et al.* 1994b). In most studies, the period that animals have been held in the trap is almost always imprecise and based upon periods between inspections. Some Australian studies are notable in that they report inspections periods of 48 hours (Stevens *et al.* 1987), irregular inspection periods (Fleming *et al.* 1998) or fail to report inspection periods (Thomson 1992) (Appendix 3). McIlroy (1986) noted that trapping practice for dingoes in south-eastern NSW could be inhumane if traps are not visited each day.

Increasing the frequency of trap inspections and human presence at the trap site is thought to reduce trapping success for wild dogs and is one reason why frequent trap inspection periods are avoided by some trappers (Lee Allen, personal communication). There are no published studies that indicate the degree to which increased frequency of inspection affects trapping success. It should be noted that if traps are inspected at dawn and then at dusk the following day (ie. daily), inspection times may allow some 36 hours to elapse (Fox *et al.* 2004, Iossa *et al.* 2007). Daily (ie. once each 24 hour period) inspection appears to be a minimum accepted world-wide standard to reduce trapping injury and more frequent inspection regimes would produce correspondingly greater welfare benefits.

8.3 Trap anchoring

Leg-hold traps and snares can be attached to fixed anchor points or a ‘drag’ such as movable objects or a grappling hook. The primary welfare advantage of drags is that an animal can seek cover and there is less resistance when pulling at the cable (Kirkwood 2005). This may be important when traps are set in exposed locations that offer no shelter from the sun, especially in arid environments (Lee Allen, personal communication). However, drags allow some animals to move to areas where they cannot be found. Englund (1982) reported that 13% of foxes held in leg-hold snares moved the drag more than 500 m from point of capture. Some authors consider that the ability of animals to be tangled in snares and trap cables is exacerbated using drags and is responsible for major injury such as fractures and dislocations

(Linhart *et al.* 1988, Logan *et al.* 1999, Powell 2005). It is likely that the attachment type most suited to a particular application will be dependent upon the habitat in which it is used and behaviour of the particular target and non-target animals. In some environments that do not have a suitable substrate to permit anchoring of trap stakes (such as loose sandy soils), a drag may offer the best welfare outcome if it is less likely that an animal will escape with a trap attached to its leg (Lee Allen, personal communication).

Body weight range may be an important influence on the trauma experienced from trapping (Seddon *et al.* 1999, Iossa *et al.* 2007). Many predators have evolved an ability to accelerate from a standing position at greater rates than prey species, so that a short and efficient chase allows them to capture prey without reaching top speed (McNeil Alexander 2006). In general, the smaller an animal's mass the shorter the distance it will need to accelerate to its maximum speed. Over short distances, some species can accelerate by leaping, using the leveraging of muscle forces and the storage of elastic energy in tendons to produce significant momentum over a very short distance that is then resisted by the anchoring chain. The forces (F) measured in Newtons produced by an animal can be approximated from its mass (m) and acceleration (a):

$$F = ma$$

The momentum (p) is given by the relationship between mass and velocity (v), where acceleration is velocity / time:

$$p = mv$$

Macropodids such as the eastern grey kangaroo accelerate to 67 m s^{-1} and potoroos to 100 m s^{-1} before the 'take off' speed necessary to leave the ground is reached (Nowak 1991), yet a species of intermediate mass such as the racing greyhound reaches maximal horizontal acceleration of 15 m s^{-1} and can do so in the first two strides (Williams *et al.* 2007). If tethers that bring them to a sudden stop close to maximum acceleration and take off speed restrain animals, these forces will be transferred to them as the tether resists their forward momentum. These forces will be largely dissipated by mechanical stress upon their body and will be responsible for much of the trauma inflicted by leg-hold traps. Animals of significant mass that have relatively greater potential for rapid acceleration (such as macropods), will absorb greater forces by virtue of their ability to attain greater momentum. Animals cannot accelerate towards a maximum speed instantaneously and the degree to which they are able to accelerate will depend upon how impaired they are by the attachment of the capture device and the length of the tether that allows them to accelerate towards a maximum speed.

There appear to be four main approaches for minimising forces of momentum and injury;

1. Reduce the restraining cable to the shortest length possible so that the potential for acceleration is minimised;

2. Use a trap device that impedes the animal's normal locomotion so that acceleration is reduced by disrupting normal gait;

3. Attach the trap tether to a drag that allows part of the force developed by momentum to be dissipated by its resistance and elasticity;

4. Use in–line springs in the restraining cable to absorb the kinetic energy that would otherwise be transferred to the animal.

It is possible that the treadle-snare does not restrict locomotion of some species as significantly as the Victor Soft-Catch leg-hold trap as the snare cable allows the foot or paw of the trapped animal to remain in contact with the ground and allows relatively normal locomotion.

Therefore, the treadle-snare permits far greater potential for an animal to accelerate and produce forward momentum, especially if the restraining cable is long (Marks, in review, Appendix 1).

Drags and in-line springs may permit the dissipation of kinetic energy and reduce the potential for injury, but they do so at a net energy cost to the animal, as work must be done to move the drag or resist the springs. Drags produce an inconsistent and unpredictable amount of resistance dependent upon their weight and the friction that they offer in the different environments in which they are used. Better welfare outcomes may be obtained if energy expenditure is minimised and there is less potential for an animal to become exhausted, hyperthermic, dehydrated or food stressed. Indications of muscle damage and dehydration in foxes and bears restrained by leg-hold snares suggest high levels of activity with consequent higher energy expenditure (Cattet *et al.* 2003; Powell 2005; Marks, in review, Appendix 1). Anchoring a trap with a short restraining chain has been described as a way to reduce energy expenditure, injury and dehydration in other studies (Table 13).

The specification of in-line springs in trap chains should be adequate to ensure that the large forces of momentum produced by macropods are based upon a realistic calculations of forces produced, given the length of the chain, potential acceleration and upper body mass. Adoption of in-line spring specifications that have been developed in North America are unlikely to have catered for species such as macropods that are capable of developing larger amounts of momentum over shorter distances. Macropodids are a very common non-target species in south-eastern Australia (Chapter 4: Table 2) and this warrants specific research to develop appropriate specifications for in-line springs.

Centre-anchored chains that attach to the base of traps permit swivels to operate more effectively than chains attached to the side of the trap and probably contribute to better welfare outcomes by reducing torsional resistance (Linhart *et al.* 1988, Hubert *et al.* 1997, Lee Allen, personal communication). Such modifications should probably be made mandatory for all leg-hold trap devices.

8.4 Deactivation of traps

Using video systems to monitor coyote traps in the USA, a temporal partitioning of target and non-target species activity was observed. Between 0600 hrs and 1800 hrs over 81% of potential non-target species were observed, corresponding to when no coyotes were recorded. The authors conclude that diurnally inactivated trap systems could exclude the majority of non-target species without affecting trap efficacy (Shivik *et al.* 2002) although a suitable inactivating mechanism to perform this was not specified. A temporal bias towards captures of dingoes was detected in one study that used a capture data logger on traps (Figure 11) (Marks *et al.* 2004). Other authors have suggested that desisting from trapping or deactivation of traps during temperature extremes could assist in reducing trap deaths (Logan *et al.* 1999, Pruss *et al.* 2002). Most of the non-target mammals identified (Chapter 4.2) in south-eastern Australia are nocturnal as appears to be the case with target canids in many regions, yet bird species such as emus, corvids and lyrebirds are strongly diurnal (Schodde *et al.* 1990) as are goannas (Cogger 2000) and their capture may be reduced by diurnal deactivation of traps. Frequent trap inspection periods are avoided by some trappers given the belief that this will affect trap success (Lee Allen, personal communication). The degree to which site disturbance from manual deactivation of traps may affect trapping success has not been the subject of any published studies.

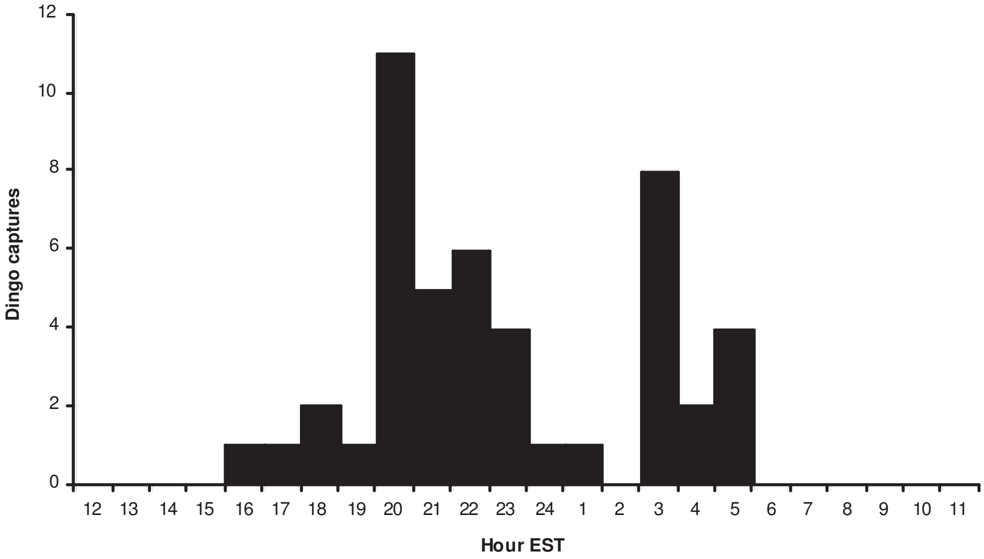

Figure 11. Time of capture (hours EST) for dingoes (n=48) trapped with Victor Soft-Catch #3 traps at Bulloo Downs (Queensland) during the study conducted by Marks *et al.* 2004.

8.5 Trap noise

There have been no published studies that address the significance of trap noise after capture on welfare outcomes, despite acoustic stressors being well known to produce stress in a range of situations (Chapter 6.1.7). Acoustic stressors produced by treadle-snares relative to Victor Soft-Catch traps may be one reason to account for elevated haematological and biochemical indicators of stress in red foxes captured by the former (Marks, in review, Appendix 1).

8.6 Trap size and weight

Padded Lane's traps were significantly less selective than Victor Soft-Catch traps and another three devices assessed by Fleming *et al.* (1998). Newsome *et al.* (1983) caught proportionately more large native animals in toothed Lane's traps than in smaller Oneida traps[8]. Lane's traps are 1.6 x greater in area when set than Oneida traps, with 383 cm^2 and 240 cm^2 capture areas respectively (Newsome *et al.* 1983). Differences in capture rates could be accounted for by better selectivity given the relative sizes and shape of macropod feet and the size of the spread of the jaws. The weight of traps may also influence welfare outcomes; the increased weight of the EZ Grip padded trap compared to the Victor Soft-Catch #3 was suggested to be a possible reason for an observed increase in bone fractures (Phillips 1996). Selection of a lightweight trap system may make a significant contribution towards reducing injury, but this has not been investigated in any detail and warrants further research. Padding, lamination or other modifications made to large steel-jawed traps may have limited value if the trap weight and jaw spread is implicated in bone fractures (Figure 12).

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[8] In this study, each device was used by a different group of trappers and the different field methods used to set these traps could have introduced an unknown bias.

Figure 12. Older styled (modified) long-spring leg-hold traps are substantially heavier and have a larger 'jaw spread' than many contemporary (coil spring) leg-hold trap devices. Their weight and tendency to catch animals higher on the leg appears implicated in increased fractures and amputations.

8.7 Pan tension

Turkowski *et al.* (1984) found that increasing the pan tension to prevent smaller animals springing the trap could enhance the selectivity of coyote traps. The US Department of Agriculture (Animal Damage Control) mandated the use of pan tension devices on all their leg-hold traps (Phillips *et al.* 1996a). Animals of comparable weight to target coyotes such as bobcats, porcupines (*Erethizon dorsatum*) and racoons are not generally excluded by pan tension devices. Overall, leaf spring tension devices were able to exclude 100% of smaller non-target species (by increasing pan tension to approximately 1.4 – 1.8 kg for coyotes), compared to only 6% exclusion by a standard trap set. This was found to reduce the potential capture rate of coyotes only marginally (CR = 0.92 v CR = 0.98) when compared to a standard trap device (Turkowski *et al.* 1984). The Paws-I-Trip® pan tension device (and other devices such as the 'Stirling Pan System') can be fitted to a range of traps and adjusted to provide a variable pan tension. Non-target exclusion rates for Victor Soft-Catch #3, Victor 3NM and Newhouse #4 traps were 99.1%, 98.1% and 91% and while exclusion was lower for heavier non-target species, rabbits and hares were excluded on 98.6% of occasions (Phillips 1996). Incorrectly set tensioning devices may exclude the capture of some coyotes, but given that non-target animals were captured far less often, the overall trapping efficacy was increased because more traps were unoccupied and required reduced effort to reset and release non-target species (Turkowski *et al.* 1984). Assessment of the Paws-I-Trip pan tension device suggested that its use on three types of traps did not adversely affect the performance of the traps (Phillips 1996).

Body weight differentials between species may be some guide to the potential success of pan tensioning systems, but should be used with caution in predicting selectivity. Other factors such as locomotor patterns (eg. quadrupedal or bipedal locomotion) and weight distribution vary between species (Turkowski *et al.* 1984). However, based upon the upper weight range of non-target species alone (Chapter 4.2: Table 2) it is possible that non-target species such as wallabies, kangaroos, wombats and goannas may overlap in weight with wild dogs and fail to be excluded by pan tensioning.

Pan tensioning is one of the most well proven, practical and inexpensive ways to increase target-specificity and promote better welfare outcomes of trapping. It will be most effective if applied to standard trap types and trap setting procedures and if based upon empirical studies that seek to understand the most appropriate trigger forces that allow reliable capture of target species and exclusion of non-targets. Temperature variation and wear from constant usage can influence the reliability of a trap trigger mechanism (Drickamer *et al.* 1993). Regular assessment of the performance of pan tensioning devices should be undertaken in the normal maintenance of overall trap performance.

8.8 Tranquilliser Trap Device (TTD)

The tranquilliser trap device was developed to eliminate or reduce injuries sustained by coyotes in steel-jawed traps that were the result of the animal's struggle to escape the trap (Balser 1965). Delivery of diazepam (Balser 1965) and propiopromazine (PPZH) (Linhart *et al.* 1981) by TTDs reduced the extent of foot injuries received by coyotes captured in leg-hold traps. Additional trials have shown that PPZH delivered by TTDs reduced the severity of limb injuries sustained by grey wolves (*Canis lupus*) (Sahr *et al.* 2000) and tabs used on neck snares containing diazepam reduced the degree of facial injuries and oral laceration associated with coyote captures with neck snares (Pruss *et al.* 2002). Appropriately selected drugs may have the potential to depress the activity of captive animals and reduce tooth damage and limb trauma that is a consequence of repeated pulling and biting at traps. Dingoes caught in traps fitted with a TTD containing diazepam were found to have sustained tooth damage that was not significantly different from the placebo group. Neither the duration of capture nor mean activity was related to the tooth damage sustained by each dingo. Drug TTDs reduced limb damage and produced a lower injury score overall, but this was not statistically significant when compared to the placebo group (Marks *et al.* 2004). These data suggested that much of the tooth damage and limb injury sustained by trapped dingoes may occur quickly after capture when activity levels (in the placebo group) are up to four times greater than in subsequent hours. From the time of capture, drug onset is unlikely to be rapid enough to prevent tooth damage unless it can be greatly accelerated (Marks *et al.* 2004).

Drugs that reduce anxiety may mitigate distress associated with capture and drug choice will be important to ensure a beneficial reduction in anxiety and fear. It is thought that all vertebrate species possess specific receptor sites for benzodiazepine drugs, which influence states of anxiety (Rowan 1988). For diazepam, receptor affinity correlates well with behavioural potency and includes anxiolytic, sedative-hypnotic, muscle relaxant and anti-convulsant effects (Feldman *et al.* 1996). Moe and Bakken (1998) used an intramuscular dose of 5 mg kg^{-1} of diazepam, which resulted in mild sedation and did not appear to affect co-ordination but successfully reduced stress-induced hyperthermia in foxes. An oral dose of 10 mg kg^{-1} apparently produced heavier sedation, accompanied by an obvious loss in co-ordination (Marks *et al.* 2000, Marks *et al.* 2004). It is reasonable to assume that diazepam used in prior TTD studies (Balser 1965, Pruss *et al.* 2002, Marks *et al.* 2004) provided anxiolysis without any observed mortality from drug toxicity. Phenothiazine tranquillisers (ie PPZH) block dopamine receptors, have anticholinergic, antihistamine, antispasmodic and α-adrenergic blocking effects and are widely used as sedatives (Plumb 1999). Some of the drugs in this group may be a poor choice for managing fear and phobia related behaviours and may produce sedation without or with limited anxiolysis. Acepromazine (a phenothiazine drug similar to PPZH) failed to reduce indicators of stress in dogs during air transport and this suggests that dogs were able to perceive stressors despite a reduction in behavioural indicators, misinterpreted as reduced fear and anxiety (Bergeron *et al.* 2002). While drowsiness, ataxia, reduced activity and less injury have been observed in trapped animals dosed with a TTD containing PPZH, it is possible that the drug does not reduce the experience of fear and anxiety, despite sedation. However, in other studies acepromazine has been shown to reduce indicators of stress associated with the capture of chamois (*Rupicapra pyrenaica*) (Lopez-Olvera *et al.* 2007). It appears that one of the major criteria for the selection of PPZH over diazepam as an active TTD drug was that it is not a controlled substance in the USA, unlike diazepam (Zemlicka *et al.* 1991).

The use of the TTD may have significant advantages for increasing the efficacy of trapping. Coyotes that had been captured by the toes were recovered on traps that had TTDs fitted, while it was thought that they would have escaped capture without it. Other advantages included the ability to release domestic or 'recalcitrant' dogs that have been captured, although tame dogs were not found to be as inclined to take TTDs as wild dogs (Balser 1965).

8.9 Lethal Trap Device (LTD)

Drugs used in the TTD may not have rapid enough onset to prevent some significant injury (Chapter 8.8) within the first hour and the drug may abate after 24 hours or in response to poor dosage. As captured dogs will ultimately be killed in most cases in south-eastern Australia, better welfare outcomes may be produced if this happens quickly after capture. Strychnine-impregnated cloth attached to jaw-traps has been used to achieve this in NSW, WA and QLD. Although potentially rapid, strychnine is inhumane and has become less favoured for this purpose (Fleming *et al.* 2001), partly because ingestion of sub-optimal quantities of strychnine cause an extremely painful toxicosis that may not be lethal for many hours. An alternative lethal trap device (LTD) formulation was proposed that causes the rapid death of trapped dogs and foxes (Nocturnal Wildlife Research Pty Ltd). Essentially it is the same device as a TTD, but with a rapid acting poison replacing the use of a tranquilliser drug.

8.10 Trap signalling devices

Reducing the time period that target or non-target animals remain trapped in a leg-hold trap will influence the degree of physical trauma and stress associated with trapping. Properly padded leg-hold traps seldom cause visible physical injury upon activation, but trauma is progressively accumulated over the period of captivity as the animal resists the trap (Proulx *et al.* 1993). Daily or even twice daily monitoring of traps is a standard practice for wildlife research and pest control work (Andelt *et al.* 1999, Larkin *et al.* 2003). Frequent trap inspection and human presence may reduce trapping success (Lee Allen, personal communication) and some trap signalling devices were constructed to reduce the necessity to closely approach and visually inspect trap sets for wild dogs (Marks 1996). To facilitate the rapid recovery of trapped animals, a range of radio-signalling devices have been developed to use in conjunction with traps (Nolan *et al.* 1984, Kaczensky 2002, Marks 1996, Larkin *et al.* 2003) and at least one purpose built device is commercially available (www.britishmoorlands.com), as are simple systems that are modified radio tracking transmitters used for wildlife studies (eg. www.avminstrument.com/transmit.html).

Trap signalling devices may theoretically assist rapid trap attendance, reduction in the overall time an animal is held and the period between capture and euthanasia or release. However as the majority of activity after capture appears to occur in the first few hours after capture in the dingo (Marks *et al.* 2004) and red fox (Kreeger *et al.* 1990, White *et al.* 1991), physical trauma such as tooth damage is probably acquired within the first hour of capture (Marks *et al.* 2004). The onset of capture myopathy in susceptible species is equally rapid (Chapter 6.2.3) and it is unlikely that signalling devices would promote a rapid enough response to reduce either of these major welfare impacts.

In east-central Illinois, radio monitoring systems allowed recovery of trapped animals in a mean of 18.3 minutes, opposed to mean capture times of 8.8 hours from trap inspections each 12 hours (Larkin *et al.* 2003). This was achieved by using constant operator vigilance of a cluster of traps deployed in a discrete area for diurnally active species. The largely nocturnal activity associated with foxes and some dingoes as well as the majority of the common non-target species (Chapter 4: Table 2) indicates that the majority of captures will occur during the evening. Monitoring of dingo captures using padded Victor Soft-Catch traps showed that there were clear nocturnal peaks in trapping success that were probably associated with dingo activity rhythms (Figure 11). Accordingly, if trap monitoring and attendance does not occur during evening hours, it is probable that a trap signalling device will have significantly less impact upon the time the animal spends in the trap and consequent welfare benefits.

8.11 Lures, odours and attractants

The detection and acquisition of prey in canids relies primarily upon visual (Mason *et al.* 1999), auditory (Gese *et al.* 1996) and chemical/olfactory (Bullard *et al.* 1978a) cues. Colour cues appear to be important in promoting the detection of lures, probably by allowing for more contrast against a particular background (ie. dark soils or snow) (Mason *et al.* 1999). Chemical/olfactory lures have been important components of trapping that increase the efficacy and capture rates of traps for coyotes. Most have been developed from blends of biological tissues and fluids (Turkowski *et al.* 1983) that are not easily replicated and this makes quality control difficult. It had been noted that volatile compounds of fox urine were powerful herbivore repellents and experiments sought to produce synthetic fermented egg compounds as carnivore attractants (Bullard *et al.* 1978a, Bullard *et al.* 1978b). These and other egg products were shown to be effective as repellents of rabbits, swamp wallabies (Marks *et al.* 1995) and brushtail possums (Woolhouse *et al.* 1995). Assessment of synthetic coyote attractants have shown an ability to influence the release of specific behaviours (Kimball *et al.* 2000). Wolf and dog faeces have a repellent effect upon sheep and the identification of the active components has been attempted in order to develop repellents for ungulates (Arnould *et al.* 1998). A generalised avoidance of predator faeces by prey species was suggested as a common adaptation for potential prey species (Dickman *et al.* 1984). Appropriate trap selection and canid-specific lures were believed to be responsible for the high degree of target selectivity in coyote control programs in Texas (Shivik *et al.* 2002). The concentration and amount of the lure used on traps may have important implications for the repellence of macropods and attraction of canids in Australia (Lee Allen, personal communication).

Predator odours have not always been shown to exclude herbivores; there was no apparent avoidance of fox scented traps by bush rats (*Rattus fuscipes*) and this suggested that naive prey species may fail to recognise odour cues from some exotic predators, due to the lack of extended periods of co-evolution and selection of predator avoidance strategies (Banks 1998). Native rodents avoided quoll faeces on 75% of sampling occasions, and a long co-evolutionary history exists between these species (Hayes *et al.* 2006).

The potential exists for lure and repellent compounds (perhaps from native carnivores) to increase the target specificity of carnivore trapping, while repelling native herbivores, such as macropods and wombats from trap sets. Successful repellence of native herbivores could be a major advance in limiting the capture of non-target herbivores that constitute the most significant non-target cohort in Victoria. The use of predator attractants has largely been applied in an *ad hoc* manner, yet systematic and standardised collection of trapping data in field assessments could be used to assess a range of available carnivore attractants. Alternatively, simple experimental procedures could be applied to rapidly assess the efficacy of herbivore repellents.

8.12 Euthanasia or release?

The most important issues concerning euthanasia relate to the particular species and circumstances under which euthanasia is appropriate and the manner in which it is undertaken.

Target species will be euthanased as soon as possible upon inspection of traps. Non-target species should be either released or euthanased depending upon the level of debilitation they have suffered, as well as a decision based upon the likelihood that non-visible debilitation has occurred that will produce suffering after release. Macropodids and birds may be highly susceptible to capture myopathy and in the absence of knowledge concerning the pathophysiology of the disease in many species, they should be euthanased if it is suspected. It is unclear how other common non-target species such as wombats and possums are affected by capture myopathy and if they have the capacity to survive without suffering if released. If removal and release of some non-target species is envisaged, appropriate training and equipment should be considered. Necrotic pathology that may arise from periods of ischemia cannot be easily predicted from gross observation of an animal's limb (Chapter 6.2.1). While this is less of a welfare issue if the animal is euthanased immediately, released non-target animals may become debilitated subsequent to release. Routine use of Heparinoid® cream prior to the release of radio-collared dingoes appeared to reduce swelling, bruising and potential necrotic conditions (Byrne and Allen 2008). Post-capture care can include treatment with antiseptics and long-acting antibiotics (Fuller and Kuehn 1983). Relatively simple post-capture treatments may significantly improve the prognosis of released non-target animals and it is appropriate that veterinary advice is sought, and where treatments are practical and beneficial, they are used routinely.

The American Veterinary Medical Association's panel on euthanasia states that euthanasia techniques should result in rapid unconsciousness followed by cardiac or respiratory arrest and the ultimate loss of brain function (Andrews *et al.* 1993). There is debate concerning what techniques of euthanasia are acceptable to kill trapped animals. An extreme example of this issue is the use of trap sets that cause the drowning of animals after capture. They are considered to be unacceptable because it takes many minutes for some species to be rendered unconscious and EEG signals may last for up to 8 minutes (Ludders *et al.* 1999). Some authors have noted the practical limitations and safety risks of using euthanasia techniques in the field that might otherwise deliver more ideal welfare outcomes in a clinical setting (Bluett 2001). Many recommendations on methods to kill furbearing animals are made in order to protect the quality of the fur and drowning, suffocation and clubbing are advocated rather than more rapid methods that may affect pelt quality. One of the limitations of the ISO trapping standards is the absence of guidelines for euthanasia (Iossa *et al.* 2007). In Australia, one of the suggested practices for the euthanasia of trapped wild dogs and foxes is use of a rifle shot to the head after approaching the trapped animal in a way that avoids unnecessary disturbance and stress (Sharp *et al.* 2005a; 2005b). This may be inadequate and impractical for the euthanasia of many non-target species and if used in urban and urban-rural fringe areas. For example, it is very unlikely that a shot to the head can be relied upon to kill birds (eg. corvids and lyrebirds etc) and smaller mammals, given the extremely small head size. Rapidly moving macropods, feral cats and foxes will also be difficult to euthanase by a shot to the head. While in theory distant points of aim using a rifle may reduce handling stress and attempted flight upon the approach to the trap site, it is unlikely to be practical in delivering reliable head shots, especially for smaller animals. The specification of firearm loads and calibres should be selected cautiously. For instance, a small calibre (eg. .22) rifle may not deliver a reliable and humane death for wombats at an appreciable distance (Marks 1998b). In dense vegetation and when an animal has concealed itself and the point of aim is unclear, this may necessitate an awkward and shallow aiming position. The safety of using long-arms is questionable in this case and handguns or shotguns with appropriate loads may be preferable and less likely to produce ricochets or explosive returns from rock and soil. Guidelines should be developed for practical and safe euthanasia techniques that are appropriate for each species and all commonly encountered field conditions.

8.13 Trap sets and target-specificity

The manner in which a trap is set is an important influence over target-specificity and humaneness. Powell and Proulx (2003) propose that important considerations include trap *elements*, trap *location* and whether a *bait* or *trail set* is used. Trap elements include pan tension (Chapter 8.7), ie. setting the pan at an appropriate tension for a particular target species, with reference to likely non-target species. Setting the trap in inappropriate locations where entanglement in vegetation may occur can result in injury (Mowat *et al.* 1994). Reduction of non-targets can be achieved by careful site selection so that waterholes, gully crossings, tracks and pads beneath fences frequented by non-target species are avoided (Sharp *et al.* 2005a; 2005b). Non-target captures will be dependent upon local knowledge of target and non-target species behaviour, lures and trap devices used, pan tensioning and field practices that can reduce non-target captures (Lee Allen, personal communication). Food baits and lures should be avoided in areas where scavenging non-target animals frequent (Sharp *et al.* 2005a; 2005b). Placing a trap in an inappropriate location or the use of animal carcasses as lures (Corbett 1974, Newsome *et al.* 1983) is known to be a major factor in encouraging non-target carnivore captures (Powell *et al.* 2003).

The behaviour of some non-target species may make them more susceptible to capture. The common wombat is known to use fecal pellets and urine to mark its range (Triggs 1988) and will do so on elevated points such as rocks, small logs and at the base of trees (Triggs 1988, Taylor 1993). At Tonimbuk (Victoria), wombats mark novel objects or those that have been disturbed, such as a moved log (C.A. Marks, unpublished data). Their propensity to mark areas of disturbance may promote their capture at trap sites that have been prepared by digging, clearing or movement of logs or if the trap is located at the base of a tree. The use of ‘stepping sticks’ placed to prevent an animal stepping on the trap jaws and to direct its path onto the trap pan is a common practice (Johnson *et al.* 1980, Mowat *et al.* 1994) and may promote the capture of common wombats. Brushtail possums would likewise be susceptible to traps located at the base of trees, as they frequently descend and spend a proportion of their time foraging on the ground (Strahan 1984).

Understanding the behaviour of individual non-target species is essential in order to avoid their capture. Local knowledge of trapping conditions and field skills developed in consultation with other trappers is an important component of training for trappers. Local conditions will often determine specific strategies that are adopted by trappers and it is unrealistic to expect that one trapping protocol will be appropriate for all locations. Forums for the exchange of information and peer review of trap setting techniques, as well as provision of appropriate scientific information will aid in fostering a positive and supportive culture of continuous improvement in trapping practices. This may be the most effective way to ensure that canid management and welfare objectives are addressed in trapping practices.

8.14 Trap modifications

There is potential to adapt and modify trapping devices and practices to increase effectiveness and positive welfare outcomes. Exploiting the differences between the physiology and behaviour of target and non-target species may lead to more target-specific control strategies (Marks 2001b). Problematically, much of the published literature indicates *ad hoc* field experimentation with inadequate experimental control and use of multiple or erratic variations in trapping practices. This does not permit a good scientific basis for assessment. Adequate strategic planning and experimental design is strongly indicated and requires the development of protocols for the collection of data that can be analysed, interpreted and used to promote better welfare outcomes.

Coil spring traps used to capture racoons were modified with a 'guard' or 'double jaw' to protect against self-directed biting and appeared likely to have reduced injury scores (although not conclusively) (Anon 2003). There is potential to develop a similar guard system to prevent macropods from triggering leg-hold traps (eg. Victor Soft-Catch #3 or #1 ½) by exploiting their elongated foot relative to that of wild dogs. Other modifications have sought to increase target-specificity by minor modifications to established practices. A snaring system used for the capture of snowshoe hares (*Lepus americanus*) permitted the release of the threatened American marten (*Martes americana*) in Canada (Proulx *et al.* 1994a) as snared martins behaved differently from hares and spun their body upon capture. An anchor mechanism that disengaged or broke due to this spinning motion enabled the snowshoe hare snare system to be target-specific.

Traps that have been modified to reduce injury to target species have also been found to be more efficacious. Egg traps (Egg Trap Company: Springfield, USA) were found to be a humane and effective alternative to leg-hold traps to capture racoons. They prevent self-mutilation as a guard prevents the animal from biting the trapped limb (Proulx *et al.* 1993b, Hubert *et al.* 1996) and were 1.04 – 1.46 times more effective at catching racoons than cage traps (Austin *et al.* 2004). Proulx *et al.* (1993) reported that this device did not cause appreciable limb damage after 24 hours of captivity and damage was reduced compared to Victor #1 coil-spring traps (Hubert *et al.* 1996). In addition, Egg traps appeared to be far more target-specific as they excluded some non-target species (eg. dogs) from accessing the trigger mechanism (Hubert *et al.* 1999). Relatively little damage has been demonstrated in opossums (n = 40) (*Didelphis virginiana*) when they were captured in the device that was set and inspected daily (Hubert *et al.* 1999).

8.15 Jaw off-set distance

The 'off-setting' of trap jaws by a set distance (so that they do not fully close) probably produces better welfare outcomes (compared to the same traps where trap jaws fully close) by reducing impact and clamping forces upon limbs. Trap jaws have been off-set by 6.35 mm (Unpadded Northwoods #3) (Houben and Holland 1993), 7.9 mm (Unpadded Northwoods #3), 6.4 mm (Unpadded Sterling MJ600) (Phillips *et al.* 1996) and 4.8 mm (Bridger #3) (Hubert *et al.* 1997). However, some authors found that padding without off-setting jaws provided superior welfare outcomes (Phillips *et al.* 1996). The practical distance that jaws can be off-set is limited by the need to ensure that the trap is capable of holding all target species, but there appears to be little empirical basis or evidence-based rationale for the upper limits of off-set distances that can be found in the scientific literature. A standard jaw off-set of ¼ inch is probably based on North American practices[9] and it is difficult to recommend an absolute value for all traps that may apply to wild dogs and non-target species in Australia without the collection of relevant local data and with reference to variations in other trap specifications (eg. jaw width, impact and clamping forces, padding material etc). A comparative study of limb morphometrics and anatomy for target and non-target species could be used to suggest evidence-based estimates of jaw off-set distances. Setting maximum practical jaw off-set distances may allow some non-target species to escape traps (eg. corvids and brushtail possums) if restrained by their limbs.

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[9] Jaw off-set distances for the modified (padded) Bridger #5 is ¼ inch as currently used in Victoria.

Table 13. Summary of modifications made to leg-hold traps, leg-hold snares and neck snares and field practices (‘Modifications/Practices’) and the reduction (‘Reduces’) in welfare impact for trap types and target species.

TRAP TYPE	TARGET		MODIFICATION/PRACTICES	REDUCES	AUTHORITY
#1½ coil spring trap	Racoon	*Procyon lotor*	Addition of a foot-guard (‘double jaw’)	Injury from self-directed biting	Anon 2003
#3 and #4 leg-hold traps	Wolves	*Canis lupus*	Use of propiopromazine TTD	Injury in target and non-target species	Sahr and Knowlton 2000
#1½ steel-jawed leg-hold	Arctic fox	*Alopex lagopus*	Daily trap inspection	Serious injuries	Proulx *et al.* 1994
#3½ EZ Grip	Coyotes	*Canis latrans*	Padded and more powerful jaw	Trap injury more than off-set and laminated jaws in similar devices	Phillips *et al.* 1996
#3 leg-hold traps	Coyotes	*Canis latrans*	Centre mounted 90 cm long chains to anchor traps	Less injury than shorter non-centred anchor chains	Linhart *et al.* 1988
#4 and #14 Newhouse steel-jawed traps	Wolves	*Canis lupus*	Use of long-acting antibiotics	Risk of bacterial infections	Fuller and Kuehn 1983
Aldridge snare	Black bears	*Ursus americanus*	Spring loading of snare cable	Abrupt stop and injury	Powell 2005
Aldridge snare	Black bears	*Ursus americanus*	Snares set so that cables cannot tangle in foliage	Tangling and injury	Powell 2005
All	Marten	*Martes americana*	Deactivation of traps during adverse weather	Hypothermia and hyperthermia	de Vos *et al.* 1952
All	All		Frequent trap inspection	Injury	Proulx *et al.* 1993
All	All		Use of radio system to alert trap activation	Restraint time and injury	Marks 1996, Kaczensky *et al.* 2002, Larkin *et al.* 2003
Egg trap	Racoon	*Procyon lotor*	Guard does not allow racoon to access trapped limb	Self mutilation	Proulx *et al.* 1993, Hubert *et al.* 1996, Austin 2004
Egg trap	Racoon	*Procyon lotor*	Guard covers limb caught by trigger mechanism	Non-target species (eg dog) captures	Hubert *et al.* 1996
Egg trap	Racoon	*Procyon lotor*	Trap anchored to a tree above ground level	Self-mutilation as animals could not use captured limb for support	Poulx *et al.* 1993
Foot-hold snares	Lynx	*Lynx rufus*	Use of multiple swivels on trap anchor cables	Injury from twisting and tangling in cable	Logan *et al.* 1999
Foot-hold snares	Lynx	*Lynx rufus*	Careful site selection to reduce entanglement in vegetation	Injury from vegetation	Logan *et al.* 1999
Foot-hold snares	Red fox	*Vulpes vulpes*	Plastic coating of snare cable	Foot injury	Englund 1982
Leg-hold snare (Margo)	Grizzly bear	*Ursus arctos*	Short anchor cable	Muscle damage to limb	Cattet *et al.* 2003
Leg-hold snare (Margo)	Grizzly bear	*Ursus arctos*	Short anchor cable	Dehydration	Cattet *et al.* 2003
Leg-hold traps	Coyotes	*Canis latrans*	Use of Paws-I-Trip pan tensioning device	Non-target captures (reduced by 91-99.1%)	Phillips and Gruver 1996

Table 13 (cont). Summary of modifications made to leg-hold traps, leg-hold snares and neck snares and field practices ('Modifications/Practices') and the reduction ('Reduces') in welfare impact for trap types and target species.

TRAP TYPE	**TARGET**		**MODIFICATION/PRACTICES**	**REDUCES**	**AUTHORITY**
Leg-hold traps	Coyotes	*Canis latrans*	Deactivate traps during diurnal periods	Non-target species (80%) not active	Shivik and Gruver 2002
Neck snare (lethal)	Snowshoe hare	*Lepus americanus*	Coil attachment/anchor point	Allows American marten (non-target) to escape	Proulx *et al.* 1994
Neck snares	Coyotes	*Canis latrans*	Use of diazepam tabs on snares	Facial and oral lacerations	Pruss *et al.* 2002
Neck snares	Coyotes	*Canis latrans*	Use of obstacles to divert ungulate non-targets	Non-target capture	Pruss *et al.* 2002
Neck snares	Coyotes	*Canis latrans*	Snare lock set to 27cm	Capture of ungulates	Pruss *et al.* 2002
Northwoods #3 offset jaws	Coyotes	*Canis latrans*	Lamination, offset jaws and replacement springs	Reduce all injuries relative to standard trap	Houben *et al.* 1993
Northwoods #3 offset jaws	Coyotes	*Canis latrans*	0.635 cm lamination and additional spring tension	Injury scores reduced by 5-7.5 times that of Victor #3 coil or long spring traps	Houben *et al.* 1993
Oneida #14 jump traps	Dingo	*Canis dingo*	Use of smaller Oneida traps compared to Lane's trap	Non-target captures (large marsupials protected wildlife)	Newsome *et al* 1983
Plastic Nordic Sport AB snare	Red fox	*Vulpes vulpes*	Use of snare in place of leg-hold traps	Tooth damage	Englund 1982
Rose leg cuff	Badger	*Meles meles*	Use of Kevlar cuff to hold limb	Injuries other than temporary swelling of limb	Kirkwood 2005
Snare	-	-	Increase diameter of snare cable	Injury	Garrett 1999
Soft-Catch #1½	Red fox	*Vulpes vulpes*	Use of padded trap	Physical trauma	Kreeger *et al.* 1990
Steel-jawed trap	Fox	*Vulpes vulpes*	Padding of trap jaws	Fractures and joint injuries	Tullar 1984
Victor long-spring #2 and #3	Red fox	*Vulpes vulpes*	Plastic coating of traps	Tooth damage	Englund 1982
Victor Soft-Catch #3	Lynx	*Lynx rufus*	Pan tension set to 1 kg	Reduced small mammal capture	Mowat *et al.* 1994
Victor Soft-Catch #3	Lynx	*Lynx rufus*	No trapping in winter or when temp below -8 °C	Freezing injury	Mowat *et al.* 1994
Victor Soft-Catch #3	Lynx	*Lynx rufus*	Fixed anchor, good quality shock absorber, short chain and 2 swivels	Entanglement, dislocation and fracture	Mowat *et al.* 1994
Victor Soft-Catch #3	Lynx	*Lynx rufus*	Increased jaw closure velocity, clamping force and impact force	Injuries and maximise restraint proximal to interdigital pad	Earle *et al.* 2003
Victor Soft-Catch #3	Coyotes	*Canis latrans*	Replaced #1.75 springs with #3 springs	Mean trap-injury scores	Linhart *et al.* 1988
Victor Soft-Catch #3	Coyotes	*Canis latrans*	Supplementary springs added	Trap related injuries	Gruver *et al.* 1996
Victor Soft-Catch #3	Coyotes	*Canis latrans*	Increased spring tension by 40%	Reduction in injury score over other studies	Houben *et al.* 1993

Table 13 (cont). Summary of modifications made to leg-hold traps, leg-hold snares and neck snares and field practices (‘Modifications/Practices’) and the reduction (‘Reduces’) in welfare impact for trap types and target species.

TRAP TYPE	TARGET		MODIFICATION	REDUCES	AUTHORITY
Victor Soft-Catch #3	Coyotes	*Canis latrans*	Use of padded trap	Limb injury	Linhart *et al.* 1986
Victor Soft-Catch #3	Coyotes	*Canis latrans*	Use of pan tension device (0.9-1.4 kg tension)	Most non-target animal captures	Phillips *et al.* 1992
Victor Soft-Catch #3	Coyotes	*Canis latrans*	Reduced weight of trap compared to #3½ EZ Grip	Fractures	Phillips *et al.* 1996
Victor Soft-Catch #3	Dingo	*Canis dingo*	Use of diazepam TTD	Limb injury and activity	Marks *et al.* 2004
Victor Soft-Catch #3	Dingo	*Canis dingo*	Use of hepranoid creams on limb prior to release to restore blood flow	Pathology associated with ischemia	Byrne and Allen 2008

9.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

9.1 Recommended devices

1. Large steel-jawed (eg. Lane's type) traps cause much greater injuries to target and non-target species and are less target-specific than smaller leg-hold devices. Their relatively greater weight, large jaw spread and side-mounted chains result in poorer welfare outcomes than other devices. Padded large steel-jawed traps probably reduce injury to target and non-target species, but such modifications have received no detailed assessment. The use of large steel-jawed traps that are modified or unmodified should be discontinued as soon as possible.

2. Laminated leg-hold traps have been found in some studies to reduce the incidence of trap related injury, when compared to non-laminated devices. Currently there is no clear scientific consensus that laminated traps have the potential to deliver better welfare outcomes than commercially available padded leg-hold traps. Lamination of existing leg-hold traps will not necessarily produce significantly improved welfare benefits.

3. Treadle-snares are reported to require more skill to set, can be prone to misfiring and are bulky to transport. International literature suggests that in general, leg-hold snares are less effective than leg-hold traps for canid control. Some data suggests that treadle-snares cause greater stress to red foxes than other capture devices. The continued use of the treadle-snare should be reviewed with reference to these concerns.

4. There appears to be potential for consistently better welfare outcomes using commercially available padded leg-hold traps such as the fourth generation Victor Soft-Catch #3 which can use short centre-mounted restraining cables, standard pan tension systems, are suited to the attachment of TTDs or LTDs, are familiar to trappers and are well supported by published data as effective in the capture of canids. Devices that conform to the 'fourth generation' of the Victor Soft-Catch #3 trap are probably current best practice for wild dog trapping. Victor Soft-Catch #1 ½ traps would be the most appropriate size trap for trapping red foxes.

5. The Collarum non-lethal neck snare appears to have potential as a device that could find limited applications in urban and urban-rural fringe areas or where particular care must be taken in avoiding capture of non-target species. It may offer greater target-specificity and has potential to cause less major injury and death than padded leg-hold traps. Consideration should be given to trial then authorise this device if deemed appropriate.

9.2 Definition and regulation of leg-hold devices

1. The definition of leg-hold traps as indicated in the POCTA rules should be extended to reflect commonly used scientific and commercial nomenclature and definition of leg-hold traps. Approved devices should be denoted by manufacturer, size and type and be stipulated in the rules.

2. Regulations should seek to discourage the use of traps that have been modified in an *ad hoc* manner (eg. use of untested padding, lamination and arbitrary jaw off-set etc) and do not use objective and evidence-based data to support claims of efficacy and welfare outcomes. Traps should be maintained within the tolerances of a performance specification. However, it is appropriate that regulations do not inhibit future testing and continuous improvements to produce better welfare outcomes. Modifications and assessment should be supervised by competent oversight.

9.3 Development of trap specifications

1. In order to promote current best practice and reliable welfare outcomes, mechanical trap specifications should be established that clearly define minimum performance based attributes. Important trap specifications should include trap size and jaw spread, trap weight, closure speed, impact force, clamping force, jaw offset distances, padding material (type, thickness etc) and pan tension characteristics. Ancillary features used with traps such as the type and number of in-line springs, swivels and anchoring methods should also be specified. A minimum benchmark for wild dog trapping could be based upon the fourth generation Victor Soft-Catch #3 trap using the manufacturer's data or physical measurements.

2. A number of rubber-jawed traps are on the market in Australia (eg. Duke™ and Jake™ traps) that have not been the subject of published research. The use of leg-hold traps that can be shown to conform or exceed the specifications established by the benchmark could be regarded as best practice. This would allow other manufacturers with trap products to certify their devices or adapt them to the benchmark if necessary. A benchmark could be a valuable tool to promote a culture of continuous improvement and further trap development.

3. It would be appropriate for DPI/BAW to request assistance from companies involved in the manufacture of leg-hold devices and their Australian agents (eg. Woodstream Corporation: Pennsylvania for the Victor Soft-Catch #3 or the Livestock Protection Company: Texas for EZ Grip # 3½) to promote standardisation of traps for better target-specificity and welfare outcomes for Victorian and Australian conditions.

4. North American humane trap standards have been developed for commercial fur harvesting and controlling wild dogs and are of some relevance to Australia. However, there are sufficient differences in the context of the wildlife management issues (eg. composition of target and non-target species, animal welfare legislation, etc) to justify developing unilateral specifications that address specific needs and requirements in Australia.

9.4 Improving welfare outcomes

1. Trap specifications such as closure speeds and jaw spread may be essential to ensure that captured animals are consistently restrained above the interdigital pad in order to reduce injury from restraint.

2. Adoption of in-line spring specifications that have been developed in North America are unlikely to have catered for macropods that are capable of developing large amounts of force through rapid acceleration and generation of momentum. The selection of in-line springs in trap restraining cables or chains should be based upon realistic calculations of the force that can be produced by macropods given the length of the chain, known acceleration and upper mass. Centre-anchored chains that attach to

the base of traps permit swivels to operate more effectively than chains attached to the side of the trap and probably contribute to better welfare outcomes by reducing torsional resistance; they should be adopted as a standard practice.

3. A positive relationship exists between the period of time held in captivity and the degree of injury and stress sustained. Worldwide, trap inspection periods of at least once per day are a minimum standard. Nocturnal animals are likely to experience additional stress if held for prolonged periods during the day. In the absence of novel ways to demonstrably improve the welfare of animals held for periods in excess of one day, trap inspection periods should be at least once per day to conform to a minimum accepted standard.

4. During specific times of the year in eastern Victoria, when peak daytime temperatures are in excess of 30°C, trapping should be discontinued or all trap inspections should be completed well before peak daytime temperatures are reached. The relative lack of arid-adapted species in the eastern highlands of Australia and frequent capture of non-target species that are susceptible to thermal stress requires greater consideration than is appropriate for other Australian habitats.

5. Various studies have contrasting recommendations concerning the merits of fixed trap anchoring or ‘drag’ fixed trap restraints. There is evidence that short chains and fixed anchoring points may provide better welfare outcomes. Drags may be appropriate when it is unavoidable to set traps in exposed locations that offer no shelter from the sun in hot and arid environments or if soil substrates do not allow reliable anchoring. It would be appropriate to monitor welfare outcomes of both options for target and non-target animals and adopt the most beneficial practice for a range of conditions.

6. The use of a TTD or LTD in conjunction with a leg-hold trap that meets best practice standards for welfare outcomes should be pursued. The successful implementation of such devices would eliminate or mitigate the majority of stressors experienced by wild dogs and red foxes and greatly improve the welfare outcomes of trapping. As either device will not be beneficial for most non-target species, the best welfare outcomes of this approach overall will be produced if ways to improve the target specificity of traps are also pursued.

7. The investment in a trap alert system might be warranted if it promotes rapid trap attendance, more frequent trap inspection and significant welfare benefits. As many target and non-target species are nocturnally active, unless 24 hour monitoring and recovery is proposed the welfare benefit is reduced. Frequent trap inspection and human presence may reduce trapping success and inexpensive and low power trap signalling devices may be a practical option to monitor the capture status of traps over a short monitoring distance that avoids close approach to the trap set if more frequent inspections are made. As much of the trauma of trapping is likely to occur within the first hour(s) of capture, the welfare benefit of this approach should be assessed with reference to other measures that could promote more cost-effective welfare outcomes.

8. A clear policy dictating the fate of non-target species upon recovery should take into account the likelihood that many trapped animals have suffered debilitation that is not visible. Macropodids and birds are highly susceptible to capture myopathy and it would seem inappropriate that after prolonged capture they are released, since suffering or death due to debilitation is highly likely. A range of other species may be susceptible to capture myopathy, yet insufficient published information exists to produce a comprehensive assessment.

9. If some non-target species are to be released from leg-hold traps or snares by a single person, the risk of operator injury is significant. Practices that are used to release non-target species should be reviewed and appropriate equipment and training needs considered to ensure that the pre-conditions that warrant euthanasia or release are known, and if release is attempted it can be done so safely and humanely.

10. Recommendations for the use of firearms to euthanase non-target species should be reviewed as it is likely that current recommendations will not produce consistent outcomes in some non-target species nor will they be appropriate and safe in all environments.

11. Standard jaw off-set distances of ¼ inch are probably based on North American practices. A comparative study of limb morphometrics and anatomy for target and non-target species could guide evidence-based estimates of jaw off-set distances for Australian conditions. Setting maximum practical jaw off-set distances may allow smaller non-target species to escape traps if restrained by their limbs.

12. The routine use of post-capture treatments such as Heparinoid cream to reduce swelling, bruising and stimulate peripheral blood flow in released non-target animals shows potential to improve welfare outcomes. Veterinary recommendations concerning appropriate post-capture treatments (which may also include the use of antibiotic and antiseptic agents) for all animals prior to release should be developed and used as a mandatory procedure. Research should be undertaken to determine the relative benefit of such practices.

9.5 Improving target-specificity

1. Pan tensioning is a well established technique to reduce the capture of non-target species that apply less ‘trigger force’ to traps than wild dogs. The use of pan tension systems should be a mandatory requirement for all leg-hold traps.

2. It is essential to ensure that pan tensioning specifications are based upon evidence-based studies relating to the force applied by non-target species relative to target species and that periodic monitoring and adjusting of pan tensions for traps is undertaken as part of a quality control process.

3. Canid lures and/or some odours associated with marsupial carnivores may be repellent to marsupial herbivores (eg. kangaroos, wallabies and wombats) that are the primary native non-target species in Victoria. Field assessment of lures and their potential to reduce non-target captures at a range of concentrations should be conducted in the eastern highlands of Victoria.

4. Trap size and jaw spread appears to affect the incidence of non-target captures and is probably an important way to limit capture of macropods and other species. There is no compelling evidence to suggest that canid capture rates and trap efficacy are significantly reduced by using leg-hold traps that have a reduced jaw area/size. Traps used in Victoria should be limited to trap sizes no greater than a size typically cited as #3 (ie. 15 cm jaw spread) for wild dogs and # 1 ½ for red foxes (ie. 13 cm jaw spread) in order to limit non-target captures. Research should seek to test if more durable smaller trap devices can be produced to offer increased target-specificity in some circumstances without a reduction in capture rates.

5. There are significant differences in the locomotion and foot anatomy of macropods and wild dogs and it may be possible to produce trap configurations that enhance target-specificity.

6. There is a substantial published scientific literature concerning the development and assessment of trapping devices and practices to improve welfare outcomes and target specificity. It would be appropriate for this resource to be summarised and communicated in a relevant way to people involved in trapping. Training in the nature of stressors, stress and pathology associated with traps in a range of species would be useful.

7. Knowledge of specific behaviours of key non-target species may allow trappers to develop strategies to further minimise their capture. The abundance and diversity of non-target species in different habitats is an important consideration. A practical summary of the behaviour of key non-target species based upon a synthesis of trapper field skills and scientific studies may assist in training, as well as sharing knowledge with members of the public that also undertake trapping.

9.6 Assessing comparative welfare outcomes

1. Adoption of a standardised protocol to test welfare impacts of different traps and trap modifications is required to assist in continuous improvement of trapping practices. This standard would be most useful if it were adopted nationally.

2. One of the chief problems associated with the assessment of welfare outcomes of trapping in the field is that the period an animal has remained in the trap is rarely known with any accuracy. The use of inexpensive timer/activity monitoring modules should be attached at least to a sample of routinely used traps. Data collected would include capture duration, time of the day that species are likely to be caught and the degree of activity and struggling associated with different species and devices.

3. The most unequivocal insight into the comparative welfare impacts of traps is likely to be produced by physiological indicators (ie. CK, AST, ALP, ALT and N:L ratios) in concert with a standardised scoring of whole body injury from necropsies. The capture period and relative activity of animals must be known in conjunction with these measures to accurately assess welfare impacts.

9.7 Reporting research and assessment

1. Licensed institutions that use leg-hold or other capture devices should be encouraged to report and/or publish details of trapping methods and results so that comparative data is produced for: location, habitat type, capture success, target specificity, injury to target and non-target species, trap inspection frequency and modifications made to trap devices. The development of a standardised reporting procedure could be an obligatory requirement under the auspice of AECs.

2. A large amount of information has been collected during field trials of various trapping methods and using trap modifications in Australia and overseas. Much of this material is of limited value due to the lack of experimental controls, inadequate sample sizes, inconsistent application of methods or a reliance on subjective interpretation. A partnership between trappers and researchers should be fostered, when possible, to encourage future assessment of potential improvements to be appropriately rigorous.

9.8 Knowledge gaps

1. As published studies are limited in their scope, advice should be sought from zoo veterinarians and keepers of Australian native fauna concerning the relative susceptibility of potential non-target species to capture myopathy. A schedule of appropriate actions concerning post-capture treatment and release or obligatory euthanasia should be prepared in order to guide the action of trappers.

2. Pressure necrosis and ischemia may arise from the use of traps or leg-hold snares that restrict blood flow to tissues for prolonged periods. The incidence of ischemia produced by different padded and laminated traps is unknown and the short and long-term impact on welfare outcomes is unknown in target and non-target species. Non-lethal studies that monitor the short-term restriction of blood flow in anaesthatised animals in the laboratory may be adequate to predict the relative likelihood of ischemia arising from different trap devices.

3. Most mechanical specifications for commercial traps used in Australia follow recommendations based upon North American experience. There is a need for empirical data to be collected locally to enable evidence-based adaptation of trapping methods to increase target specificity and promote better welfare outcomes.

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REFERENCES

Abbott, CW, Dabbert, CB, Lucia, DR and Mitchell, RB 2005 Does muscular damage during capture and handling handicap radiomarked northern bobwhites? *Journal of Wildlife Management 69*: 664-670

Akimau, P, Yoshiya, K, Hosotsubo, H, Takakuwa, T, Tanaka, H and Sugimoto, H 2005 New experimental model of crush injury of the hindlimbs in rats. *Journal of Trauma 58*: 51-58

Aktas, M, Auguste, D, Lefebvre, HP, Toutain, PL and Braun, JP 1993 Creatine kinase in the dog: A review. *Veterinary Research Communications 17*: 353-369

Allen, L and Fleming, PJS 2004 Review of canid management in Australia for the protection of livestock and wildlife - potential application to coyote management. *Sheep and Goat Research Journal 19*: 97-104

Allen, L and Sparkes, EC 2001 The effect of dingo control on sheep and beef cattle in Queensland. *Journal of Applied Ecology 38*: 76-87

Allen, LR and Gonzalez, A 1998 Baiting reduces dingo numbers, changes age structure yet often increases calf loss. *Australian Vertebrate Pest Control Conference 11*: 421-428

Amit, Z and Galina, ZH 1986 Stress-induced analgesia: adaptive pain suppression. *Physiology Reviews 66*: 1091-1120

Andelt, WF, Phillips, RL, Schmidt, RH and Gill, RB 1999 Trapping furbearers: an overview of the biological and social issues surrounding the public policy controversy. *Wildlife Society Bulletin 27*: 53-64

Andersson, B 1972 *The Physiology of Thirst*. Academic Press: New York

Andrews, EJ, Bennett, BT, Clark, JD, Houplt, KA, Pascoe, G, Robinson, W and Boyce, JR 1993 Report of the AVMA panel on euthanasia. *Journal of the American Veterinary Medical Association 202*: 229-249

Anon 1981 *Federal Provincial Committee for Humane Trapping*. Canadian Wildlife Service: Ottawa

Anon 1996 *Animal (mammals) traps - mechanically powered, trigger activated killing traps for use on land*. Canadian General Standards Board: Ottawa

Anon 1997 *Agreed minute and annex: standards for the humane trapping of specific terrestrial and semi-aquatic mammals.* USA-European Community: Brussels

Anon 2003. Assessment of three restraining traps and two protocols to capture racoons in the midwest in 2002-2003. International Association of Fish and Wildlife Agencies: Washington

Anon 2007 *Australian code of practice for the care and use of animals for scientific purposes*. Australian Government Publishing Service: Canberra

Archer, J 1979 Behavioural aspects of fear. Pages 56-85 *in* Sluckin, W, editor. Fear in animals and man. Van Nostrand Reinhold Company: New York

Arnould, C, Malosse, C, Signoret, J-P and Descoins, C 1998 Which chemical constituents from dog feces are involved in its food repellent effect in sheep? *Journal of Chemical Ecology 24*: 559-576

Atkeson, TZ 1956 Incidence of crippling loss in steel trapping. *Journal of Wildlife Management 20*: 323-324

Austin, J, Chamberlain, MJ, Leopold, BD and Burger, LW 2004 An evaluation of EGG and wire cage traps for capturing racoons. *Wildlife Society Bulletin 32*: 351-356

Baker, PJ, Harris, S, Robertson, CPJ, Saunders, G and White, PCL 2001 Differences in the capture rate of cage-trapped red foxes *Vulpes vulpes* and an evaluation of rabies control measures in Britain. *Journal of Applied Ecology 38*: 823-835

Baker, PJ, Robertson, CPJ, Funk, SM and Harris, S 1998 Potential fitness benefits of group living in the red fox. *Animal Behaviour 56*: 1411-1424

Balser, DS 1965 Tranquilizer tabs for capturing wild carnivores. *Journal of Wildlife Management 29*: 438-442

Banks, PR 1998 Response of Australian bush rats, *Rattus fuscipes*, to the odour of introduced *Vulpes vulpes*. *Journal of Mammalogy 79*: 1260-1264

Barnett, J and Jongman, E 1996 Techniques for the assessment of humaneness and measuring pain and stress in animals. Pages 22-26 *in* Fisher, Pm and Marks, Ca, editors. Humaneness and Vertebrate Pest Control. Ropet Printing: Tynong North

Bateson, P 1991 Assessment of pain in animals. *Animal Behaviour 42*: 827-840

Baumans, V, Brain, PF, Brugere, H, Clausing, P, Jeneskog, T and Perretta, G 1994 Pain and distress in laboratory rodents and lagomorphs: Report of the federation of European laboratory animal science associations (FELASA) working group on pain and distress accepted by the FELASA bord of management. *Laboratory Animals 28*: 97-112

Baxter, JD and Tyrrell, JB 1987 The adrenal cortex. *in* Felig, P, Baxter, JD, Broadus, AE, and Frohman, LA, editors. Endocrinology and metabolism. McGraw-Hill: New York

Beasom, SL 1974 Selectivity of predator control techniques in southern Texas. *Journal of Wildlife Management 38*: 837-844

Bedrak, E 1965 Blood serum enzyme activity of dogs exposed to heat stress and muscular exercise. *Journal of Applied Physiology 20*: 587-590

Beerda, B, Schilder, MB, Janssen, NS and Mol, JA 1996 The use of saliva cortisol, urinary cortisol, and catecholamine measurements for a noninvasive assessment of stress responses in dogs. *Hormones and Behaviour 30*: 272-279

Beerda, B, Schilder, MB, van Hooff, JA and de Vries, HW 1997 Manifestations of chronic and acute stress in dogs. *Applied Animal Behaviour Science 52*: 307-319

Beerda, B, Schilder, MBH, van Hooff, J, de Vries, HW and Mol, JA 2000 Behavioural and hormonal indicators of enduring environmental stress in dogs. *Animal Welfare 9*: 49-62

Beerda, B, Schilder, MBH, van Hooff, JA, de Vries, HW and Mol, JA 1998 Behavioral, saliva cortisol and heart rate response to different types of stimuli in dogs. *Applied Animal Behaviour Science 58*: 365-381

Belcher, CA 1998 Susceptibility of the tiger quoll, *Dasyurus maculatus*, and the eastern quoll, *D. viverrinus*, to 1080-poisoned baits in control programs for vertebrate pests in eastern Australia. *Wildlife Research 25*: 33-40

Belyaev, DK 1978 Destabilising selection as a factor in domestication. *Journal of Heredity 70*: 301-308

Belyaev, DK 1979 Some genetical and evolutionary problems of stress and stress resistance. *Vestnik Akademii Meditsinskikh Nauk USSR 7*: 9-14

Bennett, GJ and Xie, YK 1988 The peripheral mononeuropathy in the rat that produces disorders in pain sensations like those seen in man. *Pain 33*: 87-107

Berchielli, LT, Jn and Tullar, BF 1980 Comparison of a leg snare with a leg-gripping trap. *New York Fish and Game Journal 27*: 63-71

Bergeron, R, Scott, SS, Émond, J-P, Mercier, F, Cook, NJ and Schaefer, AL 2002 Physiology and behaviour of dogs during air transport. *Canadian Veterinary Research 66*: 211-216

Beringer, J, Hansen, LP, Wilding, W, Fischer, J and Sheriff, SL 1996 Factors affecting capture myopathy in white-tailed deer. *Journal of Wildlife Management 60*: 373-380

Bermond, B 1997 The myth of animal suffering. *in* M. Dol, Kasanmoentalib, M, S, L, Rivas, E, and Bros, R, editors. Animal Consciousness and Animal Ethics. Van Gorcum: Assen

Blanchard, DC, Hynd, AL, Minke, KA, Minemoto, T and Blanchard, RJ 2001 Human defensive behaviors to threat scenarios show parallels to fear- and anxiety-related defense patterns of non-human mammals. *Neuroscience and Biobehavioral Reviews 25*: 761-770

Block, N 1998 How can we find the neural correlates of consciousness? *Trends in Neuroscience 19*: 456-459

Bluett, RD 2001 Drowning is not euthanasia: springboard or siren's song? *Wildlife Society Bulletin 29*: 774-747

Blumenkopf, B and Lipman, J 1991 Studies in autonomy: its pathophysiology and usefulness as a model of chronic pain. *Pain 45*: 203-209

Boggess, EK 1990 *Traps, trapping and furbearer management: A review*. Wildlife Society: Bethesda

Boissy, A 1995 Fear and fearfulness in animals. *The Quarterly Review of Biology 70*: 165-191

Bolles, RC 1970 Species-specific defence reactions and avoidance learning. *Psychological Review 77*: 32-48

Bonacic, C, Feber, RE and Macdonald, DW 2006 Capture of the vicuna (*Vicugna vicugna*) for sustainable use: Animal welfare implications. *Biological Conservation 129*: 543-550

Bonney, G 1959 Prognosis in traction lesions of the brachial plexus. *Journal of Bone and Joint Surgery 41B*: 4-35

Borchelt, PL 1983 Aggressive behaviour of dogs kept as companion animals: classification and influence of sex, reproductive status and breed. *Applied Animal Behaviour Science 10*: 45-61

Bosak, JK 2004 Heat stroke in a Great Pyrenees dog. *Canadian Veterinary Journal*: 513-515

Braastad, BO 1998 Effects of prenatal stress on behaviour of offspring of laboratory and farmed mammals. *Applied Animal Behaviour Science 61*: 159-180

Braysher, M, Saunders, G and Balogh, S 1998 *New approaches to managing pest animals*. NSW Agriculture: Orange

Brice, P, Grigg, GC, Beard, LA and Donovan, JA 2002 Heat tolerance of short-beaked echidnas (*Tachyglossus aculeatus*) in the field. *Journal of Thermal Biology 27*: 449-457

Bromm, B 1985 Evoked cerebral potential and pain. *Advances in Pain Research and Therapy 9*: 305-325

Broom, DM 1988 The scientific assessment of animal welfare. *Applied Animal Behaviour Science 20*: 5-19

Broom, DM and Johnson, KG 1993 *Stress and animal welfare*. Chapman and Hall: London

Broom, DM and Zanella, AJ 2004 Brain measures which tell us about animal welfare. *Animal Welfare 13*: 41-45

Brown, GD 1984 Thermoregulation in the common wombat (*Vombatus ursinus*) in an alpine habitat. *in* Hale, JRS, editor. Thermal Physiology: New York

Bubela, T, Bartell, R and Müller, W 1998 Factors affecting the trappability of red foxes in Kosciusko National Park. *Wildlife Research 25*: 199-208

Bullard, RW, Leiker, TJ, Peterson, JE and Kilburn, SR 1978a Volatile components of fermented egg, an animal attractant and repellent. *Journal of Agriculture and Food Chemistry 26*: 155-159

Bullard, RW, Shumake, SA, Campbell, DA and Turkowski, FJ 1978b Preparation and evaluation of a synthetic fermented egg coyote attractant and deer repellent. *Journal of Agriculture and Food Chemistry 26*: 160-163

Byrne, D. and Allen L. (2008). Post-capture necrosis of the feet caused by soft-catch traps - incidents, cause and prevention. Australasian Vertebrate Pest Conference: *14*: 58

Carstens, E and Moberg, GP 2000 Recognising pain and distress in laboratory animals. *Institute for Laboratory Animal Research Journal 41*: 1-12

Casey, R 2002 Fear and stress in companion animals. Pages 144-153 *in* Horwitz, D, Mills, D, and Heath, S, editors. BSAVA manual of canine and feline behavioural medicine. British Small Animal Veterinary Association: Gloucester

Catling, PC 1979 Seasonal variation in plasma testosterone and the testis in captive male dingoes, *Canis familiaris dingo*. *Australian Journal of Zoology 27*: 939-944

Cattet, MR, Christison, K, Caulkett, NA and Stenhouse, GB 2003 Physiologic responses of grizzly bears to different methods of capture. *Journal of Wildlife Diseases 39*: 649-654

Chapman, JA, Willner, GR, Dixon, KR and Pursley, D 1978 Differential survival rates among leg-trapped and live-trapped nutria. *Journal of Wildlife Management 42*: 926-928

Chapman, JL and Reiss, MJ 1999 *Ecology: Principles and applications*. Cambridge University Press: Cambridge

Chen, AC, Dworkin, N, Hang, SF and Gehrig, J 1989 Topographic brain measures of human pain and pain responsivity. *Pain 37*: 129-141

Christie, DW and Bell, ET 1971 Some observations of the seasonal incidence and frequency of oestrus in breeding bitches in Britain. *Journal of Small Animal Practice 12*: 159-167

Clark, P 2006 Haematological characteristics of morbid members of the Macropodidae. *Comparative Clinical Pathology 14*: 191-196

Clutton-Brock, TH 1991 *The evolution of parental care*. Princeton University Press: Princeton

Coderre, TJ, Grimes, RW and Melzack, R 1986 Deafferentation and chronic pain in animals: an evaluation of evidence suggesting autotomy is related to pain. *Pain 26*: 61-84

Cogger, H 2000 *Reptiles and amphibians of Australia*. Chelsea Green Publishing: White River

Coman, BJ 1983 Red Fox. *in* Strahan, R, editor. Complete Book of Australian Mammals. Angus and Robertson: Sydney

Connor, MC, Soutiere, EC and Lancia, RA 1987 Drop-netting deer: cost and incidence of capture myopathy. *Wildlife Society Bulletin 15*: 434-438

Conover, MR 2001 Effect of hunting and trapping on wildlife damage. *Wildlife Society Bulletin 29*: 521-532

Conzemius, MG, Hill, CM, Sammarco, JL and Perkowski, SZ 1997 Correlation between subjective and objective measures used to determine severity of post-operative pain in dogs. *Journal of the American Veterinary Medical Association 210*: 1619-1622

Cooper, BY and Vierck, CJ 1986 Measurement of pain and morphine hypalgesia in monkeys. *Pain 26*: 361-392

Corbett, LK 1974. Contributions to the biology of dingoes (Carnivora: Canidae) in Victoria. MSc Thesis. Monash University: Clayton

Corbett, LK 1995 *The dingo in Australia and Asia*. University of New South Wales Press: Sydney

Coulson, G 1996 A safe and selective draw-string trap to capture kangaroos moving under fences. *Wildlife Research 23*: 621-627

Covington, EC 2000 The biological basis of pain. *International Review of Psychiatry 12*: 128-147

Christie, DW and Bell, ET 1971 Some observations of the seasonal incidence and frequency of oestrus in breeding bitches in Britain. *Journal of Small Animal Practice 12*: 159-167

Croft, D and Lugton, I, editors. 1992. Directions for use: 1080 fox and wild dog bait. NSW Department of Agriculture: Orange

Dabbert, CB and Powell, KC 1993 Serum enzymes as indicators of capture myopathy in mallards (*Anas platyrhynchos*). *Journal of Wildlife Disease 29*: 304-309

Dantzer, RP and Mormède, RM 1983 Stress in farm animals: a need for re-evaluation. *Journal of Animal Science 57*: 6-18

Davis, M, Walker, DL and Lee, Y 1997 Roles of the amygdala and bed nucleus of the stria terminalis in fear and anxiety measured with the acoustic startle reflex. Possible relevance to PTSD. *Annals of the New York Academy of Science 821*: 305-331

Dawkins, MS 1980 *Animal suffering, the science of animal welfare*. Chapman and Hall: London

Dawkins, MS 1993 *Through our eyes only. The search for animal consciousness*. Freemen: Oxford

Dawkins, MS 1998 Evolution and animal welfare. *Quarterly Review of Biology 73*: 305-328

Dawkins, MS 2001a How can we recognise and assess good welfare? Pages 63-76 *in* Broom, DM, editor. Coping with challenge: Welfare in animals, including humans. Dahlam University Press: Berlin

Dawkins, MS 2001b Who needs consciousness? *Animal Welfare 10*: S19-S29

Dawkins, MS 2006 A users guide to animal welfare science. *Trends in Ecology and Evolution 21*: 77-81

de Bruijne, JJ and de Koster, P 1983 *Glycogenolysis in the fasting dog 75*: 553-555

De Villiers, MS, Meltzer, DGA, Van Heerden, J, Mills, MGL, Richardson, PRK and Van Jaarsveld, AS 1995 Handling-induced stress and mortalities in African wild dogs (*Lycaon pictus*) *Proceedings of the Royal Society London 262*: 215-220

de Vos, A and Gunther, SA 1952 Preliminary live trapping studies of marten. *Journal of Wildlife Management 16*: 207-214

Decker, DJ and Brown, TL 1987 How animal rightists view the "wildlife management hunting system". *Wildlife Society Bulletin 15*: 599-602

Dickman, CR and Doncaster, CP 1984 Response of small mammals to red fox odour. *Journal of Zoology (London) 204*: 521-531

Dorner, JL, Hoffmann, WE and Long, GB 1974 Corticosteroid induction of an isoenzyme of alkaline phosphate in the dog. *American Journal of Veterinary Research 35*: 1457-1458

Drahos, N 1952 The century old search for a humane trap. *National Humane Review 40*: 26-27

Drickamer, LC and Mikesic, DG 1993 Differences in trapping and killing efficiency of Sherman, Victor and Museum Special traps for house mice. *American Midland Naturalist 130*: 397-401

Earle, RD, Lunning, DM, Tuovila, VR and Shivik, JA 2003 Evaluating injury mitigation and performance of #3 Victor Soft Catch traps to restrain bobcats. *Wildlife Society Bulletin 31*: 617-629

Edwards, GP and Ealy, EHM 1975 Aspects of the ecology of the Swamp Wallaby, *Wallabia bicolor*. *Australian Mammalogy 1*: 307-317

Ellard, DR, Castle, PC and Mian, R 2001 The effect of a short-term mental stressor on neutrophil activation. *International Journal of Psychophysiology 41*: 93-100

Emery, NJ and Clayton, NS 2004 The mentality of crows: convergent evolution of intelligence in corvids and apes. *Science 306*: 1903-1908

Engeman, RM 1997 On the use of injury scores for judging the acceptability of restraining traps. *Journal of Wildlife Research 2*: 124-127

Englund, J 1982 A comparison of injuries to leghold trapped and foot snared red foxes. *Journal of Wildlife Management 46*: 1113-1117

Evans, M, Green, B and Newgrain, K 2003 The field energetics and water fluxes of free-living wombats (Marsupialia: Vombatidae). *Oecologica 137*: 171-180

Fairbridge, D 2000 Keeping fox control on target. *Trees and Natural Resources 42*: 14-16

Fairbridge, D, Fisher, P, Busana, F, Pontin, K, Edwards, A, Johnston, M and Shaw, M 2001 Behaviour of the bush rat *Rattus fuscipes* and southern brown bandicoot, *Isoodon obesulus* at buried bait stations. *Australian Mammalogy 22*: 125-127

Feldman, RS, Meyer, JS and Qeanzer, LF 1996 *Principles of neuropsychopharmacology*. Sinauer Associates: Massachusetts

Fernandez-Moran, J, Saavedra, D, De La Torre, JLR and Manteca-Vilanov, X 2004 Stress in wild-caught Eurasian otters (*Lutra lutra*): effects of a long-acting neuroleptic and time in captivity. *Animal Welfare 13*: 143-149

Fisher, PM and Marks, CA 1996 *Humaneness and Vertebrate Pest Control.* Ropet Printing: Tynong North

Flecknell, PA and Roughan, JV 2004 Assessing pain in animals - putting research into practice. *Animal Welfare 13*: S71-S75

Fleming, PJS, Allen, LR, Berghout, MJ, Meek, PD, Pavlov, PM, Stevens, PL, Strong, K, Thompson, JA and Thomson, PC 1998 The performance of wild-canid traps in Australia: efficiency, selectivity and trap-related injuries. *Wildlife Research 25*: 327-338

Fleming, PJS, Allen, LR, Lapidge, SJ, Robley, A, Saunders, GR and Thomson, PC 2006 A strategic approach to mitigating the impacts of wild canids: proposed activities of the Invasive Animals Cooperative Research Centre. *Australian Journal of Experimental Agriculture 46*: 753-762

Fleming, PJS, Corbett, LK, Harden, RH and Thompson, P 2001 *Managing the impacts of dingoes and other wild dogs*. Bureau of Rural Resources: Canberra

Foex, BA 1999 Systemic response to trauma. *British Medical Journal 55*: 726-743

Forbes, TL, Carson, M, Harris, K, DeRose, G, Jamison, WJ and Potter, RF 1995 Skeletal muscle injury induced by ischemia-reperfusion. *Canadian Journal of Surgery 38*: 56-63

Fox, CH and Papouchis, CM 2004 *Cull of the wild. A contemporary analysis of wildlife trapping practices in the United States.* Bang Publishing: Brainerd

Frame, PF and Meier, TJ 2007 Field-assessed injury to wolves captured in rubber padded traps. *Journal of Wildlife Management 71*: 2074-2076

Frank, D, Gauthier, A and Bergeron, R 2006 Placebo-controlled double-blind clomipramine trial for the treatment of anxiety or fear in beagles during ground transport. *Canadian Veterinary Journal 47*: 1102-1108

Frank, L, Simpson, D and Woodroffe, R 2003 Foot snares: An effective method for capturing African Lions. *Wildlife Society Bulletin 31*: 309-314

Friend, TH 1999 Recognizing behavioral needs. *Applied Animal Behaviour Science 22*: 151-158

Fuller, TK and Kuehn, DW 1983 Immobilization of wolves using ketamine in combination with xylazine or promazine. *Journal of Wildlife Management 19*: 69-72

Galac, S and Knol, BW 1997 Fear-motivated aggression in dogs: Patient characteristics, diagnosis and therapy. *Animal Welfare 6*: 9-15

Garrett, T 1999 *Alternative traps*. Animal Welfare Institute: Washington DC

Gates, NL and Goering, EK 1976 Hematologic values of conditioned, captive wild coyotes. *Journal of Wildlife Management 12*: 402-404

Gelberman, RH, Szabo, RM, Williamson, RV, Hargens, AR, Yaru, NC and Minter-Convery, MA 1983 Tissue pressure threshold for peripheral nerve viability. *Clinical Orthopaedics 178*: 285-291

Gentile, JR 1987 The evolution of anti-trapping sentiment in the United States: A review and commentary. *Wildlife Society Bulletin 15*: 490-503

Gerstell, R 1985 *The steel trap in north America: The illustrated story of its design, production and use with furbearers and predatory animals, from its colorful past to the present controversy*. Stackpole Books: Harrisburg

Gese, EM, Ruff, RL and Crabtree, RL 1996 Intrinsic and extrinsic factors influencing coyote predation on small mammals in Yellowstone National Park. *Canadian Journal of Zoology 74*: 784-797

Gilbert, FF 1976 Impact energy for anaesthetised racoons, mink, muskrats and beavers. *Journal of Wildlife Management 40*: 669-676

Glen, AS, Dickman, CR, Soulé, ME and Mackey, BG 2007 Evaluating the role of the dingo as a trophic regulator in Australian ecosystems. *Austral Ecology 32*: 492-501

Goldingay, RL 1984 Photoperiodic control of the diel activity in the sugar glider (*Petaurus breviceps*). *in* Smith, A and Hume, I, editors. Possums and gliders. Surrey Beatty and Sons: Chipping Norton

Goode, DJ, Weinberg, DH, Mazura, TA, Curtiss, G, Moretti, RJ and Meltzer, HY 1977 Effects of limb restraints on serum creatine phosphokinase activity in normal volunteers. *Biological Psychiatry 12*: 743-755

Gregory, NG 2005 *Physiology and behaviour of animal suffering*. Blackwell: Oxford

Griffin, AS, Evans, CS and Blumstein, DT 2002 Selective learning in marsupials. *Ethology 108*: 1103-1114

Gruver, KS, Phillips, RL and Williams, ES 1996 Leg injuries to coyotes captured in standard and modified Soft-Catch traps. *17th Vertebrate Pest Control Conference 17*: 91-93

Gue, M and Peters, T 1989 Stress-induced changes in gastric emptying, postprandial motility and gut hormone plasma levels in dogs. *Gastroenterology 97*: 1101-1107

Guthery, FS and Beamson, SL 1978 Effectiveness and selectivity of neck snares in predator control. *Journal of Wildlife Management 42*: 552-554

Hackman, C 1996 Human pain *in* Fisher, PM and Marks, CA, editors. Humaneness and Vertebrate Pest Control. Ropet: Tynong North

Hajduk, P, Copland, MD and Schultz, DA 1992 Effects of capture on haematological values and plasma cortisol levels of free-range koalas, *Phascolarctos cinereus*. *Journal of Wildlife Disease 28*: 502-506

Hanley, CS, Thomas, NJ, Paul-Murphy, J and Hartup, BK 2005 Exertional myopathy in whooping cranes (*Grus americana*) with prognostic guidelines. *Journal of Zoo and Wildlife Medicine 36*: 489-497

Harden, RH 1985 The ecology of the dingo in north-eastern New South Wales. I Movements and home range. *Australian Wildlife Research 12*: 25-37

Harden, RH and Robertshaw, JD 1987 Ecology of the dingo in northeastern New South Wales: V. Human predation on the dingo. *Australian Zoologist 24*: 65-72

Hardy, EM, Hansen, BD and Carroll, GS 1997 Behaviour after ovariohysterectomy in the dog: what's normal? *Applied Animal Behaviour Science 51*: 111-128

Harris, AG and Skalak, TC 1993 Leucocyte cytoskeletal structure determines capillary plugging and network resistance *American Journal of Physiology 265*: H1670-H1675

Harris, K, Walker, PM and Mickle, D 1986 Metabolic response of skeletal muscle to ischemia. *American Journal of Physiology 250*: H213-H220

Harris, S, Soulsbury, CD and Iossa, G 2007 *Trapped by bad science: Myths behind the international humane trapping standards*. International Fund for Animal Welfare: Massachusetts

Harrison, P 1991 Do animals feel pain? *Philosophy 66*: 25-40

Harrop, SR 2000 The international regulation of animal welfare and conservation issues through standards dealing with the trapping of wild mammals. *Journal of Environmental Law 12*: 333-360

Hartley, FGL, Follet, BK, Harris, S, Hirst, D and McNeilly, AS 1994 The endocrinology of reproductive failure in foxes (*Vulpes vulpes*). *Journal of Reproduction and Fertility 113*: 151-157

Hartup, BK, Kollias, GV, Jacobsen, MC, Valentine, BA and Kimber, KR 1999 Exertional myopathy in translocated river otters from New York. *Journal of Wildlife Diseases 35*: 542-547

Hastings, AB, White, FC, Sanders, TM and Bloor, CM 1982 Comparative physiological responses to exercise stress. *Journal of Applied Physiology 52*: 1077-1083

Hayes, RA, Nahrung, HF and Wilson, JC 2006 The response of native Australian rodents to predator odours varies seasonally: a by-product of life history variation? *Animal Behaviour 71*: 1307-1314

Hayssen, V, van Tienhoven, A and van Tienhoven, A 1993 *Asdell's patterns of mammalian reproduction*. Cornell University Press: Ithaca

Heard, DJ and Huft, VJ 1998 The effects of short-term physical restraint and isoflurane anesthesia on hematology and plasma biochemistry in the island flying fox (*Pteropus hypomelanus*). *Journal of Zoo and Wildlife Medicine 29*: 14-17

Hennessy, MB, Williams, MT, Miller, DD, Douglas, CW and Vioth, VL 1998 Influence on male and female petters on plasma cortisol and behaviour: can human interaction reduce the stress of dogs in a public animal shelter? *Applied Animal Behaviour Science 61*: 63-77

Heusner, M 1985 Body size and energy metabolism. *Annual Review of Nutrition 5*: 267-293

Hiltz, M and Roy, LD 2001 Use of anaesthetised animals to test humaneness of killing traps. *Wildlife Society Bulletin 29*: 606-611

Hinchcliff, KW 1996 Performance failure in Alaskan sled dogs: biochemical correlates. *Research in Veterinary Science 61*: 271-272

Hobbs, TJ and James, CD 1999 Influence of shade covers on pitfall trap temperatures and capture success of reptiles and small mammals in arid Australia. *Wildlife Research 26*: 341-349

Holland, M and Jennings, D 1997 Use of electromyography in seven injured wild birds. *Journal of the American Veterinary Medical Association 211*: 607-609

Houben, JM, Holland, M, Jack, SW and Boyle, CR 1993 An evaluation of laminated offset jawed traps for reducing injuries to coyotes. in: Great Plains wildlife damage control workshop proceedings. Nebraska: Lincoln

House, I 1991 Harrison on animal pain. *Philosophy 66*: 376-379

How, RA 1988 Common brushtail possum. Pages 147-148 *in* Strahan, RH, editor. Complete Book of Australian Mammals. Angus and Robertson: North Ryde

Huber, D, Kusak, J, Vorg, Z and Rafaj, RB 1997 Effects of sex, age, capturing method and season on serum chemistry values in brown bears in Croatia. *Journal of Wildlife Disease 33*: 790-794

Hubert, GF, Hungerford, LL and Bluett, RD 1997 Injuries to coyotes captured in modified foothold traps. *Wildlife Society Bulletin 25*: 858-863

Hubert, GF, Hungerford, LL, Proulx, G, Bluett, RD and Bowman, L 1996 Evaluation of two restraining traps to capture raccoons. *Wildlife Society Bulletin 24*: 699-708

Hubert, GF, Wollenberg, GK, Hungerford, LL and Bluett, RD 1999 Evaluation of injuries to Virginia opossums captured in the EGG (TM) trap. *Wildlife Society Bulletin 27*: 301-305

Hulland, TJ 1993 Muscle and tendon. *in* Jubb, KVF, Kennedy, PC, and Palmer, N, editors. Pathology of domestic animals. Academic Press: New York

Iossa, G, Soulsbury, DD and Harris, S 2007 Mammal trapping: a review of animal welfare standards of killing and restraining traps (a review). *Animal Welfare 16*: 335-352

ISO 1999a *Animal (mammal) traps: Part 4: Methods for testing killing trap systems used on land or underwater*. Organisation for Standardization: Geneva

ISO 1999b *Animal (mammal) traps: Part 5: Methods for testing restraining traps*. Organisation for Standardization: Geneva

Jain, M and Baldwin, AL 2003 Are laboratory animals stressed by their housing environment and are investigators aware that this stress can affect physiological data? *Medical Hypotheses 60*: 284-289

Jarman, PJ 1991 Social behaviour and organisation in the Macropodidae. *Advances in the Study of Behaviour 20*: 1-50

Jasper, DE and Jain, NC 1965 The influence of adrenocorticotrophic hormones and prednisolone upon marrow and circulation lymphocytes in the dog. *American Journal of Veterinary Research 26*: 844-850

Jenkins, DJ and Craig, NA 1992 The role of foxes *Vulpes vulpes* in the epidemiology of *Echinococcus granulosus* in urban environments. *Medical Journal of Australia 157*: 754-756

Johnson, KG and Pelton, MR 1980 Prebaiting and snaring techniques for black bear. *Wildlife Society Bulletin 8*: 46-56

Johnston, RE, Male, CB, Linhart, SB and Engerman, RM 1986 Electronic measurement of closure speed for steel foothold traps. *Wildlife Society Bulletin 14*: 223-225

Jones, B 2003 Integrating animal welfare into vertebrate pest management. in: Solutions for achieving humane vertebrate pest control. RSPCA: Canberra

Jones, E and Stevens, PL 1988 Reproduction in wild canids, *Canis familiaris*, from the eastern highlands of Victoria. *Australian Wildlife Research 15*: 385-394

Jonsson, U, Nets, P and Stromsburg, L 1984 Solid mechanics and strength of bones in young dogs. *Acta Orthopedics Scandinavia 55*: 446-451

Jordan, B 2005 Science-based assessment of animal welfare: wild and captive animals. *Revue Scientifique Et Technique-Office International Des Epizooties 24*: 515-528

Jotham, N and Phillips, RL 1994 Developing International trap standards-a progress report. *Proceedings of the Vertebrate Pest Conference 13*: 226-229

Kaczensky, P, Knauer, F, Jonozovic, M, Walzer, C and Huber, T 2002 Experiences with trapping, chemical immobilization, and radiotagging of brown bears in Slovenia. *Ursus 13*: 347-356

Kakulas, BA 1966 Regeneration of skeletal muscle in the Rottnest quokka. *Australian Journal of Experimental Biology and Medical Science 44*: 673-688

Kavaliers, M and Choleris, E 2001 Antipredator response and defensive behaviour: ecological and ethological approaches for the neurosciences. *Neuroscience and Biobehavioural Reviews 25*: 577-586

Kavanau, JL and Ramos, J 1975 Influences of light on the activity and phasing of carnivores. *The American Naturalist 109*: 391-408

Kay, B, Gifford, E, Perry, R and van der Ven, R 2000 Trapping efficacy for foxes (*Vulpes vulpes*) in central New South Wales: age and sex biases and the effects of reduced fox abundance. *Wildlife Research 27*: 547-552

Kayser, C 1957 Physiological aspects of hypothermia. *Annual Reviews of Physiology 19*: 83-120

Keep, JM and Fox, AM 1971 The capture, restraint and translocation of kangaroos in the wild. *Australian Veterinary Journal 47*: 141-145

Kenttämines, H, Nordrum, NV, Brenøe, UT, Smeds, K, Johannessen, KR and Bakken, M 2002 Selection for more confident foxes in Finland and Norway: Heritability and selection response for confident behaviour in blue foxes (*Alopex lagopus*). *Applied Animal Behaviour Science 78*: 67-82

Kim, SH and Chung, JM 1992 An experimental model for peripheral myopathy produced by segmental spinal nerve ligation in the rat. *Pain 50*: 355-363

Kimball, BA, Mason, JR, Blom, S, Johnston, JJ and Zemlicka, DE 2000 Development and testing of seven new synthetic coyote attractants. *Journal of Agriculture and Food Chemistry 48*: 1892-1897

Kimber, K and Kollias, GV 2005 Evaluation of injury severity and hematologic and plasma biochemistry values for recently captured North American river otters (*Lontra canadensis*). *Journal of Zoo and Wildlife Medicine 36*: 371-384

King, T, Hemsworth, PH and Coleman, GJ 2003 Fear of novel and startling stimuli in domestic dogs. *Applied Animal Behaviour Science 82*: 45-64

Kinga, CP, Devide, DP, Vierck, CJ, Mauderli, A and Yezierski, RP 2007 Opioid modulation of reflex versus operant responses following stress in the rat. *Neuroscience 147*: 174-182

Kirkwood, JK. editor 2005. Report of the independent working group on snares. www.defra.gov.uk/wildlife-countryside/vertebrates/snares/pdf/iwgs-report.pdf

Kirschbaum, C and Hellhammer, DH 1989 Salivary cortisol in psychobiological research: an overview. *Neuropsychobiology 22*: 150-169

Klennerman, L and Crawley, J 1977 Limb blood flow in the presence of a tourniquet. *Acta Orthopedics Scandanavia 48*: 291-295

Kluger, MJ, O'Reilly, B, Shope, TR and Vander, AJ 1987 Further evidence that stress hypothermia is a fever. *Physiology and Behaviour 39*: 763-766

Korte, SM, Koolhaas, JM, Wingfield, JC and McEwen, BS 2005 The Darwinian concept of stress: benefits of allostasis and costs of allostatic load and the trade-offs in health and disease. *Neuroscience and Biobehavioral Reviews 29*: 3-38

Kreeger, TJ, White, PL, Seal, US and Tester, JR 1990 Pathological response of red foxes to foothold traps. *Journal of Wildlife Management 54*: 147-160

Krum, SH and Osborn, CA 1977 Heatstroke in the dog: a polysystemis disorder. *Journal of the American Veterinary Medical Association 170*: 531-535

Kuehn, DW, Fuller, TK, Mech, LD, William, JP, Fritts, SH and Berg, WE 1986 Trap related injuries to gray wolves in Minnesota. *50*: 90-91

Kuhn, G, Lichtwald, K, Hardegg, HH and Abel, J 1991 The effect of transportation stress on circulating corticosteroids, enzyme activity and hematology values in laboratory dogs. *Journal of Experimental Animal Science 34*: 99-104

Landsberg, GM, Hunthaussen, W and Ackerman, L 2003 *Handbook of behavioural problems of the cat and dog*. Saunders: London

Larcombe, AN, Withers, PC and Nicol, SC 2006 Thermoregulatory, metabolic and ventilatory physiology of the eastern barred bandicoot (*Perameles gunnii*). *Australian Journal of Zoology 54*: 9-14

Larkin, RP, VanDeelen, TR, Sabick, RM, Gosselink, TE and Warner, RE 2003 Electronic signalling for prompt removal of an animal from a trap. *Wildlife Society Bulletin 31*: 392-398

Le Mar, K and McArthur, C 2005 Comparison of habitat selection by two sympatric macropods, *Thylogale billardierii* and *Macropus rufogriseus ruforgriseus*, in a patchy eucalypt-forestry environment. *30*: 674-683

Lee, AK and Cockburn, A 1985 *Evolutionary ecology of marsupials.* Cambridge University Press: Melbourne

Lee, JK, Ronald, K and Øritsland, NA 1977 Some blood values of wild polar bears. *Journal of Wildlife Management 41*: 520-526

Lemieux, R and Czetwertynski, S 2006 Tube traps and rubber padded snares for capturing American black bears. *Ursus 17*: 81-91

Lentle, RG, Potter, MA, Springett, BP and Stafford, KJ 1997 A trapping and immobilisation technique for small macropods. *Wildlife Research 24*: 373-377

Lilliehöök, I 1997 Diurnal variation of canine blood leukocyte counts. *Veterinary Clinical Pathology 26*: 113-117

Linhart, SB, Blom, FS, Dasch, GJ, Engeman, RM and Olsen, GH 1988 Field evaluation of padded jaw coyote traps: effectiveness and foot injury. *Vertebrate Pest Control Conference 13*: 226-229

Linhart, SB and Dasch, GJ 1992 Improved performance of padded jaw traps for capturing coyotes. *Wildlife Society Bulletin 20*: 63-66

Linhart, SB, Dasch, GJ, Male, CB and Engeman, RM 1986 Efficacy of padded and unpadded steel foothold traps for capturing coyotes *Wildlife Society Bulletin 14*: 212-218

Linhart, SB, Dasch, GJ and Turkowski, FJ 1981 The steel leg-hold trap: techniques for reducing foot injury. *Worldwide Furbearer Conference* 3: 1560-1678

Linscombe, RG and Wright, VL 1988 Efficacy of padded foothold traps for capturing terrestrial furbearers. *Wildlife Society Bulletin 16*: 307-309

Littin, KE and Mellor, DJ 2005 Strategic animal welfare issues: ethical and animal welfare issues arising from the killing of wildlife for disease control and environmental reasons. *Revue Scientifique Et Technique-Office International Des Epizooties 24*: 767-782

Littin, KE, Mellor, DJ, Warburton, B and Eason, CT 2004 Animal welfare and ethical issues relevant to the humane control of vertebrate pests. *New Zealand Veterinary Journal 52*: 1-10

Lloyd, HG and Englund, J 1973 The reproductive cycle of the red fox in Europe. *Journal of Reproduction and Fertility (Supplement) 19*: 119-130

Logan, KA, Sweanor, LL, Smith, JF and Hornocker, MG 1999 Capturing pumas with foot-hold snares. *Wildlife Society Bulletin 27*: 201-208

Lopez-Figueroa, MO, Day, HE, Akil, H and Watson, SJ 1998 Nitric oxide in the stress axis. *Histology and Histopathology 13*: 1243-1252

Lopez-Olvera, JR, Marco, I, Montane, J, Casas-Diaz, E and Lavin, S 2007 Effects of acepromazine on the stress response in southern chamois (*Rupicapra pyrenaica*) captured by means of drive-nets. *Canadian Journal of Veterinary Research 71*: 41-51

Lorenzo, N, Wan, TL, Harper, RJ, Hsu, Y, Chow, M, Rose, S and Furton, KG 2003 Laboratory and field experiments used to identify *Canis lupus* var. *familiaris* active odor signature chemicals from drugs, explosives and humans. *Analytical and Bioanalytical Chemistry 376*: 1212-1224

Ludders, JW, Schmidt, RH, Dein, FJ and Klein, PN 1999 Drowning is not euthanasia. *Wildlife Society Bulletin 27*: 666-670

Lyne, AG 1971 Bandicoots in captivity. *International Zoo Yearbook 11*: 41-43

Manser, CE 1992 *The assessment of stress in laboratory animals*. RSPCA: Horsham

Marchettini, P 1993 Muscle Pain - Animal and human experimental and clinical studies. *Muscle and Nerve 16*: 1033-1039

Marino, L 2002 Convergence of complex cognitive abilities in cetaceans and primates. *Brain Behaviour and Evolution 59*: 21-32

Marks, CA 1996 A radiotelemetry system for monitoring the treadle snare in programmes for control of wild canids. *Wildlife Research 23*: 381-386

Marks, CA 1998a Field assessment of electric fencing to reduce fence damage by the common wombat *Vombatus ursinus*. Pages 298-304 *in* Wells, RT and Pridmore, PA, editors. *Wombats*. Surrey Beatty and Sons: Chipping Norton

Marks, CA 1998b Review of the humaneness of destruction techniques used on the common wombat *Vombatus ursinus* in Victoria. Pages 287-297 *in* Wells, RT and Pridmore, PA, editors. *Wombats*. Surrey Beatty and Sons: Chipping Norton

Marks, CA 1999 Ethical issues in vertebrate pest management: can we balance the welfare of individuals and ecosystems? *in* Mellor, D and Monamy, V, editors. The Use of Wildlife for Research. ANZCCART: Glen Osmond

Marks, CA 2001a Bait delivered cabergoline for the reproductive control of the red fox (*Vulpes vulpes*): estimating mammalian non-target risk in south-eastern Australia. *Reproduction, Fertility and Development 13*: 499-510

Marks, CA 2001b The Achilles heel principle. Pages 330-335 in: Proceedings of the 12th Australasian Vertebrate Pest Conference: Melbourne

Marks, CA 2003 What is possible to ensure that existing control methods are more humane? in: Solutions for achieving humane vertebrate pest control. RSPCA: Canberra

Marks, CA, Allen, L, Gigliotti, F, Busana, F, Gonzalez, T, Lindeman, M and Fisher, PM 2004 Evaluation of the tranquilliser trap device (TTD) for improving the humaneness of dingo trapping. *Animal Welfare 13*: 393-399

Marks, CA and Bloomfield, TE 1998 Canine heartworm (*Dirofilaria immitis*) detected in red foxes (*Vulpes vulpes*) in urban Melbourne. *Veterinary Parasitology 78*: 147-154

Marks, CA and Bloomfield, TE 1999a Distribution and density estimates for urban foxes (*Vulpes vulpes*) in Melbourne: implications for rabies control. *Wildlife Research 26*: 763-775

Marks, CA and Bloomfield, TE 1999b Bait uptake by foxes (*Vulpes vulpes*) in urban Melbourne: the potential of oral vaccination for rabies control. *Wildlife Research 26*: 777-787

Marks, CA and Bloomfield, TE 2006 Home range size and selection of natal den and diurnal shelter sites by urban red foxes (*Vulpes vulpes*) in Melbourne. *Wildlife Research 33*: 339-347

Marks, CA, Fisher, PM, Moore, S and Hauge, N 1995 Techniques for the mitigation of plantation seedling damage by the European rabbit (*Oryctolagus cuniculus*) and the swamp wallaby (*Wallabia bicolor*). Proceedings of the 10th Australian Vertebrate Pest Control Conference. DPI: Hobart

Marks, CA, Hackman, C, Busana, F and Gigliotti, F 2000 Assuring that 1080 toxicosis in the red fox (*Vulpes vulpes*) is humane: fluoroacetic acid (1080) and drug combinations. *Wildlife Research 27*: 483-494

Martini, A, Lorenzini, RN, Cinotti, S, Fini, M, Giavaresi, G and Giandino, R 2000 Evaluation of pain and stress levels of animals used in experimental research. *Journal of Surgical Research 88*: 114-119

Masini, CV, Sauer, S, White, J, Day, HEW and Campeau, S 2006 Non-associative defensive responses of rats to ferret odor. *Physiology and Behavior 87*: 72-81

Mason, JW 1968 "Over-all" hormone balance as a key to endocrine organisation. *Psychosomatic Medicine 30*: 791-808

Mason, RJ, Belant, J, Barras, AE and Guthrie, JW 1999 Effectiveness of color as an M-44 attractant for coyotes. *Wildlife Society Bulletin 27*: 86-90

McCue, PM and O'Farrell, TP 1987 Hematologic values of the endangered San Joaquin kit fox *Vulpes macrotis mutica*. *Journal of Wildlife Disease 23*: 144-151

McCutchan, JC 1980 *Electric fence design principles*. University of Melbourne: Melbourne

McFarland, D 1981 *The Oxford companion to animal behaviour*. Oxford University Press: Oxford

McGregor, IS, Schrama, L, Ambermoon, P and Dielenberg, RA 2002 Not all 'predator odours' are equal: cat odour but not 2,4,5 trimethylthiazoline (TMT; fox odour) elicits specific defensive behaviours in rats. *Behavioural Brain Research 129*: 1-16

McIIroy, JC, Saunders, G and Hinds, LA 2001 The reproductive performance of female red foxes, *Vulpes vulpes*, in central-western New South Wales during and after drought. *Canadian Journal of Zoology 79*: 545-553

McIlroy, JC 1977 Aspects of the ecology of the common wombat (*Vombatus ursinus*) II. Methods for estimating population numbers. *Australian Wildlife Research 4*: 223-228

McIlroy, JC 1981 The sensitivity of Australian animals to 1080 poison II. Marsupial and eutherian carnivores. *Australian Wildlife Research 8*: 385-399

McIlroy, JC, Cooper, RJ, Gifford, EJ, Green, BF and Newgrain, KW 1986 The effect on wild dogs, *Canis familiaris*, of 1080-poisoning campaigns in Kosciusko National Park, NSW. *Australian Wildlife Research 13*: 535-544

McIntosh, DL 1963 Reproduction and growth of the fox in the Canberra district. *CSIRO Wildlife Research 8*: 132-141

McKillop, IG and Silby, RM 1988 Animal behaviour at electric fences and the implication for management. *Mammal Review 18*: 91-103

McLeod, R 2004 *Counting the cost: impact of invasive animals in Australia, 2004*. Cooperative Research Centre for Pest Animal Control: Canberra

McNeil Alexander, R 2006 *Principles of animal locomotion*. Princeton University Press: Princeton

Meek, PD, Jenkins, DJ, Morris, B, Ardler, AJ and Hawksby, RJ 1995 Use of two humane leg-hold traps for catching pest species. *Wildlife Research 22*: 733-739

Mellor, DJ and Stafford, KJ 2000 Acute castration and/or tailing distress and its alleviation in lambs. *New Zealand Veterinary Journal 46*: 387-391

Melzack, R, Wall, PD and Ty, TC 1982 Acute pain in an emergency clinic: Latency of onset and descriptor pattens related to different injuries. *Pain 14*: 33-43

Mendl, M and Paul, ES 2004 Consciousness, emotion and animal welfare: insights from cognitive science. *Animal Welfare 13*: S17-S25

Menkhorst, PW 1995 *Mammals of Victoria*. Oxford University Press: Melbourne

Menkhorst, PW and Knight, F 2004 *A field guide to the mammals of Australia*. Oxford University Press: Melbourne

Mersky, H and Brogduk, N 1994 *IASP taskforce on taxonomy. Chronic Pain.* IASP Press: Seattle

Millar, JS and Hickling, GJ 1990 Fasting endurance and the evolution of mammalian body size. *Functional Ecology 4*: 5-12

Mills, DS and Simpson, BS 2002 Psychotropic agents. *in* Horwitz, D, Mills, D, and Heath, S, editors. BSAVA manual of canine and feline behavioural medicine. British Small Animal Veterinary Association: Gloucester

Millspaugh, JJ, Coleman, MA, Bauman, PJ, Raedeke, KJ and Brundige, GC 2000 Serum profiles of American elk (*Cervus elaphus*) at the time of handling for three capture methods. *Canadian Field Naturalist 114*: 196-200

Moberg, GP 1985 Biological response to stress: key to assessment of animal well-being? Pages 27-49 *in* Moberg, GP, editor. Animal Stress. American Physiology Society: Bethesda

Moberg, GP 1999 When does stress become distress? *Laboratory Animals 28*: 422-426

Moe, RO and Bakken, M 1997 Effects of handling and physical restraint on rectal temperature, cortisol, glucose and leucocyte counts in the silver fox (*Vulpes vulpes*). *Acta Veterinaria Scandinavica 38*: 29-39

Moe, RO and Bakken, M 1998 Anxiolytic drugs inhibit hyperthermia induced by handling in farmed silver foxes (*Vulpes vulpes*). *Animal Welfare 7*: 97-100

Moe, RO, Bakken, M, Kittilsen, S, Kingsley-Smith, H and Spruijt, BM 2006 A note on reward related behaviour and emotional expressions in farmed silver foxes (*Vulpes vulpes*) - Basis for a novel tool to study animal welfare. *Applied Animal Behaviour Science 101*: 362-368

Mohawk, JA and Lee, TM 2005 Restraint stress delays reentrainment in male and female diurnal and nocturnal rodents. *Journal of Biological Rhythms 20*: 245-256

Molony, V, Kent, JE and McKendrick, IJ 2002 Validation of a method for an assessment of an acute pain in lambs. *Applied Animal Behaviour Science 76*: 215-238

Molsher, RL 2001 Trapping and demographics of feral cats (*Felis catus*) in central NSW. *Wildlife Research 28*: 631-636

Monclus, R, Rodel, H and Von Holst, D 2006 Fox odor increases vigilance in European rabbits: A study under semi-natural conditions. *Ethology 112*: 11861193

Montane, J, Marco, I, Manteca, X, Lopez, J and Lavin, S 2002 Delayed acute capture myopathy in three roe deer. *Journal of veterinary medicine. A, Physiology, pathology, clinical medicine 49*: 93-98

Morgan, KN and Tromborg, CT 2007 Sources of stress in captivity. *Applied Animal Behaviour Science 102*: 262-302

Morris, JP, Ong, RM, O'Dwyer, JK, Barnett, JL, Hemsworth, PH, Clarke, IJ and Jongman, EC 1997 Pain-related cerebral potentials in response to acute painful electrical stimuli in sheep. *Australian Veterinary Journal 75*: 883-886

Morris, MC and Weaver, SA 2003 Minimizing harm in possum control operations and experiments in New Zealand. *Journal of Agricultural and Environmental Ethics 16*: 367-385

Mowat, G, Slough, BG and Rivard, R 1994 A comparison of three live capturing devices for lynx: capture efficiency and injuries. *Wildlife Society Bulletin 22*: 644-650

Muir, W 2006 Trauma: physiology, pathophysiology, and clinical implications. *Journal of Veterinary Emergency and Critical Care 16*: 253-263

Münster, AM, Ingermann, JJ, Bech, B and Gram, J 2001 Activation of blood coagulation in pigs following lower limb gunshot trauma. *Blood Coagulation and Fibrinolysis 12*: 477-485

Murphy, GD and Backholer, JR. 1990. A management information system for wild dogs. Keith Turnbull Research Institute: Frankston (unpublished report).

Nagal, T 1974 What is it like to be a bat? *Philosophical Reviews 83*: 435-450

Nagy, KA 2005 Field metabolic rate and body size. *Journal of Experimental Biology 208*: 1621-1625

Nagy, KA, Girard, IA and Brown, TK 1999 Energetics of free-ranging mammals, reptiles and birds. *Annual Review of Nutrition 19*: 247-277

Neilson, JC 2002 Fear of places and things. Pages 144-153 *in* Horwitz, D, Mills, D, and Heath, S, editors. BSAVA manual of canine and feline behavioural medicine. British Small Animal Veterinary Association: Gloucester**Nellis, CH** 1968 Some methods for capturing coyotes alive. *Journal of Wildlife Management 32*: 402-405

Newsome, AE, Corbett, LK, Catling, PC and Burt, RJ 1983 The feeding ecology of the dingo .1. Stomach contents from trapping in south-eastern Australia, and the non-target wildlife also caught in dingo traps. *Australian Wildlife Research 10*: 477-486

Nicholson, HP and Vetter, MH 1950 A lethal trap for capturing small mammals with their ectoparasites. *Journal of Parasitology 36*: 235-237

Nitz, AJ, Dobner, JJ and Matulionis, DH 1986 Pneumatic tourniquet application and nerve integrity: motor function and electrophysiology. *Experimental Neurology 94*: 264-279

Nolan, JW, Russell, RH and Anderka, F 1984 Transmitters for monitoring Aldrich snares set for grizzly bears *Journal of Wildlife Management 48*: 942-945

Novak, MA 1987 Traps and trap research. *in* Novak, M, Baker, JA, Obbard, ME, and Malloch, B, editors. Wild furbearer management and conservation in North America. Ministry of Natural Resources: Toronto

Nowak, RM 1991 *Mammals of the world*. John Hopkins University Press: Baltimore

O'Connor, WJ 1977 Drinking caused by exposing dogs to radiant heat. *Journal of Physiology 264*: 229-237

Okarma, H and Jedrzejewski, W 1997 Live trapping wolves with nets. *Journal of Wildlife Management 25*: 78-82

Olsen, GH, Linhart, SB, Holmes, RA, Dasch, GJ and Male, CB 1986 Injuries to coyotes caught in padded and unpadded steel foothold traps. *Wildlife Society Bulletin 14*: 219-223

Olsen, GH, Linscombe, RG, Wright, VL and Holmes, RA 1988 Reducing injuries to terrestrial furbearers by using padded foothold traps. *Wildlife Society Bulletin 16*: 303-307

Onderka, DK, Skinner, DL and Todd, AW 1990 Injuries to coyotes and other species caused by four models of footholding devices. *Wildlife Society Bulletin 18*: 175-182

Ong, RM, Morris, JP, O'Dwyer, JK, Barnett, JL, Hemsworth, PH and Clarke, IJ 1996 Behavioural and EEG changes in sheep in response to painful acute electrical stimuli. *Australian Veterinary Journal 75*: 189-193

Osadchuk, LV, Braastad, BO, Hovland, A and Bakken, M 2001 Morphometric and hormonal changes following persistent handling in pregnant blue fox vixens (*Alopex lagopus*). *Animal Science 72*: 407-414

Palestrini, C, Previde, EP, Spiezio, C and Verga, M 2005 Heart rate and behavioural responses of dogs in the Ainsworth's strange situation: A pilot study. *Applied Animal Behaviour Science 94*: 75-88

Pascoe, PJ and Dyson, DH 1993 Analgesia after lateral thoracotomy in dogs: epidural morphine versus intercostal bupivacaine. *Veterinary Surgery 22*: 141-147

Patterson, BD, Neiburger, EJ and Kasiki, SM 2003 Tooth breakage and dental disease as causes of carnivore-human conflicts. *Journal of Mammalogy 81*: 190-196

Payne, NF 1980 Furbearer management and trapping. *Wildlife Society Bulletin 8*: 345-348

Peichl, L 2005 Diversity of mammalian photoreceptor properties: adaptations to habitat and lifestyle. *The Anatomical Record Part A 287A*: 1001-1012

Petrides, GA 1946 Snares and deadfalls. *Journal of Wildlife Management 10*: 234-238

Phillips, RL 1996 Evaluation of 3 types of snares for capturing coyotes *Wildlife Society Bulletin 24*: 107-110

Phillips, RL, Blom, FS, Dasch, GJ and Guthrie, JW 1992 Field evaluation of three types of coyote traps. in: 15th Vertebrate Pest Conference. University of California: Davis

Phillips, RL and Gruver, KS 1996a Performance of the Paws-I-Trip pan tension device on 3 types of traps. *Wildlife Society Bulletin 24*: 119-122

Phillips, RL, Gruver, KS and Williams, ES 1996b Leg injuries to coyotes captured in three types of foothold traps. *Wildlife Society Bulletin 24*: 260-263

Phillips, RL and Mullis, C 1996c Expanded field testing of the No. 3 Victor Soft Catch® trap. *Wildlife Society Bulletin 24*: 128-131

Pizzey, G and Knight, F 1997 *Field guide to the birds of Australia*. Angus and Robertson: Sydney

Plumb, DCE 1999 *Veterinary drug handbook*. Iowa State University Press: Ames

Powell, RA 2005 Evaluating welfare of American black bears (*Ursus americanus*) captured in foot snares and in winter dens. *Journal of Mammalogy 86*: 1171-1177

Powell, RA and Proulx, G 2003 Trapping and marking terrestrial mammals for research: integrating ethics, performance criteria, techniques, and common sense. *ILAR Journal 44*: 259-276

Price, EO 1984 Behavioural aspects of animal domestication. *The Quarterly Review of Biology 59*: 1-32

Princen 2004 EC compliance with WTO law: The interplay of law and politics. *European Journal of International Law 15*: 555-574

Proulx, G and Barrett, MW 1990 Assessment of power snares to effectively kill red fox. *Wildlife Society Bulletin 18*: 27-30

Proulx, G and Barrett, MW 1991 Evaluation of the Bionic trap to quickly kill mink (*Mustela vison*) in simulated natural environments. *Journal of Wildlife Diseases 27*: 276-280

Proulx, G and Barrett, MW 1993a Evaluation of the Bionic trap to quickly kill fisher (*Martes pennanti*) in simulated natural environments. *Journal of Wildlife Diseases 29*: 310-316

Proulx, G and Barrett, MW 1993b Evaluation of mechanically improved Conibear 220 traps to quickly kill fisher (*Martes pennanti*) in simulated natural environments. *Journal of Wildlife Diseases 29*: 317-323

Proulx, G, Kolenosky, AJ, Badry, MJ, Cole, PJ and Drescher, RK 1994a A snowshoe hare snare system to minimize capture of martens. *Wildlife Society Bulletin 22*: 639-643

Proulx, G, Kolenosky, AJ and Cole, PJ 1993 Assessment of the Kania trap to humanely kill red squirrels (*Tamiasciurus hudsonicus*) in enclosures. *Journal of Wildlife Diseases 29*: 324-329

Proulx, G, Kolenosky, AJ, Cole, PJ and Drescher, RK 1995 A Humane Killing Trap for Lynx (*Felis lynx*) - the Conibear-330 (TM) with clamping bars. *Journal of Wildlife Diseases 31*: 57-61

Proulx, G, Morley, W, Barrett, S and Cook, R 1989 The C120 Magnum: An effective quick-kill trap for marten. *Wildlife Society Bulletin 17*: 294-298

Proulx, G, Pawlina, IM, Onderka, DK, Badry, MJ and Sielel, K 1994b Field evaluation of the number 1 1/2 steel-jawed leghold and the Sauvageau 2001-8 traps to humanely capture arctic fox. *Wildlife Society Bulletin 22*: 179-183

Prudhomme, JC, Bhatia, R, Nutik, J and Shusterman, D 1999 Chest wall pain and possible rhabdomyolysis after chloropicrin exposure: A case series. *Journal of Occupational and Environmental Medicine 41*: 17-22

Pruss, SD, Cool, NL, Hudson, RJ and Gaboury, AR 2002 Evaluation of a modified neck snare to live-capture coyotes. *Wildlife Society Bulletin 30*: 508-516

Putman, RJ 1995 Ethical considerations and animal-welfare in ecological field studies. *Biodiversity and Conservation 4*: 903-915

Rabinowitz, AR 1986 Jaguar *Panthera onca* predation on domestic livestock in Belize. *Wildlife Society Bulletin 14*: 170-174

Ramsay, DJ and Thrasher, TN 1991 Regulation of fluid intake in dogs following water deprivation. *Brain Research Bulletin 27*: 495-499

Reagan, SR, Ertel, JM, Stinson, P, Yakupzack, P and Anderson, D 2002 A passively triggered foot snare design for American black bears to reduce disturbance by non-target animals. *Ursus 13*: 317-320

Rendle, M. 2006. Stress and capture myopathy in hares. Irish Hare Initiative. Department of Environment: Northern Ireland

Reynolds, JC and Trapper, SC 1996 Control of mammalian predators in game management and conservation. *Mammal Review 26*: 127-155

Robertshaw, JD and Harden, RH 1985 The ecology of the dingo in north-eastern NSW. II Diet. *Australian Wildlife Research 12*: 163-171

Robinson, NA and Marks, CA 2001 Genetic structure and dispersal of red foxes (*Vulpes vulpes*) in urban Melbourne. *Australian Journal of Zoology 49*: 589-601

Robinson, W 1943 The "humane coyote-getter" vs the steel trap in control of predatory animals. *Journal of Wildlife Management 7*: 179-189

Rodin, BE and Kruger, L 1984 Deafferentation in animals as a model for the study of pain: an alternative hypothesis. *Brain Research Review 7*: 213-228

Rodriguez, J, Bruyns, J, Askanazi, J, DiMauro, W, Bordley, J, Elwyn, DH and Kinney, JW 1986 Carnitine metabolism during fasting in dogs. *Surgery 99*: 684-687

Rogers, DI, Battley, PF, Sparrow, J, Koolhaas, A and Hassell, CJ 2004 Treatment of capture myopathy in shorebirds: a successful trial in north-western Australia. *Journal of Field Ornithology 75*: 157-164

Romero, LM and Romero, RC 2002 Corticosterone responses in wild birds: The importance of rapid initial sampling. *Condor 104*: 129-135

Rorabeck, CH and Kennedy, JC 1980 Tourniquet-induced nerve ischemia complicating knee ligament surgery. *American Journal of Sports Medicine 8*: 98-102

Ross, J 1986 Comparisons of fumigant gases used for rabbit control in Great Britain. *in* Salmon, TP, editor. Proceedings of the 12th Vertebrate Pest Conference. University of California: Davis

Rowan, AN 1988 Animal anxiety and suffering. *Applied Animal Behaviour Science 20*: 135-142

RSPCA. 2004. A national approach towards humane vertebrate pest control. Discussion paper arising from the proceedings of an RSPCA Australia/AWC/VPC joint workshop. RSPCA Australia: Melbourne

Rupiński, S 1989 Effects of tourniquet ischemia of the arm on changes in selected parameters of muscle and metabolism. *Annales Academiae Medicae Stetinensis 35*: 131-143

Rushen, J 1996 Using aversion learning techniques to assess the mental state, suffering, and welfare of farm animals. *Journal of Animal Science 74*: 1990-1995

Russel, PA 1979 Fear evoking stimuli. Pages 86-124 *in* Sluckin, W, editor. Fear in Animals and Man. van Nostrand Reinhold: New York

Rutherford, KMD 2002 Assessing pain in animals. *Animal Welfare 11*: 31-53

Ryan, GE 1976 Observations on the reproduction and age structure of the fox (*Vulpes vulpes*) in New South Wales. *Australian Wildlife Research 3*: 11-20

Sacks, BN, Blejwas, KM and Jaeger, MM 1999 Relative vulnerability of coyotes to removal methods on a northern California ranch. *Journal of Wildlife Management 63*: 939-949

Sahr, DP and Knowlton, FF 2000 Evaluation of tranquilizer trap devices (TTDs) for foothold traps used to capture gray wolves. *Wildlife Society Bulletin 28*: 597-605

Sanchez, O, Arnau, A, Pareja, M, Poch, E, Ramirez, I and Soley, M 2002 Acute stress-induced tissue injury in mice: differences between emotional and social stress. *Cell Stress and Chaperones 7*: 36-46

Saunders, BP and Rowsell, HC 1984 Padded trap testing in British Columbia. *Proceedings of the Western Association of Fish and Wildlife Agencies 64*: 136-142

Saunders, G, Coman, BJ, Kinnear, J and Braysher, M 1995 *Managing Vertebrate Pests: Foxes.* Australian Government Publishing Service: Canberra

Saunders, G, White, PCL, Harris, S and Rayner, MV 1993 Urban foxes (*Vulpes vulpes*): food acquisition, time and energy budgeting of a generalised predator. *Zoology Society of London Symposium 65*: 215-234

Schmid-Schönbein, GW 1987 Capillary plugging by granulocytes and the no-reflow phenomenon in the microcirculation. *Federation Proceedings 46*: 2397-2410

Schmidt, RH and Brunner, JG 1981 A professional attitude towards humaneness. *Wildlife Society Bulletin 9*: 289-291

Schodde, R and Tideman, SC 1990 *Readers Digest complete book of Australian birds*. Reader's Digest Pty Ltd: Sydney

Schraufstatter, IU, Revak, SD and Cohrane, CG 1984 Proteases and oxidants in experimental pulmonary inflammatory injury. *Journal of Clinical Investigation 73*: 1175-1184

Schroeder, MT 1987 Blood chemistry, hematology, and condition evaluation of black bears in northcoastal California. Pages 284-290 *in* International Conference on Bear Research and Management: Virginia.

Scott, WN 1976 *The use of poisons in animal destruction: Humane destruction of unwanted animals.* Universities Federation of Animal Welfare: Hertfordshire

Seddon, PJ, Van Heezik, Y and Maloney, RM 1999 Short and medium term evaluation of foot-hold trap injuries in two species of fox in Saudi Arabia. Pages 67-78 *in* Proulx, G, editor. Mammal Trapping. Alpha Wildlife and Research: Alberta

Seligman, MEP 1972 Learned helplessness. *Annual Reviews of Medicine 23*: 407-412

Seryle, H 1950 *Stress*. Acta: Montreal

Shamir, MH, Leisner, S, Klement, E, Gonen, E and Johnston, DE 2002 Dog bite wounds in dogs and cats: a retrospective study of 196 cases. *Journal of the Veterinary Medical Association 49*: 107-112

Sharp, T and Saunders, G, editors. 2005a. Humane pest animal control: codes of practice and standard operating procedures: DOG001 trapping of wild dogs using padded jaw traps. NSW Department of Primary Industries: Orange

Sharp, T and Saunders, G, editors. 2005b. Humane pest animal control: codes of practice and standard operating procedures: FOX005 trapping of foxes using padded jaw traps. NSW Department of Primary Industries: Orange

Sheldon, WG 1949 A trapping and tagging technique for wild foxes. *Journal of Wildlife Management 13*: 309-311

Shepherd, NC, Hopwood, PR and Dostine, PL 1988 Capture myopathy - 2 techniques for estimating its prevalence and severity in red kangaroos, *Macropus rufus*. *Australian Wildlife Research 15*: 83-90

Shivik, JA and Gruver, KS 2002 Animal attendance at coyote trap sites in Texas. *Wildlife Society Bulletin 30*: 502-507

Shivik, JA, Gruver, KS and DeLiberto, TJ 2000 Preliminary evaluation of new cable restraints to capture coyotes. *Wildlife Society Bulletin 28*: 606-613

Shivik, JA, Martin, DJ, Pipas, MJ, Turnam, J and DeLiberto, TJ 2005 Initial comparison: jaws, cables and cage traps to capture coyotes. *Wildlife Society Bulletin 33*: 1375-1383

Short, J, Turner, B and Risbey, D 2002 Control of feral cats for nature conservation. III. Trapping. *Wildlife Research 29*: 475-487

Skerratt, LF, Skerratt, JHL, Banks, S, Martin, R and Handasyde, K 2004 Aspects of the ecology of common wombats *Vombatus ursinus* at high density in agricultural land in Victoria. *Australian Journal of Zoology 52*: 303-330

Skinner, DL and Todd, AW 1990 Evaluating efficiency of footholding devices for coyote capture. *Wildlife Society Bulletin 18*: 166-175

Soares, DD, Fernandez, F, Aguerre, S, Foury, A, Mormede, P and Chaouloff, F 2003 Fox odour affects corticosterone release but not hippocampal serotonin reuptake and open field behaviour in rats. *Brain Research 961*: 166-170

Spangenburg, E, Bjorklund, L and Dahlborn, K 2006 Outdoor housing of laboratory dogs: Effects on activity, behaviour and physiology. *Applied Animal Behaviour Science 98*: 260-276

Spraker, TR 1993 Stress and capture myopathy in artiodactylids. *in* Fowler, ME, editor. *Zoo and Wild Animal Medicine*. W.B. Saunders: Philadelphia

Stafleu, F, Vorstenbosch, J., Tramper, R., de Jong, M., Eckelboom, E., and Krijger, F. 2000 The concepts of "severe suffering" of experimental animals and "essential needs of man and animal" as used in cost-benefit analyses. Pages 833-839 in: Proceedings of the 3rd World Congress on Alternatives and Animal Use in the Life Sciences, held in Bologna, Italy. Elsevier: Amsterdam

Stevens, PL and Brown, AM 1987 Alternative traps for dog control *in* 8th Australian Vertebrate Pest Conference: Coolangatta

Stocek, RF and Cartwright, DJ 1985 Birds as non-target catches in the New Brunswick furbearer harvest. *Wildlife Society Bulletin 13*: 314-317

Strahan, R 1984 *Complete Book of Australian Mammals*. Angus and Robertson: Sydney

Suleman, MA, Wango, E, Farah, IO and Hau, J 2000 Adrenal cortex and stomach lesions associated with stress in wild male African green monkeys (*Cercopithecus aethiops*) in the post-capture period. *Journal of Medical Primatology 29*: 338-342

Tachibana, T 1982 Open-field test for rats: correlational analysis. *Psychological Reports 50*: 899-910

Taylor, RJ 1993 Observations on the behaviour and ecology of the common wombat *Vombatus ursinus* in northeast Tasmania. *Australian Mammalogy 16*: 1-7

Tembrock, G 1957 Zur Ethologie des Rotfuchses (*Vulpes vulpes*) unter besandere Berucksiehtigung der Fortpflanzung. *Zoologische Gaerten (Leipzig) 23*: 289-332

Temple-Smith, P and Grant, T 2001 Uncertain breeding: a short history of reproduction in monotremes. *Reproduction, Fertility and Development 13*: 487-497

Thomas, RM, Urban, JH and Peterson, DA 2006 Acute exposure to predator odor elicits a robust increase in corticosterone and a decrease in activity without altering proliferation in the adult rat hippocampus. *Experimental Neurology 201*: 308-315

Thomson, PC 1992 The behavioural ecology of dingoes in north-western Australia: III Hunting and feeding behaviour. *Wildlife Research 19*: 531-541

Thrasher, TN, Wade, CE, Keil, LC and Ramsay, DJ 1984 Sodium balance and aldosterone during dehydration and rehydration in the dog. *American Journal of Physiology: Regulatory, Integrative and Comparative Physiology 247*: R76-R83

Tobin, ME, Engeman, RM and Sugihara, RT 1995 Effects of mongoose odors on rat capture success. *Journal of Chemical Ecology 21*: 1573-1571

Tolosa, T and Regassa, F 2007 The husbandry, welfare and health of captive African civets (*Vivera civetica*) in western Ethiopia. *Animal Welfare 16*: 15-19

Triggs, B 1988 *The wombat: common wombats in Australia*. University of New South Wales Press: Sydney

Trut, LN, Plyusnina, IZ and Oskina, IN 2004 An experiment on fox domestication and debatable issues of evolution of the dog. *Russian Journal of Genetics 40*: 644-655

Tullar, BF 1984 Evaluation of a padded leg-holding trap for capturing foxes and racoons. *New York Fish and Game Journal 31*: 97-103

Tully, TN, Hodgin, C, Morris, JM, Williams, JL and Zebreznik, B 1996 Exertional myopathy in an emu. *Journal of Wildlife Disease 23*: 454-462

Turkowski, FJ, Armistead, AR and Linhart, SB 1984 Selectivity and effectiveness of pan tension devices for coyote foothold traps. *Journal of Wildlife Management 48*: 700-708

Turkowski, FJ, Popelka, ML and Bullard, RW 1983 Efficacy of odor lures and baits for coyotes. *Wildlife Society Bulletin 11*: 136-135

Tyndale-Biscoe, CH and Renfree, MB 1987 *Reproductive physiology of marsupials.* Cambridge University Press: Melbourne

Valentine, BA, Blue, JT, Shelley, SM and Cooper, BJ 1990 Increased serum alanine aminotransferase activity associated with muscle necrosis in the dog. *Journal of Veterinary Internal Medicine 4*: 140-143

Vallee, M, Mayo, W, Dellu, F, LeMoal, M, Simon, H and Maccari, S 1997 Prenatal stress induces high anxiety and postnatal handling induces low anxiety in adult offspring: Correlation with stress-induced corticosterone secretion. *Journal of Neuroscience 17*: 2626-2636

Valverde, A 2005 Pain management in horses and farm animals. *Journal of Veterinary Emergency and Critical Care 15*: 295-307

Van Ballenberghe, V 1984 Injuries to wolves sustained during live capture. *Journal of Wildlife Management 48*: 1425-1429

Van de Kar, LD and Blair, ML 1999 Forebrain pathways mediating stress induced hormone secretion. *Frontiers in Neuroendocrinology 20*: 1-48

Vanholder, R, Sever, MS, Ekrem, E and Lameire, N 2000 Rhabdomyolysis. *Journal of American Society of Nephrology 11*: 1553-1561

Vidal, C and Jacob, JJ 1982 Stress hyperalgesia in rats: an experimental animal model of anxiogenic hyperalgesia in humans. *Life Science 31*: 1241-1244

Viña, J, Gimeno, A, Sastre, J, Desco, C, Asensi, M, Pallardó, FV, Cuesta, A, Ferrero, AA, Terada, LS and Repine, JE 2000 Mechanism of free radical production in exhaustive exercise in humans and rats: Role of xanthine oxidase and protection by allopurinol. *International Union of Biochemistry and Molecular Biology Life 49*: 539 - 544

Walker, DL and Davis, M 2002 Light-enhanced startle: Further pharmacological and behavioral characterization. *Psychopharmacology 159*: 304-310

Walker, PM 1991 Ischemia/reperfusion injury in skeletal muscle. *Annals of Vascular Surgery 5*: 399-402

Wall, PD, Devor, M, Inbal, R, Scadding, JW, Schonfeld, DD, Seltzer, Z and Tomkiewicz, MM 1979 Autotomy following peripheral nerve lesion: experimental anaesthesia dolorosa. *Pain 7*: 103-111

Wallace, RS, Bush, M and Montali, RJ 1987 Deaths from exertional myopathy at the National Zoological park from 1975 to 1985. *Journal of Wildlife Disease 23*: 454-462

Warburton, B 1982 Evaluation of seven trap models as humane and catch-efficient possum traps. *New Zealand Journal of Zoology 9*: 409-418

Warburton, B 1992 Victor foot-hold traps for catching Australian brushtail possums in New Zealand: Capture efficiency and injuries. *Wildlife Society Bulletin 20*: 67-73

Warburton, B, Gregory, NG and Morris, G 2000 Effect of jaw shape in kill-traps on time to loss of palpebral reflexes in brushtail possums. *Journal of Wildlife Diseases 36*: 92-96

Warburton, B and Hall, JV 1995 Impact momentum and clamping force thresholds for developing standards for possum kill traps. *New Zealand Journal of Zoology 22*: 39-44

Warburton, B and O'Connor, C 2004 Research on vertebrate pesticides and traps: Do wild animals benefit? *Atla-Alternatives to Laboratory Animals 32*: 229-234

Waser, PM and Brown, CH 1986 Habitat acoustics and primate communication. *American Journal of Primatology 10*: 135-154

Way, JG, Ortega, IM, Auger, PJ and Straus, EG 2002 Box trapping eastern coyotes in south-eastern Massachusetts. *Wildlife Society Bulletin 30*: 695-707
Weary, DM, Niel, L, Flower, FC and Fraser, D 2006 Identifying and preventing pain in animals. *Applied Animal Behaviour Science 100*: 64-76
Webster, AJ 1998 What use is science to animal welfare? *Naturwissenschaften 85*: 262-269
Wells, RT 1978 Thermoregulation and activity rhythms in the hairy-nosed wombats, *Laisorhinus latifrons* (Owen) Vombatidae *Australian Journal of Zoology 26*: 639-651
White, J, Kreeger, TJ, Seal, US and Tester, JR 1991 Pathological responses of red foxes to capture in box traps. *Journal of Wildlife Management 55*: 75-80
Widowski, TM, Curtis, SE and Graves, CN 1989 The neutrophil:lymphocyte ratio in pigs fed cortisol. *Canadian Journal of Animal Science 69*: 501-504
Willenbring, S, DeLeo, JA and Cooms, DW 1994 Differential behavioural outcomes in the sciatic cryoneurolysis model of neuropathic pain in rats. *Pain 58*: 135-140
Williams, ES and Thorne, ET 1996 Excertional myopathy (capture myopathy). *in* Locke, LN and Hoff, Gl, editors. Non-infectious diseases of wildlife. Iowa State University Press: Ames
Williams, S, Usherwood, J and Wilson, A 2007 Acceleration in the racing greyhound. *Comparative Biochemistry and Physiology A 146*: S107-S127
Windberg, LA and Knowlton, FF 1990 Relative vulnerability of coyotes to some capture procedures. *Wildlife Society Bulletin 18*: 282-290
Winstanley, RK, Buttemer, WA and Saunders, G 2003 Field metabolic rate and body water turnover of the red fox *Vulpes vulpes* in Australia. *Mammal Review 33*: 295-301
Wintrobe, MM 1976 *Clinical Hemotology.* Lea and Febiger: Philadelphia
Wladis, A, Hahn, RG, Brismar, B, Kjellström, B and Thomas, B 2002 Induced hyperthermia after high energy soft-tissue injury and subsequent hemorrhagic shock. *Shock 17*: 120-126
Woolf, CJ 1994 The dorsal horn: state dependent sensory processing. *in* Bond, MR, Charlton, JE, and Woolf, CJ, editors. *Textbook of Pain*. Churchill Livingstone: Edinburgh
Woolhouse, AD and Morgan, DR 1995 An evaluation of repellents to suppress browsing by possums. *Journal of Chemical Ecology 21*: 1571-1583
Zelin, S, Jofriet, JC, Percival, K and Abdinoor, DJ 1983 Evaluation of humane traps: momentum thresholds for four furbearers. *Journal of Wildlife Management 47*: 863-868
Zemlicka, DE and Bruce, KJ. 1991. Comparison of handmade and moulded rubber tranquilizer tabs for delivering tranquilizing materials to coyotes captured in leg-hold traps. Great Plains Wildlife Damage Control Workshop. University of Nebraska: Lincoln
Zimmerman, M 1986 Behavioural investigation of pain in animal. *in* Duncan, IJH and Molony, V, editors. Assessing pain in farm animals. Commission of European Communities: Luxembourg
Zoellick, BW and Smith, NS 1986 Capturing desert kit foxes at dens with box traps. *Wildlife Society Bulletin 14*: 284-286

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APPENDIX 1.0

Haematological and biochemical responses of red foxes (*Vulpes vulpes*) to different recovery methods

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Abstract

Haematology and blood biochemistry profiles were produced for red foxes (*Vulpes vulpes*) recovered by either cage traps, treadle-snares, Victor Soft-Catch (VSC) #3 traps, netting or shooting. Compared to all other recovery methods, foxes captured in treadle-snares had significantly higher mean albumin (ALB), creatine kinase (CK), red cell count (RCC), neutrophil to lymphocyte (N:L) ratio, sodium (Na), total protein (TP) and white cell counts (WCC). Treadle-snares were also associated with higher chloride (Cl), haemoglobin (Hb) and packed cell volume (PCV) than cage trapping and netting. Treadle-snares produced indicators of greater muscle damage, exertion and dehydration compared to cage and VSC traps. These data do not support former studies that concluded that due to similar injury scores, treadle-snares and VSC traps produced equivalent welfare outcomes. Injury and death are end-points of poor welfare and monitoring stress using physiological indicators allows the relative potential for different recovery techniques to cause pathological and pre-pathological states to be compared. Different pest control and wildlife management techniques may vary greatly in the magnitude and nature of stress they produce and physiological indicators might be a highly informative way to investigate, qualify and rank relative welfare outcomes.

Keywords: Trapping, snares, foot-hold traps, leg-hold traps, stress, red fox, *Vulpes vulpes*

Introduction

The assessment of welfare outcomes arising from different leg-hold (or ‘foot-hold’) traps used for coyotes (*Canis latrans*), wolves (*Canis lupus*), dingoes (*Canis lupus dingo*) and red foxes (*Vulpes vulpes*) (collectively referred to as ‘canids’) has relied upon contrasting the extent of visible injuries assessed upon their recovery (eg. Tullar 1984; Van Ballenberghe 1984; Olsen *et al.* 1986; Onderka *et al.* 1990; Houben *et al.* 1993; Hubert *et al.* 1997; Phillips *et al.* 1996; Fleming *et al.* 1998). However, physical injury is only one indicator of the overall stress and potential suffering (Iossa *et al.* 2007). Trapping produces a wide range of stressors (Moberg 1985; Gregory 2005) and stress which if intense or prolonged can have negative impacts upon an animal's welfare (Jordan 2005). Anxiety may result from stressors such as abnormal light exposure, unfamiliar odours, aversive sounds and restricted movement (Morgan and Tromborg 2007). Limb oedema is frequently observed after trapping in leg-hold traps (Andelt *et al.* 1999), yet its relationship to the onset of ischemic injury cannot be easily predicted from gross examination, as necrotic tissue develops over many days or weeks (Walker 1991). Stress can produce pathology such as myocardial lesions and affect tissue integrity in vital organs (Sanchez *et al.* 2002) and increase the risk of infectious disease by reducing the effectiveness of the immune system (Raberg *et al.* 1998). Capture myopathy can cause chronic debilitation in some species and predispose them to morbidity and death weeks after capture (Hulland 1993). Dehydration caused by prolonged confinement and/or intense activity during captivity (eg. Powell 2005) is not frequently considered as a specific welfare problem associated with trapping.

Welfare indicators are required to assist with good welfare in conservation activities (Bonacic *et al.* 2003) and to support the development of more humane vertebrate pest control (Marks 2003; Littin *et al.* 2004; Littin and Mellor 2005). Physiological responses to different capture techniques have proved to be useful indicators for assessing welfare outcomes for red foxes (Kreeger *et al.* 1990a; White *et al.* 1991), kit foxes (*Vulpes macrotis mutica*) (McCue and O'Farrell 1987), African wild dogs (*Lycaon pictus*) (De Villiers *et al.* 1995), grizzly bears (*Ursus arctos*) (Cattet *et al.* 2003), black bears (*Ursus americanus*) (Powell 2005), river otters (*Lontra canadensis*) (Kimber and Kollias 2005), Eurasian otters (*Lutra lutra*) (Fernandez-Moran *et al.* 2004), brushtail possums (*Trichosurus vulpecula*) (Warburton *et al.* 1999) and koalas (*Phascolarctos cinereus*) (Hajduk *et al.* 1992). The International Standards Organization (ISO) Technical Working Group on Traps rejected the use of hormone and blood biochemistry to develop welfare indicators for canid trapping (Harrop 2000), yet many haematological and biochemical indicators are standardised, cost-effective and widely available. Currently there are few data on physiological responses to different traps (Powell 2005), especially for canids that continue to be the focus of on-going trapping in Australia (Saunders *et al.* 1995; Fleming *et al.* 2001; Allen and Fleming 2004) and the United States (Fox and Papouchis 2004).

Analysis of visible trauma scores after the capture of foxes and dogs led to the conclusion that treadle-snares were more humane (Stevens and Brown 1997; Fleming *et al.* 1998) or delivered approximately equivalent welfare outcomes to Victor Soft-Catch #3 (VSC) traps (Meek *et al.* 1995). As a range of trapping and recovery techniques were used during a study of urban red foxes in Melbourne (Australia), the influence of recovery methods upon haematology and blood biochemistry values were investigated and compared with published normal values or those reported after known periods of confinement in traps or after shooting. This paper sought to determine if common haematology and blood biochemistry values might assist in determining the relative welfare outcomes arising from different red fox recovery techniques and if the previous conclusions about welfare outcomes produced by treadle-snares and VSC traps were supportable.

Methods

Capture and recovery methods

All foxes were recovered from urban habitats within 20 km of central Melbourne, Australia (37.8° S 145.0° E) that were used in previously reported studies (Marks and Bloomfield 1998; 1999a,b, 2006; Robinson and Marks 2001). The treadle-snare (Glenburn Motors: Yea) and Victor® "Soft-Catch" #3 traps (VSC) (Animal Capture Equipment and Services: Warrick) were set as described by Meek *et al.* (1995), using fish-based cat food as a lure. The treadle-snare is shaped like a small banjo and has a circular pan or 'treadle' similar to the Aldridge snare (see Skinner and Todd 1990). A wire cable snare is placed around the pan and the snare is thrown up the animal's limb, and tightened by a spring arm when triggered (Meek *et al.* 1995; Fleming *et al.* 1998). Cage traps measuring 1200 × 450 × 450 mm with a hook and modified floor press trigger (Wiretainers: Preston, Australia) or 1800 × 450 × 600 mm custom-made cage traps were baited with whole chicken carcasses. Traps were set on or alongside known fox trails, fences, gates, culverts or outside diurnal shelter sites that were typically beneath houses or on the periphery of patches of blackberry (*Rubus fruiticosus* agg.), wandering tradescantia (*Tradescantia albiflora*), African thistle (*Berkheya rigida*), fennel (*Foeniculum vulgare*) and introduced grasses (Marks and Bloomfield 2006). Traps were inspected at least every four hours during the evening and were de-activated during the day. Blood samples were opportunistically taken during fox control programmes that used terrier dogs to flush foxes from shelter sites into 1-m high, 50-m long micro-filament 'gill nets' that were set loosely surrounding diurnal shelter sites. A sample of shot foxes was taken at urban locations at the end of all research activities when this could be achieved safely. Sub-sonic .22 calibre ammunition was used with a Ruger 10/22 rifle that had been modified with a target-rifle barrel and fitted with a silencer and a telescopic sight. Foxes were head shot from a distance of < 25 m after being illuminated with a 100 W spotlight.

Sedation and blood sampling

Upon recovery, live captured foxes were covered with a hessian sack, restrained with a hand noose and dosed with an intramuscular injection of 10 mg kg^{-1} of a tiletamine/zolazepam combination (Zoletil®: Virbac, Australia), based upon an assumed adult median weight of 4 kg; this produced deep sedation and light anaesthesia. Tiletamine and zolazepam combinations have been used successfully for minor surgery in foxes without an indication that they caused significant alteration in haematology and blood biochemistry values (Kreeger *et al.* 1990b). A 30 mL sample of blood was taken from the jugular vein with a 1 x 30 mm (19G) needle and apportioned into 10 mL lithium heparin, EDTA and clot vacutainer tubes (Becton-Dickenson: Melbourne). Blood samples were taken close to the point of recovery usually within the first hour of capture and before the anaesthetic had fully abated. If anaesthesia was insufficient, an hour was allowed to elapse before administering the full dose again. After shooting, blood samples were taken by cardiac puncture immediately after death had been confirmed by the loss of corneal reflex. Vacutainers were transported to Dorevitch Pathology (Camberwell) at 0600 hrs the following morning for haematology and biochemistry analysis.

Statistical analysis and comparison with published data

Foxes were deemed to be adults if their weight exceeded 3 kg and they were at least 9 months old, based upon a minimum estimated age at the time of capture using August as the birth month in Melbourne (Robinson and Marks 2001; Marks and Bloomfield 2006). Residual data were stabilised by transformation if necessary, together with non-normally distributed data prior to analysis. Comparisons of recovery method with haematological and blood biochemistry values were analysed using a general linear model using the least significant difference (LSD) test for *post hoc* comparison. Relationships between adult fox gender, weight and recovery method were tested using binary logistic regression (SPSS version 16: SPSS, Chicago). Comparisons were made with published accounts of blood values following trapping in VSC traps, shooting (Kreeger *et al.* 1990a), cage traps (White *et al.* 1991) and normal blood data based upon sampling a mixed population of captive silver and red foxes (both *V. vulpes*) (Benn *et al.* 1986).

Results

A total of 125 foxes were recovered. Two were euthanased due to trapping injury (broken leg and trauma to the scrotum) and excluded from the sample, along with 35 juvenile foxes. Foxes recovered by either VSC traps or treadle-snares typically had mild oedematous swelling of the captured limb two hours after recovery but no injuries were detected in cage trapped or netted foxes.

A total of 88 adult foxes (female = 38, male = 50) had blood samples successfully analysed after recovery with cage traps (n = 8), netting (n = 17), shooting (n = 11), treadle-snares (n = 45) and Victor Soft-Catch traps (n = 7). There was no significant relationship between the recovery method and gender (ß = -0.28, Wald = 1.62, d.f. = 1, P = 0.760) or the mean weight of males (5.2 kg, sd = 1) and females (4.7 kg, sd = 1.44) (F = 1.9, d.f. = 1, P < 0.174). Inconsistent records for alkaline phosphatase and eosinophil values produced a small data set and precluded analysis. In the remaining data there were insufficient data to test responses due to sex and weight, data were pooled for analysis. Recovery methods had no significant effects upon bicarbonate, triglyceride, urea, mean corpuscular volume, mean corpuscular haemoglobin or platelets. Significant effects were detected for red cell count (RCC) (F = 17.7, d.f. = 4, P < 0.001), packed cell volume (PCV) (F = 19.1, d.f. = 4, P < 0.001), white cell count

(WCC) ($F = 15.5$, d.f. = 4, $P < 0.001$), haemoglobin (Hb) ($F = 3.07$, d.f. = 4, $P < 0.05$), neutrophil to lymphocyte (N:L) ratio ($F = 10.8$, d.f. = 4, $P < 0.001$), albumin (ALB) ($F = 21.8$, d.f. = 4, $P < 0.001$), total protein (TP) ($P = 20.0$, d.f. = 4, $P < 0.001$), creatine kinase (CK) ($F = 60.7$, d.f. = 4, $P < 0.001$), sodium (Na) ($F = 18.6$, d.f. = 4, $P < 0.001$), potassium (K) ($F = 15.5$, d.f. = 4, $P < 0.001$) and chloride (Cl) ($F = 3.3$, d.f. = 4, $P < 0.05$).

Foxes captured in the treadle-snare had significantly higher mean ALB, CK, RCC, N:L ratio, Na, TP and WCC when compared to all other recovery methods. Compared to cage trapping and netting, treadle-snares were also associated with higher Cl, Hb and PCV values. Foxes captured in Victor Soft-Catch traps had significantly higher mean ALB and CK compared to shot foxes ($P < 0.05$) and higher mean CK values than observed in foxes that had been shot, netted or captured in cage traps ($P < 0.01$). Shot foxes had a significantly higher concentration of Na compared to those that had been captured in a cage trap ($P < 0.01$) or by netting ($P < 0.01$) (Table 1).

Discussion

What are appropriate physiological indicators of trapping stress?

Trappers were reported to inspect traps every 8 hours in Sweden (Englund 1982). In the United States (in 1995) 33 states required that traps must be inspected every 24 hours (Andelt *et al.* 1999), yet in Victoria (Australia) some trappers are compelled to inspect leg-hold traps only every 48 hours. Different trap inspection periods suggest that welfare outcomes for the same trapping devices may be correspondingly variable. Comparisons of injury data from different traps will only be valid if the mean period of captivity for any experimental group is not significantly different between or within studies that are compared. Few studies have sought to monitor the duration and changing intensity of struggling during captivity and then related this to welfare indicators and outcomes (Marks *et al.* 2004).

Activation of the hypothalamic-pituitary-adrenal axis and flight-fight response following capture causes a period of vigorous struggling that is likely to influence the degree of trauma experienced by foxes (Kreeger *et al.* 1990) and the onset of pre-pathological states. Struggling by foxes was intense immediately following capture in VSC #1 ½ traps, but decreased rapidly after the first two hours (Kreeger *et al.* 1990a). A similar pattern was observed for foxes captured in cage traps (White *et al.* 1991) and dingoes captured in VSC #3 traps fitted with activity monitoring devices (Marks *et al.* 2004). Foxes may adopt a strategy of conservation-withdrawal after some hours and a reduction in observed struggling with reduced potential for injury (Kreeger *et al.* 1990a).

Physiological measures that provide a generalised indication of the cumulative physiological and pathological impact of trapping must have sufficient persistence to be meaningful many hours after initial capture, in order to be useful indicators of welfare outcomes. While cortisol has been commonly used to investigate stressors (Carstens *et al.* 2000) and capture stress in dogs (De Villiers *et al.* 1995) and foxes (Kreeger *et al.* 1990a), sequential sampling may be required if stress response changes substantially during the period of capture. This is difficult to achieve in the field without introducing additional stressors from restraint, venipuncture or human presence (Beerda *et al.* 1996; Hennessy *et al.* 1998). Moreover, as the duration of a canid's captivity is rarely known with accuracy, the magnitude of the cortisol response at recovery of an animal is of limited value as an indicator of overall stress, given that peak cortisol is usually achieved in minutes and may decline within an hour (Beerda *et al.* 1998).

Injection of corticosteroids or adrenocorticotrophic hormones in dogs was reported to cause an increase in neutrophils (N) and a decrease in lymphocytes (L) within 2 – 4 hours (Jasper and Jain 1965). Stress may reduce the number of neutrophils held in marginal pools in some species and increase the number of circulating neutrophils, but will be contingent upon the nature and intensity of a stressor (Oishi *et al.* 2003). The N:L ratio may not be immediately detectable after periods of stress, yet was informative about trapping stress in foxes (Kreeger *et al.* 1990a). Short-term mental stressors have also been shown to cause a significant increase in neutrophil activation (Ellard *et al.* 2001). Neutrophil counts were significantly increased while lymphocytes decreased in dogs subjected to air transport (Bergeron *et al.* 2002) and in coyotes following capture and restraint (Gates and Goering 1976). Monitoring neutrophil activation due to transport stress was found to be a useful welfare indicator in European badgers (*Meles meles*) (Montes *et al.* 2004). Leukocytes counts are subject to diurnal variation, with neutrophils typically peaking in dogs during the day, corresponding to a decline in lymphocytes which tend to peak during the mid evening (Lilliehook 1997; Bergeron *et al.* 2002) and this may be significant if small changes in N:L ratios are being monitored.

Creatine kinase concentrations are used for diagnosing skeletal muscle damage (Aktas *et al.* 1993). In rats, the concentration of serum CK correlated strongly with the volume of muscle traumatised by crushing injury (Akimau *et al.* 2005). Tourniquet ischemia of the arm produced with the application of a pneumatic cuff for one hour caused elevations in CK and TP in humans that could be detected for three days after its removal (Rupiński 1989). Human patients that are manually or mechanically restrained respond with elevation in CK values (Goode *et al.* 1977) typically associated with muscle trauma (rhabdomyolysis), although shock, surgery or disease affecting the skeletal muscles (Prudhomme *et al.* 1999), myocardial damage (Moss *et al.* 1987) or prolonged and stressful exercise (Noakes 1987). Elevated CK was found in foxes captured in padded and unpadded leg-hold traps (Kreeger *et al.* 1990a), but not significantly in those captured in cage traps (White *et al.* 1991). Some stressors do not produce a significant increase in CK in some species or breeds (probably due to genotypic differences). In Alaskan sled dogs there was little indication of increases in serum CK after days of strenuous racing (Hinchcliff *et al.* 1996), yet elevation of CK is associated with physical exertion in most domestic dog breeds (Aktas *et al.* 1993). The reliability of CK as a specific marker for diagnosis of muscle disease (Auguste 1992, in Aktas *et al.* 1993) is also influenced by snake venom toxicosis, myocardial disease associated with parvovirus, dirofilariasis, haemolysis and venipuncture and interaction with some therapeutic agents (reviewed in Aktas *et al.* 1993). The progressive evaluation of recently captured river otters (*Lontra canadensis*) showed that CK was not a good indicator of musculoskeletal injury due to possible interactions with existing pathology independent of capture injury (Kimber and Kollias 2005). In flying foxes (*Pteropus hypomelanus*), anaesthesia with isoflurane (an anaesthetic) reduced the intensity of CK changes (Heard and Huft 1998).

Comparison of fox trapping data with other studies

Treadle-snares had a significantly greater effect upon blood values than VSC #3 traps and these data corresponded closely with those reported for foxes held in VSC #1 ½ traps for 8 hours for WCC, ALB, TP, CK, N:L and RCC (Kreeger *et al.* 1990a). Kreeger *et al.* (1990a) concluded that leg-hold traps produced a classic stress response characterised by an increase in HPA hormones, neutrophilia (high N:L ratio) and elevated CK, as well as other serum chemicals such as lactate dehydrogenase (LDH), alkaline phosphatase (ALP) and aspartate aminotransferase (AST). Foxes captured using VSC #3 traps in the Melbourne study revealed similar shifts in ALB, CK, WCC and Na values that were intermediate between those found after 2 and 8 hour confinement in VSC # 1 ½ traps (Kreeger *et al.* 1990a). Similarly, foxes held in a cage trap for 8 hours (White *et al.* 1991) had higher mean values for ALB, CK, Hb, RBC and N:L ratio compared to those held for < 4 hours in cage traps in Melbourne. The standard errors observed for the mean blood values obtained from shot foxes in Melbourne overlapped with those reported by Kreeger *et al.* (1990a) and White *et al.* (1991) for CK, Na, TP and WCC, and closely approximated the ALB and N:L values. Blood PCV taken from shot foxes in the Melbourne study and by Kreeger *et al.* (1990a) were higher than normals reported by Benn *et al.* (1986) or those from cage trapped foxes and may be an artefact of blood sedimentation *post mortem* (Table 2).

In some species, excitement and strenuous exercise can cause contraction of the spleen and expulsion of erythrocytes into circulation (Wintrobe 1976) and this may alter normal RBC, Hb and PCV (Hajduk *et al.* 1992). Blood normals for captive-bred foxes had higher Hb and RCC and were attributed to splenic contraction as a stress response during blood sampling in manually restrained and unsedated foxes (Benn *et al.* 1986). Other studies have used transponder collars to remotely anaesthetise free-ranging animals prior to blood sampling (eg. Powell 2005) and this appears to provide less equivocal blood normals typical of unrestrained animals. Elevated TP in captive foxes could be due to a high quality artificial diet (Benn *et al.* 1986) or a genotypic consequence of selective breeding. Normal CK values were reported to be substantially lower in fox blood normals (Benn *et al.* 1986) and captive wild red foxes prior to surgery (Kreeger *et al.* 1990b). This is possibly because shooting trauma elevates CK values, as seen in shot pigs (Münster *et al.* 2001) and after brain gunshot trauma (Kaste *et al.* 1981) (Table 2).

Black bears captured in Aldridge snares had higher CK and ALB values and this was attributed to greater exertion, muscle damage and dehydration compared to values generated from individuals captured by remote activated tranquilising collars (Powell 2005). Elevation of CK has also been reported for polar bears captured in snares (*Ursus maritimus*) (Lee *et al.* 1977; Schroeder 1987; Hubert *et al.* 1997). Grizzly bears had higher N:L ratios, as well as increased concentrations of Na and Cl that were attributed to dehydration due to water deprivation over 2-23 hours of captivity in snares and this was probably aggravated by intense activity (Cattet *et al.* 2003). Increased CK, PCV, ALB, Na, TP and Cl in treadle-snare when compared to cage trapped foxes appears consistent with these profiles and is suggestive of dehydration due to intense activity in red foxes.

Why do treadle-snares cause a greater physiological response?

Treadle-snares require adequate clearance from obstacles to allow the mechanism to function without obstruction, whereas VSC traps could be placed closer to or beneath overhanging vegetation. Treadle-snares were tethered to a solid fixture by 2 m lengths of snare cable and chain, in contrast to 0.5 m chains that were used to anchor the VSC traps. The snaring mechanism allow the fox's foot to remain in contact with the ground, so that they have the ability to run or leap to the end of the snare tether where they are brought to a sudden stop, while in VSC traps their coordinated movement appears to be impaired (C.A. Marks, personal observations). Many predators have evolved an ability to accelerate at greater rates than prey species, so that a short and efficient chase allows the predator to capture the prey without reaching top speed (McNeil-Alexander 2006). For example, racing greyhounds reach maximal horizontal acceleration of 15 m s^{-1} and can do so from a standing start in the first two strides (Williams *et al.* 2007). Being pulled to a sudden stop at higher speed may be associated with greater muscle damage, similar to the case hypothesised for Aldridge snares (Powell 2005) where constant tugging by bears captured in snares caused fractures, muscle, tendon, nerve and joint injury (Lemieux *et al.* 2006).

Traps have a wide range of moving parts with attachments, chains and mechanisms that produce a varying amount of sound when activated and resisted by captive animals. Loud noises were shown to be aversive to domestic dogs and affected gastric motility and hormone release (Gue *et al.* 1989), activity and behaviour (King *et al.* 2003). Noise is an important stressor that affects the welfare of captive laboratory animals (Jain *et al.* 2003). In a forest habitat, ambient noise levels ranged from 40 – 70 dB and in savannah habitats it was 20 – 36 dB (Waser *et al.* 1986). However, the sound of metal on metal during cage cleaning in a laboratory was measured to be 80 dB and had a wide spectrum of harmonics that were rich in different frequencies (Morgan *et al.* 2007). Noise made by the capture device may compound stress experienced by the captured animal and contribute to the initial startle responses. When inspecting fox trap lines that also used Victor Soft-Catch #3 traps, treadle-snares holding foxes were heard up to 50 m away by a characteristic 'metal against metal' sound of the treadle plate, the chain moving through the eye of the main spring and the sound of the device hitting hard surfaces. In contrast, Victor Soft-Catch #3 traps appeared to make far less sound if they were tethered on a short chain and fox captures could not be heard until a close approach was made to the trap site (C.A. Marks, personal observations). Post-capture noise stressors could be hypothesised as a possible contributing reason why comparative blood biochemistry values for foxes trapped in treadle-snares and Victor Soft-Catch traps differed significantly.

By reducing the length of snare anchoring cables used for bears it was suggested that dehydration and muscle injury could be reduced (Cattet *et al.* 2003). Traps and snares can also be attached to a movable object that produces less resistance than pulling at a fixed cable and this may also permit animals to seek shelter (Kirkwood 2005), yet Englund (1982) reported that 13% of foxes held in leg-hold snares moved the drag more than 500 m from point of capture and could avoid detection. Foxes also may become tangled in snares and trap cables more easily when drags are used and this may be responsible for increased incidence of fractures and dislocations (Linhart *et al.* 1988; Logan *et al.* 1999; Powell 2005).

Fate of foxes after release

No deaths or debilitation following the release of foxes recovered by any live capture method were detected in radio-collared adult foxes (Marks and Bloomfield 2006) and cubs (Robinson and Marks 2000), which were frequently observed for up to two years. Of these, 13/20 adults had been captured by treadle-snares and no obvious diminished mobility was seen after release (C.A. Marks unpublished data) nor were injuries related to prior trapping seen upon later recovery (Marks and Bloomfield 1999b). Bubella *et al.* (1998) radio-collared and observed 40 red foxes that had been captured with treadle-snares in an alpine habitat. Treadle-snares had been inspected each morning and periods of captivity of up to 12 hours were likely as captures predominantly occurred at night. Recovered foxes had signs of oedema and skin abrasions, yet no deaths or debilitation, deformation of limbs or limping was observed in the two years of the study. Nine foxes that were later recaptured showed no sign of having been trapped previously (Bubella *et al.* 1998). Foxes appear to recover from the stress associated with treadle-snare captures for up to 12 hours and their survival does not appear to be compromised. Longer periods confined to leg-hold traps are thought to be associated with correspondingly larger exertion, struggling, injury and death (Powell *et al.* 2003). The level of physiological response that might be indicative of chronic debilitation in foxes after capture remains speculative.

Animal welfare implications

Scoring injuries and monitoring survival may discern relative differences in extreme welfare outcomes. However, injury and death are end-points of poor welfare and monitoring trapping stress using physiological indicators allows the relative impact of different recovery techniques to be compared and the potential for pathological states to be predicted. Treadle-snares are unlikely to produce similar welfare outcomes to the VSC #3 trap as elevated N:L ratios, CK values and profiles indicative of dehydration suggest that treadle-snares were the most stressful of the live recovery techniques used. Different pest control and wildlife management techniques might vary greatly in the magnitude and nature of stress they produce and physiological indicators may be highly informative for qualifying and ranking relative welfare states. Blood normals, especially those obtained *post mortem* or after restraint, are susceptible to variations caused by the collection techniques. Establishing blood normals that provide a good benchmark for free-ranging canids is an important step in developing the capacity to use physiological indicators to investigate comparative welfare states.

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References

Akimau, P, Yoshiya, K, Hosotsubo, H, Takakuwa, T, Tanaka, H, and Sugimoto, H 2005 New experimental model of crush injury of the hind limbs in rats. *Journal of Trauma 58*: 51-58

Aktas, M, Auguste, D, Lefebvre, HP, Toutain, PL, and Braun, JP 1993 Creatine kinase in the dog: A review. *Veterinary Research Communications 17*: 353-369

Allen, L, and Fleming, PJS 2004 Review of canid management in Australia for the protection of livestock and wildlife - potential application to coyote management. *Sheep and Goat Research Journal 19*: 97-104

Andelt, WF, Phillips, RL, Schmidt, RH, and Gill, RB 1999 Trapping furbearers: an overview of the biological and social issues surrounding the public policy controversy. *Wildlife Society Bulletin 27*: 53-64

Baxter, JD, and Tyrrell, JB 1987 The adrenal cortex. In: Felig, P, Baxter, JD, Broadus, AE and Frohman, LA, (eds) Endocrinology and metabolism. McGraw-Hill, New York

Beerda, B, Schilder, MB, Janssen, NS, and Mol, JA 1996 The use of saliva cortisol, urinary cortisol, and catecholamine measurements for a noninvasive assessment of stress responses in dogs. *Hormones and Behaviour 30*: 272-279

Beerda, B, Schilder, MBH, van Hooff, JA, de Vries, HW, and Mol, JA 1998 Behavioral, saliva cortisol and heart rate response to different types of stimuli in dogs. *Applied Animal Behaviour Science 58*: 365-381

Benn, DM, McKeown, DB, and Lumsden, JH 1986 Hematology and biochemistry reference values for the ranch fox. *Canadian Journal of Veterinary Research 50*: 54-58

Bergeron, R, Scott, SS, Émond, J-P, Mercier, F, Cook, NJ, and Schaefer, AL 2002 Physiology and behaviour of dogs during air transport. *Canadian Veterinary Research 66*: 211-216

Bonacic, C, and Macdonald, DW 2003 The physiological impact of wool-harvesting procedures in vicunas (*Vicugna vicugna*). *Animal Welfare 12*: 387-402

Broom, DM 1988 The scientific assessment of animal welfare. *Applied Animal Behaviour Science 20*: 5-19

Bubela, T, Bartell, R, and Müller, W 1998 Factors affecting the trappability of red foxes in Kosciusko National Park. *Wildlife Research 25*: 199-208

Carstens, E, and Moberg, GP 2000 Recognising pain and distress in laboratory animals. *Institute for Laboratory Animal Research Journal 41*: 1-12

Cattet, MR, Christison, K, Caulkett, NA, and Stenhouse, GB 2003 Physiologic responses of grizzly bears to different methods of capture. *Journal of Wildlife Diseases 39*: 649-654

De Villiers, MS, Meltzer, DGA, Van Heerden, J, Mills, MGL, Richardson, PRK, and Van Jaarsveld, AS 1995 Handling-induced stress and mortalities in African wild dogs (*Lycaon pictus*) *Proceedings of the Royal Society London 262*: 215-220

Ellard, DR, Castle, PC, and Mian, R 2001 The effect of a short-term mental stressor on neutrophil activation. *International Journal of Psychophysiology 41*: 93-100

Englund, J 1982 A comparison of injuries to leg-hold trapped and foot snared red foxes. *Journal of Wildlife Management 46*: 1113-1117

Fernandez-Moran, J, Saavedra, D, De La Torre, JLR, and Manteca-Vilanov, X 2004 Stress in wild-caught Eurasian otters (*Lutra lutra*): effects of a long-acting neuroleptic and time in captivity. *Animal Welfare 13*: 143-149

Fleming, PJS, Allen, LR, Berghout, MJ, Meek, PD, Pavlov, PM, Stevens, PL, Strong, K, Thompson, JA, and Thomson, PC 1998 The performance of wild-canid traps in Australia: efficiency, selectivity and trap-related injuries. *Wildlife Research 25*: 327-338

Fleming, PJS, Corbett, LK, Harden, RH, and Thompson, P 2001 *Managing the impacts of dingoes and other wild dogs*. Bureau of Rural Resources, Canberra

Fox, CH, and Papouchis, CM 2004 *Cull of the wild. A contemporary analysis of wildlife trapping practices in the United States.* Bang Publishing, Brainerd

Gates, NL, and Goering, EK 1976 Hematologic values of conditioned, captive wild coyotes. *Journal of Wildlife Management 12*: 402-404

Goode, DJ, Weinberg, DH, Mazura, TA, Curtiss, G, Moretti, RJ, and Meltzer, HY 1977 Effects of limb restraints on serum creatine phosphokinase activity in normal volunteers. *Biological Psychiatry 12*: 743-755

Gregory, NG 2005 *Physiology and behaviour of animal suffering*. Blackwell Oxford

Gue, M and Peters, T 1989 Stress-induced changes in gastric emptying, postprandial motility and gut hormone plasma levels in dogs. *Gastroenterology 97*: 1101-1107

Hajduk, P, Copland, MD, and Schultz, DA 1992 Effects of capture on haematological values and plasma cortisol levels of free-range koalas, *Phascolarctos cinereus*. *Journal of Wildlife Disease 28*: 502-506

Harrop, SR 2000 The international regulation of animal welfare and conservation issues through standards dealing with the trapping of wild mammals. *Journal of Environmental Law 12*: 333-360

Heard, DJ, and Huft, VJ 1998 The effects of short-term physical restraint and isoflurane anesthesia on hematology and plasma biochemistry in the island flying fox (*Pteropus hypomelanus*). *Journal of Zoo and Wildlife Medicine 29*: 14-17

Hennessy, MB, Williams, MT, Miller, DD, Douglas, CW, and Vioth, VL 1998 Influence on male and female petters on plasma cortisol and behaviour: can human interaction reduce the stress of dogs in a public animal shelter? *Applied Animal Behaviour Science 61*: 63-77

Hinchcliff, KW 1996 Performance failure in Alaskan sled dogs: biochemical correlates. *Research in Veterinary Science 61*: 271-272

Holland, M, and Jennings, D 1997 Use of electromyography in seven injured wild birds. *Journal of the American Veterinary Medical Association 211*: 607-609

Houben, JM, Holland, M, Jack, SW, and Boyle, CR 1993 An evaluation of laminated offset jawed traps for reducing injuries to coyotes. In: Great Plains wildlife damage control workshop proceedings. Nebraska, Lincoln

Hubert, GF, Hungerford, LL, and Bluett, RD 1997 Injuries to coyotes captured in modified foothold traps. *Wildlife Society Bulletin 25*: 858-863

Iossa, G, Soulsbury, DD, and Harris, S 2007 Mammal trapping: a review of animal welfare standards of killing and restraining traps (a review). *Animal Welfare 16*: 335-352

Jain, M and Baldwin, AL 2003 Are laboratory animals stressed by their housing environment and are investigators aware that this stress can affect physiological data? *Medical Hypotheses 60*: 284-289

Jasper, DE, and Jain, NC 1965 The influence of adrenocorticotrophic hormones and prednisolone upon marrow and circulation lymphocytes in the dog. *American Journal of Veterinary Research 26*: 844-850

Jordan, B 2005 Science-based assessment of animal welfare: wild and captive animals. *Revue Scientifique Et Technique-Office International Des Epizooties 24*: 515-528

Kaste, M, Hernesniemi, J, Somer, H, Hillbom, M, and Konttinen, A 1981 Creatine kinase isoenzymes in acute brain injury. *Journal of Neurosurgery 55*: 511-515

Kimber, K, and Kollias, GV 2005 Evaluation of injury severity and hematologic and plasma biochemistry values for recently captured North American river otters (*Lontra canadensis*). *Journal of Zoo and Wildlife Medicine 36*: 371-384

King, T, Hemsworth, PH and Coleman, GJ 2003 Fear of novel and startling stimuli in domestic dogs. *Applied Animal Behaviour Science 82*: 45-64

Kirkwood, JK. (ed) 2005. Report of the Independent Working Group on Snares. http://www.defra.gov.uk/wildlife-countryside/vertebrates/snares/pdf/iwgs-report.pdf

Kirschbaum, C, and Hellhammer, DH 1989 Salivary cortisol in psychobiological research: an overview. *Neuropsychobiology 22*: 150-169

Kreeger, TJ, Seal, US, Tester, JR, Callahan, M, and Beckel, M 1990b Physical responses of red foxes (*Vulpes vulpes*) to surgery. *Journal of Wildlife Diseases 26*: 219-224

Kreeger, TJ, White, PL, Seal, US, and Tester, JR 1990a Pathological response of red foxes to foothold traps. *Journal of Wildlife Management 54*: 147-160

Lee, JK, Ronald, K, and Øritsland, NA 1977 Some blood values of wild polar bears. *Journal of Wildlife Management 41*: 520-526

Lemieux, R, and Czetwertynski, S 2006 Tube traps and rubber padded snares for capturing American black bears. *Ursus 17*: 81-91

Lilliehöök, I 1997 Diurnal variation of canine blood leukocyte counts. *Veterinary Clinical Pathology 26*: 113-117

Linhart, SB, Blom, FS, Dasch, GJ, Engeman, RM, and Olsen, GH 1988 Field evaluation of padded jaw coyote traps: effectiveness and foot injury. *13th Vertebrate Pest Control Conference 13*: 226-229

Littin, KE, and Mellor, DJ 2005 Strategic animal welfare issues: ethical and animal welfare issues arising from the killing of wildlife for disease control and environmental reasons. *Revue Scientifique Et Technique-Office International Des Epizooties 24*: 767-782

Littin, KE, Mellor, DJ, Warburton, B, and Eason, CT 2004 Animal welfare and ethical issues relevant to the humane control of vertebrate pests. *New Zealand Veterinary Journal 52*: 1-10

Logan, KA, Sweanor, LL, Smith, JF, and Hornocker, MG 1999 Capturing pumas with foot-hold snares. *Wildlife Society Bulletin 27*: 201-208

Marks, CA 2003 What is possible to ensure that existing control methods are more humane? In: Solutions for achieving humane vertebrate pest control. RSPCA, Canberra

Marks, CA, Allen, L, Gigliotti, F, Busana, F, Gonzalez, T, Lindeman, M, and Fisher, PM 2004 Evaluation of the tranquilliser trap device (TTD) for improving the humaneness of dingo trapping. *Animal Welfare 13*: 393-399

Marks, CA, and Bloomfield, TE 1998 Canine heartworm (*Dirofilaria immitis*) detected in red foxes (*Vulpes vulpes*) in urban Melbourne. *Veterinary Parasitology 78*: 147-154

Marks, CA, and Bloomfield, TE 1999a Distribution and density estimates for urban foxes (*Vulpes vulpes*) in Melbourne: implications for rabies control. *Wildlife Research 26*: 763-775

Marks, CA, and Bloomfield, TE 1999b Bait uptake by foxes (*Vulpes vulpes*) in urban Melbourne: the potential of oral vaccination for rabies control. *Wildlife Research 26*: 777-787

Marks, CA, and Bloomfield, TE 2006 Home range size and selection of natal den and diurnal shelter sites by urban red foxes (*Vulpes vulpes*) in Melbourne. *Wildlife Research 33*: 339-347

McCue, PM, and O'Farrell, TP 1987 Hematologic values of the endangered San Joaquin kit fox *Vulpes macrotis mutica*. *Journal of Wildlife Disease 23*: 144-151

McNeil Alexander, R 2006 *Principles of animal locomotion*. Princeton University Press, Princeton

Meek, PD, Jenkins, DJ, Morris, B, Ardler, AJ, and Hawksby, RJ 1995 Use of two humane leg-hold traps for catching pest species. *Wildlife Research 22*: 733-739

Moberg, GP 1985 Biological response to stress: key to assessment of animal well-being? Pages 27-49 In: Moberg, GP, (ed) *Animal stress*. American Physiology Society, Bethesda

Montes, I, McLaren, GW, Macdonald, DW, and Mian, R 2004 The effect of transport stress on neutrophil activation in wild badgers (*Meles meles*). *Animal Welfare 13*: 355-359

Morgan, KN, and Tromborg, CT 2007 Sources of stress in captivity. *Applied Animal Behaviour Science 102*: 262-302

Moss, DW, Henderson, AR, and Kachmar, JF 1987 Enzymes. In: Tietz, NW, (ed) Fundamentals of Clinical Chemistry. W.B. Saunders, Philadelphia

Münster, AM, Ingermann, JJ, Bech, B, and Gram, J 2001 Activation of blood coagulation in pigs following lower limb gunshot trauma. *Blood Coagulation and Fibrinolysis 12*: 477-485

Noakes, TD 1987 Effects of exercise on serum enzyme activities in humans. *Sports Medicine 4*: 245-267

Oishi, K, Nishio-Shimoyama, N, Konishi, K, Shimokawa, M, Okuda, T, Kuriyama, T, and Machida, K 2003 Differential effects of physiological and psychological stressors on immune function in rats. *Stress 6*: 33-40

Olsen, GH, Linhart, SB, Holmes, RA, Dasch, GJ, and Male, CB 1986 Injuries to coyotes caught in padded and unpadded steel foothold traps. *Wildlife Society Bulletin 14*: 219-223

Onderka, DK, Skinner, DL, and Todd, AW 1990 Injuries to coyotes and other species caused by four models of footholding devices. *Wildlife Society Bulletin 18*: 175-182

Phillips, RL 1996 Evaluation of 3 Types of Snares for Capturing Coyotes *Wildlife Society Bulletin 24*: 107-110

Powell, RA 2005 Evaluating welfare of American black bears (*Ursus americanus*) captured in foot snares and in winter dens. *Journal of Mammalogy 86*: 1171-1177

Powell, RA, and Proulx, G 2003 Trapping and marking terrestrial mammals for research: integrating ethics, performance criteria, techniques, and common sense. *ILAR Journal 44*: 259-276

Prudhomme, JC, Bhatia, R, Nutik, J, and Shusterman, D 1999 Chest wall pain and possible rhabdomyolysis after chloropicrin exposure: A case series. *Journal of Occupational and Environmental Medicine 41*: 17-22

Raberg, L, Grahn, M, Hasselquist, D, and Svensson, E 1998 On the adaptive significance of stress-induced immunosuppression. *Proceedings of the Royal Society of London, Series B, Biological Science 265*: 1637-1641

Robinson, NA, and Marks, CA 2001 Genetic structure and dispersal of red foxes (*Vulpes vulpes*) in urban Melbourne. *Australian Journal of Zoology 49*: 589-601

Rupiński, S 1989 Effects of tourniquet ischemia of the arm on changes in selected parameters of muscle and metabolism. *Annales Academiae Medicae Stetinensis 35*: 131-143

Sanchez, O, Arnau, A, Pareja, M, Poch, E, Ramirez, I, and Soley, M 2002 Acute stress-induced tissue injury in mice: differences between emotional and social stress. *Cell Stress and Chaperones 7*: 36-46

Saunders, G, Coman, BJ, Kinnear, J, and Braysher, M 1995 *Managing Vertebrate Pests: Foxes.* Australian Government Publishing Service, Canberra, Australia.

Schroeder, MT 1987 Blood chemistry, hematology, and condition evaluation of black bears in northcoastal California. Pages 284-290 In: International Conference on Bear Research and Management

Stevens, PL, and Brown, AM 1987 Alternative traps for dog control. In: 8th Australian Vertebrate Pest Conference, Coolangatta

Tullar, BF 1984 Evaluation of a padded leg-holding trap for capturing foxes and raccoons. *New York Fish and Game Journal 31*: 97-103

Van Ballenberghe, V 1984 Injuries to wolves sustained during live capture. *Journal of Wildlife Management 48*: 1425-1429

Walker, PM 1991 Ischemia/reperfusion injury in skeletal muscle. *Annals of Vascular Surgery 5*: 399-402

Warburton, BN, Gregory, N, and Nunce, M 1999 Stress response of Australian brushtail possums captured in foothold and cage traps. In: Proulx, G, (ed) *Mammal trapping*. Alpha Wildlife Research and Management, Alberta

Waser, PM and Brown, CH 1986 Habitat acoustics and primate communication. *American Journal of Primatology 10*: 135-154

White, J, Kreeger, TJ, Seal, US, and Tester, JR 1991 Pathological responses of red foxes to capture in box traps. *Journal of Wildlife Management 55*: 75-80

Williams, ES, and Thorne, ET 1996 Excertional myopathy (capture myopathy). In: Locke, LN and Hoff, GL, (eds) Non-infectious diseases of wildlife. Iowa State University Press, Ames

Williams, S, Usherwood, J, and Wilson, A 2007 Acceleration in the racing greyhound. *Comparative Biochemistry and Physiology A 146*: S107-S127

Wintrobe, MM 1976 *Clinical hemotology.* Lea and Febiger, Philadelphia

Table 1. Mean haematology and blood biochemistry values with standard error (SE) and standard deviation (SD) for foxes recovered using cage traps (C), netting (N), shooting (S), treadle-snares (T) and Victor Soft-Catch #3 traps (VSC). The level of significant difference from multiple comparisons using the Least Significant Difference (LSD) test is given at two probability (*P*) levels.

		unit	**T**	**n**	**mean**	**SE**	**SD**	***P***	
								< 0.05	< 0.01
Haemoglobin	Hb	g/L^{-1}	C	8	104	3.7	10	T	S
			N	17	116	6.4	26	S,T	
			S	11	125	7.4	25	N	C
			T	45	152	2.8	19	C,N	
			V	7	135	4.6	12		
Neutrophil:Lymphocytes	N:L	ratio	C	8	4.0	1.4	4.0		T
			N	17	2.3	0.4	1.6		T
			S	11	5.4	2.1	7.0		T
			T	45	22.0	2.8	18.8		V,C,N,S
			V	7	5.9	1.9	5.0		T
Packed cell volume	PCV	%	C	8	35.2	0.25	0.7	N	S,T,V
			N	17	37.3	1.6	6.6	C,V	T
			S	11	39.6	2.2	7.3		C,T
			T	45	48.9	0.87	5.8		C,N,S
			V	7	42.1	1.0	2.6	N	C
Red cell count	RCC	μL^{-1} x 10^{-6}	C	8	8.3	0.31	0.9	N	S,T
			N	17	8.9	0.41	1.7	C	T
			S	11	9.0	0.54	1.8		C,T
			T	45	11.3	0.2	1.3		S,V,C,N
			V	7	10.13	0.24	0.6		T
White cell count	WCC	μL^{-1} x 10^{-3}	C	8	9.03	1.5	4.2	S,T	
			N	17	6.1	0.9	3.7		T
			S	11	3.8	1.1	3.6		T
			T	45	12.3	0.8	5.4		C,N,S,V
			V	7	5.7	1.4	3.7		T
Albumin	ALB	$g\ dL^{-1}$	C	8	2.6	0.1	0.3		T
			N	17	2.7	0.1	0.4		T
			S	11	2.7	0.1	0.4	V	T
			T	45	3.4	0.7	0.5		V,C,N,S
			V	7	3.0	0.1	0.2	S	T
Chloride	Cl	$mmol/L^{-1}$	C	8	109.3	1.4	4.0	T	
			N	17	114.3	0.8	3.3	V	T
			S	11	113.4	1.1	3.6		
			T	45	116.7	0.6	4.0	C	N
			V	7	116.0	2.1	5.6	N	
Creatine kinase	CK	$\log IU/L^{-1}$	C	8	6.3	0.33	0.9		T,V
			N	17	6.2	0.33	1.4		T,V
			S	11	6.3	0.21	0.7		V,T
			T	45	9.5	0.13	0.9		C,N,S,V
			V	7	7.7	0.76	2.0		C,S,N,T
Glucose	Gl		C	8	6.0	0.4	0.7		
			N	17	7.6	0.8	2.7		
			S	11	7.5	1.0	2.8		
			T	45	3.5	0.3	2.1		C,N,S,V
			V	7	6.5	1.6	3.6		
Potassium	K	$mmol/L^{-1}$	C	8	4.7	0.2	0.6		S
			N	17	4.4	0.1	0.4	T,V	S
			S	11	5.9	0.3	1.0		S,N,T,V
			T	45	4.7	0.1	0.7	N	S
			V	7	5.1	0.2	0.5	N	T
Protein (total)	TP	g/dL^{-1}	C	8	5.0	0.2	0.5	V	T
			N	17	5.4	0.2	0.9		T
			S	11	5.3	0.2	0.7		T
			T	45	6.6	0.1	0.7	V	C,N,S
			V	7	5.9	0.3	0.7	C,T	
Sodium	Na	$mmol/L^{-1}$	C	8	139	1.1	3.1		V,S,T
			N	17	141.6	1.0	4.1	V	S,T
			S	11	144.9	0.9	3.0	T	N,C
			T	45	149.0	0.7	4.7	V	S,C,N
			V	7	144.8	0.9	2.4		C,T

[1] White *et al.* (1991), [2] Kreeger *et al.* (1990a), [3] Benn *et al.* (1986), [4] Kreeger (1990b)

Table 2. Published mean haematology and blood biochemistry values with standard error (SE) and standard deviation (SD) taken after red foxes were held in cage (C) or Victor Soft-Catch #1 ½ (VSC) traps for known times in hours (h) or samples taken from shot (S) foxes, captive populations (Norm) and immediately prior to surgery (PRS) and eight hours post-surgery (POS).

		unit	Group	n	H	mean	SE	SD
Haemoglobin	Hb	g/L^{-1}	C[1]	10	8	136	7.0	22.1
			Norm[3]	30	-	170	2.6	14.2
			PRS[4]	20	-	155	2.0	8.9
Neutrophil:Lymphocytes	N:L	ratio	C[1]	10	8	10.4	0.7	2.2
			S[2]	19	-	2.1	0.6	2.6
			VSC[2]	6	2	10.5	1.5	3.7
			VSC[2]	4	8	25.1	1.8	3.6
			Norm[3]	30	-	0.9	0.2	1.1
Packed Cell Volume	PCV	%	C[1]	10	8	42.8	2.6	8.2
			S[2]	20	-	50.2	1.5	6.7
			VSC[2]	6	-	44.2	2.9	7.1
			VSC[2]	9	-	46.7	5.3	15.9
			Norm[3]	30	-	48.0	0.7	4.0
			PRS[4]	10	-	48.1	0.4	1.3
Red cell count	RCC	µL^{-1} x 10^{-6}	C[1]	10	8	9.4	0.6	1.9
			S[2]	20	-	11.6	0.3	1.3
			VSC[2]	6	2	10.9	0.6	1.5
			VSC[2]	4	8	11.8	0.9	1.8
			Norm[3]	30	-	10.8	0.1	0.5
			PRS[4]	20	-	11.6	0.1	0.4
White cell count	WCC	µL^{-1} x 10^{-3}	C[1]	10	8	7.1	1.1	3.5
			S[2]	20	-	3.4	0.4	1.8
			VSC[2]	6	2	4.2	1.0	2.4
			VSC[2]	4	8	7.8	1.9	3.8
			Norm[3]	30	-	9.3	0.4	2.2
			PSR[4]	10	-	7.6	0.6	1.9
			POS[4]	10	8	11.7	0.7	2.2
Albumin	ALB	g dL^{-1}	C[1]	10	8	3.0	0.1	0.3
			S[2]	6	-	3.1	0.1	0.2
			VSC[2]	5	2	3.1	0.1	0.2
			VSC[2]	23	8	2.9	0.1	0.5
			Norm[3]	30	-	2.9	0.7	3.8
			PRS[4]	20	-	3.4	0.1	0.4
Creatine kinase	CK	log IU/L^{-1}	C[1]	10	8	7.3	0.2	0.6
			S[2]	23	-	6.6	0.3	1.4
			VSC[2]	6	2	6.9	0.4	1.0
			VSC[2]	5	8	10.8	0.3	0.7
			Norm[3]	30	-	1.9	0.2	1.1
			PRS[4]	10	-	2.6	2.0	6.3
			POS[4]	10	8	3.6	2.8	8.9
Glucose	Gl		Norm[3]	30	-	7.6		1.1
Protein (total)	TP	g/dL^{-1}	C[1]	10	8	4.6	0.1	0.3
			S[2]	23	-	4.8	0.2	1.0
			VSC[2]	6	2	5.3	0.3	0.7
			VSC[2]	5	8	5.1	0.2	0.4
			Norm[3]	30	-	6.5	0.1	0.5
			PSR[4]	10	-	5.4	0.1	0.3
Sodium	Na	mmol/L^{-1}	C[1]	10	8	150.4	1.4	4.4
			S[2]	23	-	144.4	2.3	11.0
			VSC[2]	6	2	157.3	1.6	3.9
			VSC[2]	5	8	138.6	4.6	10.3
			Norm[3]	30	-	156	0.8	4.4

[1]White *et al.* (1991), [2]Kreeger *et al.* (1990a), [3]Benn *et al.* (1986), [4]Kreeger (1990b)

APPENDIX 2.0

Table 1: Steel-jawed (non-padded) trap type, size and manufacturer (Note: list is non-extensive).

DUKE TRAPS
1 Coil Spring
1 Coil Spring, Double Jaw
1½ Coil Spring
1¾ Coil Spring
2 Coil Spring
2 Coil Spring, Off-set
3 Coil Spring
3 Coil Spring, Off-set
1 Long Spring
1 Long Spring, D. Jaw
1 Long Spring, Guard Trap
11 Long Spring
11 Long Spring, D. Jaw
6 Bear Trap
15 Bear Trap

SLEEPY CREEK TRAPS
1 Long Spring
1½ Long Spring
11 Long Spring
11 Long Spring, Double Jaw
11 Long Spring, Adj. pan
11 Long Spring, Adj. pan, D. Jaw.
2 Long Spring
1 Coil Spring
1 Coil Spring, Double Jaw
1½ Coil Spring
1½ Coil Spring, Off-set
1¾ Coil Spring
1¾ Coil Spring, Off-set

MINNESOTA BRAND
MB-650 - Standard
MB-650 - Outside Laminated
MB-650 - Inside Laminated
MB-650-C - Cast Jaws
MB-750 - Beaver
MB-750 - Beaver, Laminated
MB-750 - Beaver, Off-set
MB-750 - Off-set, Laminated
MB-750-Wolf/Lion, ¼" Off-set
MB-750-Wolf/Lion, 3/8" Off-set

BRIDGER TRAPS
1 Long Spring
1 Sure Grip
11 Long Spring
5 Long Spring
5 Long Spring, Laminated
1 Coil Spring
1.65 Coil Spring
1.65 Coil Spring, Off-set
1.65 Coil Spring, Laminated
1.65 Coil Spring, Laminated, Off-set
2 Coil Spring
2 Coil Spring, Off-set
2 Coil Spring, Laminated
2 Coil Spring, Laminated, Off-set
3 Coil Spring
3 Coil Spring, Off-set
3 Coil Spring, Laminated, Off-set
3 Coil Spring, Laminated
5 Coil Spring, Round Jaw
5 Coil Spring, Round Jaw., Off-set
5 Coil Spring, Laminated
5 Coil Spring, Laminated, Off-set

BLAKE AND LAMB TRAPS
1 Long Spring
1 Long Spring
1½ Long Spring
2 Long Spring
2½ Long Spring
3 Long Spring
1½ Coil Spring

BUTERA TRAPS - BMI
1.5 Coil Spring, 2 coil
1.75 Coil Spring, 2 coil
1.75 K-9 Wolfer, 2 coil
1.75 4x4, Off-set
2 K-9 Wolfer, 4 coil
2 Coil Spring, 2 coil
3 Coil Spring

Table 1 (cont): Steel-jawed (non-padded) trap type, size and manufacturer (Note: list is non-extensive).

VICTOR TRAPS
0 Long Spring
1 Long Spring
1 VG Stoploss
1½ VG Stoploss
11 Long Spring
1½ Long Spring
2 Long Spring
3 Long Spring
3 Long Spring, Off-set

STERLING
MJ 600 Coyote Trap
4 Long Spring
1 Coil Spring, Single
1 Coil Spring, Double
1½ Coil Spring
1.75 Regular Coil Spring
1.75 Coil Spring, Off-set
1.75 Coil Spring, 4x4
2 Coil Spring, Round Jaw
3 Coil Spring, Round Jaw
3 Coil Spring, Off-set
3 Coil Spring, Square Jaw

JUMP TRAPS, VICTOR AND BLAKE AND LAMB
Victor # 1 Jump Trap
Victor # 1½ Jump Trap
Blake and Lamb # 3 Jump Trap
Victor # 4 Jump Trap

NORTHWOOD TRAPS
1 Coil Spring
1¾ Coil Spring, Rd J.
2 Coil Spring, Sq. Jaw
3 Coil Spring, Sq. Jaw
11 Long Spring
2½ 2 Long Spring
2½ Long Spring, Off-set

ALASKAN
No. 9, Off-set

F.C. TAYLOR
2 Coil Spring
4 Long Spring
4 long Spring Off-set

C.D.R. 7.5 Beaver Trap
Standard
Inside laminated
Outside laminated

COYOTE CUFF
22
33

MONTGOMERY TRAPS
1½ Round Jaw
1½ Dogless
2 Round Jaw
2 Dogless
4 Dog on, Reg. Jaw

Table 2: Padded steel-jawed trap type, size and manufacturer commonly referred to in scientific literature (Note: list is non-extensive).

PADDED TRAPS

LANES
Paws

LIVESTOCK PROTECTION COMPANY
3½ EZ Grip

BRAUN
Padded Jawed Wolf Trap

BUTERA TRAPS – BMI
1½ Coil Spring
2 Coil Spring

JAKES (J.C. Conner)
Jake trap - padded

DUKE TRAPS
1½ Coil Spring
3 Coil spring

ONEIDA VICTOR INC. LTD.
1 Coil Spring
2 Coil Spring
3 Coil Spring

Table 3 Leg-hold and neck snares and manufacturer commonly referred to in scientific literature (Note: list is non-extensive).

FOOTHOLD SNARES

ALDRIDGE TRAP/SNARE

GLENBOURN MOTORS
Treadle-snare

WILDLIFE SERVICES
WS-T Turman snare

GREEN MOUNTAIN INC
Collarum neck snare/restraint

E.R. STEELE PRODUCTS
Novak Foot-snare

FREEMONT HUMANE TRAPS
Fremont foot-snare

UNKNOWN MANUFACTURER
RL04 trap/snare
Ezyonem foot-snare
Rose leg cuff
L83 trap/snare
Goodwin humane leg-hold trap

APPENDIX 3:

Trapping practices used for canid research in Australia

The following details the devices and summarises the trapping methods reported during wildlife research studies in Australia (as discussed in Chapter 7).

Table 1. Trap type (TS = treadle snare, VSC = Victor Soft-Catch), size and modification (P = padded) for Australian research studies that have used leg-hold traps for the recovery of wild dogs (D), red foxes (F) or feral cats (C). The number of foxes captured (Nc), radio-collared (Nr), those that received major injuries due to capture (Ni), the number that exhibited abnormal behaviour after release (Nab), and mortality associated with trapping injuries subsequent to release (Nm). (NS = not stated).

TRAP	SIZE	MOD	TS	INSPECTION	Nc	Nr	Ni	Nab	Nm	AUTHORITY
Lane's	NS		D	≈D	95	-	NS	-	-	Newsome *et al.* 1983
Oneida	#14		D	≈D	51	-	NS	-	-	Newsome *et al.* 1983
Lane's	NS		D	NS	13	-	NS	-	-	Corbett 1974
Lane's	NS	P	D	D	15	11	NS	0	0	Harden *et al.* 1985
Oneida	#14	P	D	≈D	9	9	NS	0	0	McIlroy *et al.* 1986
Lane's			D/F	≈48h	73	-	23	-	-	Stevens and Brown 1987
TS			D/F	≈48h	71	-	4	-	-	Stevens and Brown 1987
Lane's	NS		D	NS	160	NA	NS	-	-	Jones and Stevens 1988
Lane's ?	NS	P	F	NS	6	6	NS	NS	0	Phillips and Catling 1991
Lane's	NS	P	D	NS	205		54	12	2	Thomson 1992
TS	NA		F	NS	6		NS	0	0	Coman *et al.* 1991
VSC	#3		F	D	28	NA	3	-	-	Meek *et al.* 1995
TS	NA		F	D	7	NA	0	-	-	Meek *et al.* 1995
VSC	#3		D	D	11	NA	0	-	-	Meek *et al.* 1995
TS	NA		D	D	7	NA	0	-	-	Meek *et al.* 1995
TS	NA		F	D	71	40	3	0	0	Bubella *et al.* 1998
TS/VSC	#3		F	< 4 hours	125	-	3	0	0	Marks and Bloomfield (1998, 1999b)
VSC	#3		F	D	21	18	NS		4?	Meek and Saunders 2000
VSC	1 1/2		F/C		1	1	NA	-	-	Molsher 2001
TS/VSC	#3		F	< 4 hours	21	21	0	0	0	Robinson and Marks 2001
TS/VSC	#3		D	D	20	0	0	0	0	Marks *et al.* 2004
VSC	NS		F	D			0	0	0	White *et al.* 2006
TS/VSC	#3		F	< 4 hours	20	20	0	0	0	Marks and Bloomfield 2006

Wild dogs

Newsome *et al.* (1983) used Lane's steel traps (Stockbrands Pty Ltd: Western Australia) and lighter Oneida No. 14 steel jump-traps (Victor Oneida Co.: U.S.A.). Traps were mostly checked daily but not always if trap-lines were long, in remote and rugged country, or where access was impeded by heavy snow. Traps were set on fauna trails, forestry roads, and creek crossings, were dingoes had urinated or defecated, and where dingoes had killed livestock. Trap-sites were mostly baited with lures or carcasses to attract dingoes. Most lures included dog or dingo faeces, urine or both, and sometimes the contents of the lower intestines of trapped dingoes. Traps were set up to a metre away from main trails or wheel tracks to try to avoid catching non-target species, set with dingo scats along fire trails, ridge tops and creeks, and inspected at least daily (Harden *et al.* 1985). McIlroy *et al.* (1986) used modified Oneida No. 14 jump traps set along fire trails, at sites where dogs were likely to urinate or defecate. Each trap was attached to a steel post in the ground by a short chain and a coil spring. Jones and Stevens (1988) analysed 160 dingo carcasses that were trapped with Lane's steel-jawed traps for their reproductive status, but no details of trapping methods, injuries or non-target captures are given. Marks *et al.* (2004) trapped dingoes with modified #3 Victor Soft-Catch® leg-hold traps (Woodstream Corporation, Lititz, PA, USA). Trap modifications included: #11 PIT Pan Tension Kit; #4 Montgomery coil springs; D-ring base plate; 1.2m chain containing double swivels and a #19 PIT Cushion Spring attached midway on the chain (Minnesota Trapline Company). Trap sites were lured with either a commercial canid attractant (Canine Call, Magna Glan or Final Touch: Minnesota Trapline Company) or with fermented meat preparations.

Red foxes

Phillips and Catling (1991) used steel leg-hold traps with padded jaws to capture six foxes in the southern portion of Nadgee Nature Reserve in south-eastern Australia. Foxes were radio-collared and monitored for 13-35 days. Coman *et al.* (1991) radio-collared six foxes after capture using treadle-snares and monitored them for up to two months. Neither of these studies record trapping injuries or non-target captures. Meek *et al.* (1995) used Victor Soft-Catch traps and treadle-snares to catch foxes and dogs. Traps were usually set in groups of two or three around a carcass or along roadsides and fire tracks, or were set without using lures, in the furrows made by car tyres along sandy bush tracks. All traps were checked early each morning. Lures consisted of beef pieces, road-kill macropod carcasses, fox urine and synthetic fermented egg (SFE). Treadle-snares were used by Bubela *et al.* (1998) in snow-covered habitat and most (81%) were set on baits - usually whole or half rabbit carcasses tethered to a stake or a bush. Whole road-killed kangaroo, wallaby, wombat and sheep carcasses were used. Snares were generally paired, and on large (kangaroo and sheep) carcasses, up to five snares were set. Baits were covered with clumps of snow grass to avoid attracting ravens. Some snares (19%) were also set on walking or animal tracks that showed signs of red fox activity. Snares were checked every morning immediately following dawn. Forty individuals were fitted with two-stage radio-transmitters and radio-tracked for an average of seven months. Marks and Bloomfield (1998, 1999b, 2006) and Robinson and Marks (2001) trapped foxes at six field sites in metropolitan Melbourne using the treadle-snare (Stevens and Brown, 1987; Meek *et al.*, 1995) as the predominant capture device, although the #3 Victor Soft-Catch traps were occasionally used with a small number of cage traps. Traps were generally set alongside known fox trails beneath fences or gates, along culverts or outside natal dens and diurnal shelter sites. When it was necessary to position traps in relatively open areas, the trap site was baited with chicken carcasses or a fish-based cat food. Traps were inspected at least every four hours during the evening, were monitored with wireless microphones or trap monitoring transmitters (C.A. Marks, unpublished data) and covered during the day and uncovered at 2000 hrs. Radio-collars were attached to a sample of foxes and 20 individuals were tracked to obtain home range and diurnal shelter positions. Another 21 cubs were radio-collared and, of these, 14 cubs were located at, or after three months, for up to two years (Robinson and Marks 2001). Meek and Saunders (2000) trapped 21 foxes using #3 Victor Soft-Catch Traps. Kay *et al.* (2000) used Victor Soft-Catch size #1½ trap tethered to a 50-cm steel peg that was driven into the ground beneath the trap. The traps were set at irregular intervals along fire trails and farm roads and baited with either meat (rabbit, sheep, and kangaroo) or lure (fox urine, fox faeces, synthetic fermented egg), or both. Multiple trap sets of 2–6 traps were occasionally established around animal carcasses (sheep or kangaroo). Traps were checked for captures each morning and, if necessary, were reset each afternoon. White *et al.* (2006) trapped 9 foxes using Victor Soft-Catch traps (size not specified) (Woodstream Corporation, Lititz, USA), set just below ground level and tethered to a peg. The traps were set along tracks, against fallen trees and fence posts and at other locations considered suitable for capturing foxes. Trap sets were baited with chicken, beef or salami baits or anal gland or tuna oil lures, or a combination of both, set in the late afternoon and deactivated in the morning. Each fox was fitted with a radio-tracking collar after trapping and all were checked again during the evening and were watched moving throughout their home range to ensure that they had fully recovered. The ranging behaviour of foxes was determined from nine individuals. Molsher (2001) used Victor #1½ Soft-Catch traps to capture cats; trap sites were chosen to minimise capture of non-target species by setting under bushes, beside vehicle tracks, beside logs, on animal runways and at rabbit warrens. Traps were set just below ground level and tethered to a stake. They were most commonly set at the entrance to fallen hollow logs so as to provide cover for the trapped individual and also to allow the bait to be hidden from view of non-target bird species. The bait at leg-hold traps was tethered on wire (usually to the log) and positioned approximately 10–15 cm behind (i.e. furthest from the approaching cat) the plate of the trap.

REFERENCES

Corbett, L. K. 1974. Contributions to the biology of dingoes (Carnivora: Canidae) in Victoria. Monash University, Clayton.

Harden, R. H. 1985. The ecology of the dingo in north-eastern New South Wales. I Movements and home range. Australian Wildlife Research **12**:25 - 37.

Jones, E., and P. L. Stevens. 1988. Reproduction in wild canids, Canis familiaris, from the eastern highlands of Victoria. Australian Wildlife Research **15**:385-394.

Kay, B., E. Gifford, R. Perry, and R. van der Ven. 2000. Trapping efficacy for foxes (*Vulpes vulpes*) in central New South Wales: age and sex biases and the effects of reduced fox abundance. Wildlife Research **27**:547-552.

Marks, C. A., L. Allen, F. Gigliotti, F. Busana, T. Gonzalez, M. Lindeman, and P. M. Fisher. 2004. Evaluation of the tranquilliser trap device (TTD) for improving the humaneness of dingo trapping. Animal Welfare **13**:393-399.

Marks, C. A., and T. E. Bloomfield. 1999b. Bait uptake by foxes (*Vulpes vulpes*) in urban Melbourne: the potential of oral vaccination for rabies control. Wildlife Research **26**:777-787.

Marks, C. A., and T. E. Bloomfield. 1998. Canine heartworm (*Dirofilaria immitis*) detected in red foxes (*Vulpes vulpes*) in urban Melbourne. Veterinary Parasitology **78**:147-154.

Marks, C. A., and T. E. Bloomfield. 2006. Home range size and selection of natal den and diurnal shelter sites by urban red foxes (*Vulpes vulpes*) in Melbourne. Wildlife Research **33**.

McIlroy, J. C., R. J. Cooper, E. J. Gifford, B. F. Green, and K. W. Newgrain. 1986. The effect on wild dogs, Canis familiaris, of 1080-poisoning campaigns in Kosciusko National Park, NSW. Australian Wildlife Research **13**:535-544.

Meek, P. D., D. J. Jenkins, B. Morris, A. J. Ardler, and R. J. Hawksby. 1995. Use of two humane leg-hold traps for catching pest species. Wildlife Research **22**:733-739.

Meek, P. D., and G. Saunders. 2000. Home range and movement of foxes (*Vulpes vulpes*) in costal New South Wales, Australia. Wildlife Research **27**:663-668.

Molsher, R. L. 2001. Trapping and demographics of feral cats (*Felis catus*) in central NSW. Wildlife Research **28**:631-636.

Murphy, G. D., and J. R. Backholer. 1990. A management information system for wild dogs. Keith Turnbull Research Institute, Frankston (unpublished).

Newsome, A. E., L. K. Corbett, P. C. Catling, and R. J. Burt. 1983. The Feeding Ecology of the Dingo .1. Stomach Contents from Trapping in South-eastern Australia, and the Non-Target Wildlife Also Caught in Dingo Traps. Australian Wildlife Research **10**:477-486.

Phillips, M., and P. C. Catling. 1991. Home range and activity patterns of red foxes in Nadgee Nature Reserve. Wildlife Research **18**:677-686.

Robinson, N. A., and C. A. Marks. 2001. Genetic structure and dispersal of red foxes (*Vulpes vulpes*) in urban Melbourne. Australian Journal of Zoology **49**:589-601.

Stevens, P. L., and A. M. Brown. 1987. Alternative traps for dog control. *in* 8th Australian Vertebrate Pest Conference, Coolangatta.

Thomson, P. C. 1992. The behavioural ecology of dingoes in north-western Australia: III Hunting and feeding behaviour. Wildlife Research **19**:531-541.

White, J. G., R. Gubiani, N. Smallman, K. Snell, and A. Morton. 2006. Home range, habitat selection and diet of foxes (*Vulpes vulpes*) in a semi-urban riparian environment. **33**:175-180.

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How the United States Was Able to Dodge International Reforms Designed to Make Wildlife Trapping Less Cruel

Tara Zuardo*

1. Introduction

Each year in the United States, more than 6 million animals are trapped in the wild for their fur, primarily with steel-jaw leghold traps, body-gripping kill traps, and strangling neck snares.[1] Although factors such as reduced domestic demand for fur, plummeting pelt prices, and increased public pushback have led to a decline in commercial trapping over the past several decades, the United States continues to be among the world's leaders in the number of wild animals trapped for their fur.

Raccoons, coyotes, muskrats, beavers, red foxes, bobcats, and mink are among the most commonly trapped species.[2] However, official reports are mere estimates (using known data to extrapolate more broadly) and fail to include all animals who are actually trapped. Many unreported nontarget animals fall victim to steel-jaw traps and Conibear traps,[3] including dogs, cats, deer, and birds, as well as threatened and endangered species.[4] Moreover, many wild species, particularly predators such as coyotes, are trapped and killed for wildlife damage management because they are deemed "nuisance" animals.[5] Kills by government-

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[1] Caught By Mistake: Pets Suffer Serious Steel-Jaw Leghold Trap Injuries, ANIMAL WELFARE INSTITUTE (2016), https://awionline.org/awi-quarterly/2016-spring/caught-mistake-pets-suffer-serious-steel-jaw-leghold-trap-injuries.

[2] Ass'n of Fish & Wildlife Agencies, Trap Use Report (2015), available at http://www.fishwildlife.org/files/AFWA_Trap_Use_Report_2015_ed_2016_02_29.pdf.

[3] *See, e.g.*, Christina M. Russo, *"Antiquated" Trapping Laws Can Inflict Torture on Wildlife…And Family Pets*, THE DODO (March 25, 2015), https://www.thedodo.com/wyoming-trapping-laws-1058977987.html.

[4] NOCTURNAL WILDLIFE RESEARCH PTY., WELFARE OUTCOMES OF LEG-HOLD TRAP USE IN VICTORIA (Sept. 2008), http://agriculture.vic.gov.au/__data/assets/pdf_file/0019/261712/REVIEW-WELFARE-OUTCOMES-OF-LEG-HOLD-TRAP-USE-IN-VICTORIA.pdf; G. Iossa et al., *Mammal Trapping: A review of animal Welfare Standards of Killing and Restraining Traps*, 16 ANIMAL WELFARE 335 (2007); BRIAN J. FRAWLEY ET AL., MICH. DEP'T. OF NAT. RESOURCES, FOX AND COYOTE TRAPPING SURVEY, WILDLIFE REPORT DIVISION, no. 3430 (Feb. 2005); Roger Powell & Gilbert Proulx, *Trapping and Marking Terrestrial Mammals for Research: Integrating Ethics, Performance Criteria, Techniques, and Common Sense*, 44 ILAR J. no. 4, 259 (2003); Thomas N. Tomsa & James E. Forbes, FOURTH EASTERN WILDLIFE DAMAGE CONTROL CONFERENCE, Coyote Depredation Control in New York – An Integrated Approach (Sept. 25 1989), http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1039&context=ewdcc4; Gary R. Bortolotti, *Trap and Poison Mortality of Golden and Bald Eagles*, 48 J. WILDLIFE MGMT. no. 4, 1173 (1984).

[5] *See, e.g.*, United States Department of Agriculture Animal and Plant Health Inspection Service, *Resolving Wildlife Damage to Protect People, Agriculture and Wildlife* (2012) (referring to actions targeting "nuisance" animals), https://www.aphis.usda.gov/wildlife_damage/informational_notebooks/2012/Section_1_combined.pdf; Indiana Department of Natural Resources, *Nuisance Wildlife*, http://www.in.gov/dnr/fishwild/2351.htm (last visited March 31, 2017).

sanctioned trappers are supposed to be reported and eventually made public by the US Department of Agriculture's Wildlife Services program. Other animals may be trapped and killed by ranchers or trappers who act on their behalf because the animals are deemed a threat to livestock.[6] Approximately 250,000 people are employed by the pest control and nuisance wildlife control industries (although they are may be employing methods other than trapping).[7] The vast majority of trappers are engaged in some trapping of so-called nuisance animals. Because few states require trappers to report nontarget animals caught in traps,[8] we do not know the total number of animals trapped and killed each year in the United States beyond the number reported to state wildlife agencies by licensed commercial and recreational trappers and the number reported by federal trappers with Wildlife Services. What we do know is that millions of animals continue to be killed, maimed, and made to suffer unnecessarily in cruel traps for the domestic and overseas fur trade and for the purpose of conducting "wildlife damage control" and eradicating "nuisance" wildlife.

This article examines the impediments to trapping reforms at the state level, as well as nationally and internationally. Section 2 provides a brief overview of wildlife trapping regulations and the traps most commonly used in the United States. Section 3 discusses the United States' response to the European Union's trapping reform legislation and how this response creates an impediment to future trapping reforms domestically. Section 4 examines the underlying cultural and legal sources of resistance to trapping reforms in the United States in particular. Section 5 summarizes the various efforts that have been directed at reforming trapping laws in the United States, and suggests efforts to overcome the resistance to further trapping reforms in the United States and internationally. Final thoughts are offered in Section 6.

2. Regulation of wildlife trapping in the United States

Trapping is predominantly regulated at the state level,[9] and regulations vary greatly depending on the state.[10] For example, states such as Nevada and Louisiana have very few restrictions on trapping, while others, such as Colorado and Arizona, feature more complex regulations.[11]

2.1 Steel-jaw traps

Steel-jaw traps operate in the same manner as those brought from Europe to North America more than 300 years ago.[12] When the trap is activated, steel jaws clamp together with bone-crushing

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[6] Camilla H. Fox, *Wildlife Control: Out of Control*, 35 ANIMAL ISSUES no. 2, 15 (2004); Camilla H. Fox, *Analysis of the Marin County Strategic Plan for Protection of Livestock & Wildlife: An Alternative to Traditional Predator Control* (2008) (unpublished thesis, Prescott College); Michael Robinson, *Predatory Bureaucracy: The Extermination of Wolves and the Transformation of the West* (2005) (on file with the University Press of Colorado).

[7] Minutes of the Agreement on International Humane Trapping Standards Joint Management Committee Meeting, Edmonston, Alberta, Canada, Oct 4-5, 2011, p. 14: http://www.fishwildlife.org/files/2011JMCReport.pdf.

[8] ANIMAL PROTECTION INST., CULL OF THE WILD: A CONTEMPORARY ANALYSIS OF WILDLIFE TRAPPING IN THE UNITED STATES (Camilla H. Fox & Christopher M. Papouchis eds. 2004).

[9] *Id.* at 71.

[10] *Id.*

[11] *Id.*

[12] RICHARD GERSTELL, THE STEEL TRAP IN NORTH AMERICA (1985) (Stackpole Books).

force on the limb of the animal. The traps come in a wide array of sizes, and utilize one or two long or paired coil springs. Some may have extra coil springs added (a "beefer kit") or an extra set of jaws ("double-jawed"). The steel-jaw trap often used on muskrat is called a "stop-loss" trap and has an auxiliary arm that is intended to hold the animals away from their trapped limbs so that they are unable to chew them off to escape. This self-mutilating behavior is called "wring-off" by trappers. An enclosed style of steel-jaw trap, also called a foot-encapsulating trap or a dog-proof trap, is used on raccoons to prevent wring-off. The front feet of raccoons are hypersensitive, yet they will commonly chew them off to escape from steel-jaw traps. Using a steel-jaw trap in an enclosure merely prevents the raccoon from accessing the limb close to the trap to chew it off; it does not reduce the pain. One particularly grim account of the suffering of an animal during trap testing describes a raccoon who had nearly amputated his leg to get out of an enclosed steel-jaw trap by chewing at his limb near the shoulder, as that was the only portion he could access.[13] This trap modification and others are described further below.

A few states have banned or restricted the use of steel-jaw traps for commercial and/or recreational trapping under some circumstances.[14] Five of these banned steel-jaw traps via voter initiatives: Arizona in 1994 (ban on trapping on public lands), Colorado and Massachusetts in 1996, California in 1998, and Washington in 2000.[15] Two states banned or strongly restricted the use of steel-jaw traps through legislation. Rhode Island enacted a law in 1977 banning the use of steel-jaw traps except under permit for "animal damage control." New Jersey followed suit in 1984, with stronger legislation banning the use, manufacture, sale, import, transport, and possession of steel-jaw traps.[16] In 1972, Florida became the only state to restrict the use of steel-jaw traps through the administrative process, by mandating that padded steel-jaw traps are allowed only under permit for "animal damage control." In 1999, Hawaii—although it contains no commercially targeted furbearers—banned all forms of trapping.[17]

A number of states have implemented regulations placing some limits on steel-jaw traps. For example, several states have placed an upper limit on the size of steel-jaw traps used on land and/or in water.[18] Several states have disallowed the use of steel-jaw traps with teeth or

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[13] George F. Hubert, Jr. et al., *Evaluation of Two Restraining Traps to Capture Raccoons*, 24 WILDLIFE SOC'Y BULL., no. 4, 1996, 699–708.

[14] ANIMAL PROTECTION INST., *supra* note 8.

[15] *See* Ballotopedia for a list of state initiatives: https://ballotpedia.org/Arizona_Public_Land_Trapping_Statute,_Proposition_201_(1994); https://ballotpedia.org/Colorado_Prohibited_Methods_of_Taking_Wildlife,_Initiative_14_(1996); https://ballotpedia.org/Massachusetts_Ban_on_Leghold_Traps_Initiative,_Question_1_(1996); https://ballotpedia.org/California_Proposition_4,_Prohibition_on_Trapping_Fur-Bearing_Mammals_(1998); https://ballotpedia.org/Washington_Animal_Trapping_Act,_Initiative_713_(2000).

[16] *See* New Jersey Dep't of Envtl. Prot., Trapping Regulations (2016), *available at http://www.state.nj.us/dep/fgw/pdf/2016/trapping_summary16-17.pdf*. New Jersey now allows for the use of "enclosed" or "foot encapsulating" traps; live-restraint traps which operate as steel-jaw traps enclosed by a housing; *see also* Dena Jones & Sheila Rodriguez, *Restricting the Use of Animal Traps in the United States: An Overview of Laws and Strategy*, 9 ANIMAL L. 135 (2003), available at https://www.animallaw.info/sites/default/files/lralvol9_p136.pdf.

[17] Hawai'i Fishing Regulations, Board of Land and Natural Resources (Aug. 2015), *available at* http://dlnr.hawaii.gov/dar/files/2015/08/fishing_regs_Aug_2015.pdf.

[18] States that have restricted the size of steel-jaw traps used in land sets include Alabama, Alaska, Arizona, Arkansas, Connecticut, Delaware, Georgia, Idaho, Illinois, Indiana, Iowa, Kentucky, Maine, Maryland, Minnesota, Nevada, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Utah, Virginia, Washington, West Virginia, and Wisconsin. States that have restricted the size of steel-jaw traps used in water sets include Alaska, Arizona, Arkansas, Connecticut, Delaware, Illinois, Maryland, Minnesota, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, and

serrations; however, such traps are still allowed in a significant number of states.[19] Although some wildlife managers claim that padded steel-jaw traps are more humane than traps without this modification, only a few states specifically mandate the use of padded steel-jaw traps in some circumstances in lieu of non-padded steel-jaw traps.[20] In addition, a national survey indicated that less than three percent of steel-jaw traps used by US trappers were padded.[21] A number of states mandate the use of "offset jaws" (jaws that leave a small gap when closed) when steel-jaw traps are used in water or land sets.[22] The small gap between the jaws (typically 3/16 inch) ostensibly allows small nontarget animals to escape and reduces trap injuries in larger animals.[23]

In June 2015, the New Jersey Fish and Game Council voted to legalize enclosed steel-jaw traps through a rulemaking process, calling them "enclosed foothold traps" in an attempt to circumvent the state's 31-year ban on steel-jaw traps.[24] As described earlier, enclosed traps operate in the same manner as the banned steel-jaw traps; they merely encapsulate the jaws in plastic or metal and the trap is tripped by the animal pulling up on the trigger rather than depressing it. While the traps in question are intended for raccoons, opossums are taken as

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Tennessee. Information about the details of these state laws, and other state laws mentioned in these notes, is on file with the authors.

[19] Nineteen states allow the use of teeth or serrations in land sets of steel-jaw traps. Twenty-six states allow the use of such traps for water sets. States that have not banned the use of teeth or serrations on steel-jawtraps used in land sets include Alaska, Delaware, Georgia, Idaho, Kansas, Minnesota, Mississippi, Montana, Nevada, New Hampshire, North Dakota, South Carolina, South Dakota, Texas, Utah, and Wyoming. States that have not banned the use of teeth or serrations on steel-jaw traps used in water sets include these same states plus Alabama, Iowa, Maine, New Mexico, Tennessee, Virginia, and Wisconsin.

[20] States prohibiting or restricting steel-jaw traps used in land sets except for use of padded steel-jaw traps under certain circumstances are California (padded steel-jaw traps used by "federal, state, county, or municipal government employees or their duly authorized agents in the extraordinary case where the otherwise prohibited padded-jaw steel-jaw trap is the only method available to protect human health or safety"), Colorado (padded steel-jaw traps may be used after obtaining a permit for "animal damage control purposes," by the state Department of Health, or under other regulatory exemptions), Connecticut ("on land, trappers must use padded-jawed traps, and set the traps in the animal's burrow; steel-jawed leghold traps may be set only in water bodies"), Florida ("permits for padded steel-jaw traps may be issued to trap nuisance animals"), and Washington ("padded steel-jaw traps used by permit for human health/safety, endangered species protection, wildlife research, and animal damage control")..

[21] WildEarth Guardians, *FAQ on Trapping*, http://www.wildearthguardians.org/site/DocServer/FAQ-ON-TRAPPING.pdf?docID=4562; *see also* Ass'n of Fish & Wildlife Agencies, *supra* note 3.

[22] ANIMAL PROTECTION INST., *supra* note 8 at 80.

[23] States that mandate the use of offset jaws under some circumstances include Arizona ("footholds"must be "padded or rubber-jawed or unpadded with jaws permanently offset to a minimum of 3/16 inch and a device that allows for pan tension adjustment"), Arkansas ("all steel-jaw traps with a jaw spread greater than 5 inches must have offset jaws"), Delaware ("any footholds above waterline must be offset, laminated, or padded"), Indiana (illegal to use a "foothold trap with saw-toothed or spiked jaws and illegal to take a wild animal with a foothold trap if the widest inside jaw-spread measured perpendicular to the trap's base plate and the inside width between the trap's hinge posts (both measurements) is greater than 5¾ inches and less than or equal to 6½ inches, unless the jaws of the trap have at least a 1/8-inch offset, the gap of the offset is filled with securely attached rubber pads, or the trap is completely covered by water"), Nevada ("all steel leg hold traps size No. 2 or larger or with an outside jaw spread of 5.5 inches or larger must maintain a minimum trap opening of three-sixteenths of one inch"), New Mexico ("any foot-hold trap with an inside jaw spread 5½ inches or larger shall be offset, unless it has padded jaws"), North Carolina ("if the jaw spread is between 5½ and 7½ inches, the jaws must be offset by 3/16th of an inch"), Oregon (illegal to use a "No. 3 or larger steel-jaw trap not having a jaw spacing of at least 3/16 of one inch when the trap is sprung"), and Utah (traps "must leave an opening of at least 3/16 of an inch when the jaw is closed").

[24] *See* New Jersey Dep't of Envtl. Prot., Comment Letter on Proposed Rule to Amend N.J.A.C. 7:25-5.12(g) to Allow for the Use of Enclosed Leghold Traps (May 15, 2015), *available at* https://awionline.org/sites/default/files/uploads/documents/AWI-WL-NJTrapping-DEP-DktNo011502-2015.pdf.

incidental catch. The enclosure is meant to prevent the trapped animal from chewing off his or her foot to escape, and the pull trigger is meant to prevent dogs from being caught. Nonetheless, the 60-pound clamping force is strong enough to inflict severe trauma and pain and restrict blood flow, and domestic cats are among the trap's potential nontarget victims.[25]

2.2 Conibear traps

Conibear traps are kill or body-gripping traps composed of two metal rectangles with a scissor-like hinge in the center, with one or two springs. When the device is tripped, the rectangles clamp together with tremendous force on the neck and/or torso of an animal. The springs are so strong, a setting tool is needed to open the device; family members' efforts to rescue trapped companion animals are futile. Such traps are restricted in a number of states because of the lethal danger posed to nontarget animals, particularly domestic dogs and cats.[26]

2.3 Snares

Snares are wire nooses that most often are set to strangle an animal to death. The traps can operate in a manner that uses the animal's movement to draw the loop tight, or they can employ some form of spring mechanism to do so. While some states regulate and restrict the use of snares, others ban strangling snares outright due to their indiscriminate and lethal nature. Some of the various restrictions placed on snares include requiring the use of "locks" or "stops," which prevent the snare from closing beyond a set diameter, thereby making it a restraining rather than a killing trap; another is to require a "breakaway" device to allow animals of a particular size to escape. Few states differentiate between neck, body, and foot (leg) snares.[27] Death in killing snares is brutal and can take an extended period, particularly for canids who have thick musculature along the neck. The canids suffer severe edema, with the animal's neck and head swelling terribly, a condition commonly referred to as "jelly head."[28]

2.4 Cage/Box traps

Cage or box traps are designed to allow an animal to enter an enclosure, trip the device, and remain contained inside it. There are a variety of such traps. The log box trap is used on larger species in Canada and is likely the least cruel trap. It is a very large box made almost entirely of logs from native trees. The captured animal is sheltered instead of being held brutally by an appendage, and, because there are no metal bars, animals will not break their teeth trying to

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[25] *See id.*

[26] ANIMAL PROTECTION INST., *supra* note 8 at 81.

[27] *Id*. States that prohibit the use of snares for commercial trapping and recreational trapping: Arizona (complete ban), California, Colorado, Connecticut (complete ban), Hawaii, NewYork (complete ban), Rhode Island (complete ban), Vermont (complete ban), and Washington (although note that snares are permissible to use under some circumstances in Washington).

[28] TOM GARRETT, ALTERNATIVE TRAPS: THE ROLE OF CAGE AND BOX TRAPS IN MODERN TRAPPING, THE ROLE OF LEGSNARES IN MODERN TRAPPING, AND THE ROLE OF SPRING-POWERED KILLING TRAPS IN MODERN TRAPPING (rev. ed., 1999).

escape. However, as with any live restraint device, a cage/box trap can be inhumane if left unchecked for extended periods as, depending on the device, trapped animals can die of thirst, hunger, exposure, self-mutilation, or predation.[29]

2.5 Trap sets

A trap set is the specific manner in which a trap is placed in order to catch and hold an animal. A land or dry set holds an animal on land, while a water set is meant to hold an animal underwater so that if the device does not kill instantly, the animal will still drown. A slide set describes a trap set on land that causes the trapped animal to slide on a line into the water and drown. Most traps are held in place by a chain affixed to a stake in the ground to prevent a live-trapped animal from moving away. Sometimes a "drag" is used instead, where the trap is affixed to a large object—such as a branch or a steel grapple—so that the trapped animal can move away to hide in brush.

Pole sets are typically steel-jaw traps (although sometimes snares or Conibear traps) set above ground and attached to a pole, post, log, or tree branch.[30] The traps work by catching animals who are then left dangling from the pole, ensuring that they cannot escape via chewing off a trapped limb. The use of pole sets is legal in most states;[31] however, their use has been controversial, as threatened, endangered, and other nontarget animals are often caught.[32] Some states have responded to this by restricting the use of pole sets that are placed in a way that can capture nontarget animals, such as certain raptors.[33] For example, in Minnesota, "A person may not take a bird with a steel jaw leg-hold trap mounted on a pole, post, tree stump, or other perch more than three feet above the ground."[34] Other states (such as New York) have simply banned the use of traps set "in such a manner that causes a captured animal to be suspended in the air."[35] A majority of the states, however, are silent on their use, which indicates that it is legal to use them.[36]

2.6 Colony traps (also Known as submarine traps)

A colony trap is a cage or box trap set in water to capture and drown multiple animals.[37] They are commonly used due to their efficiency in capturing large numbers of animals. Because they

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[29] *Id.*
[30] ANIMAL PROTECTION INST., *supra* note 8, at 83.
[31] *Id.*
[32] *Id.*
[33] *Id.*
[34] MINN. STAT. § 97B.705 (2016), https://www.revisor.mn.gov/statutes/?id=97b.705.
[35] *See* Trapping Regulations, New York State Department of Environmental Conservation (Mar. 27, 2017), *available at* http://www.dec.ny.gov/outdoor/9209.html.
[36] ANIMAL PROTECTION INST., *supra* note 8, at 83. States that have banned pole traps only if set for birds: South Dakota (if set in a manner that a raptor may be captured, injured, or killed: http://gfp.sd.gov/hunting/trapping/regulations.aspx) and Wisconsin (http://dnr.wi.gov/files/pdf/pubs/wm/wm0002.pdf). States that explicitly prohibit pole traps are New Jersey, Pennsylvania, South Dakota, Tennessee, Washington, and West Virginia. Others may indirectly prohibit by excluding from list of acceptable traps for use.
[37] *Id.*

are so efficient at catching multiple animals, colony traps are explicitly banned in a number of states. Most states, however, are silent on their use.[38]

3. The European Union's ban on steel-jaw traps—and Canadian and US efforts to sidestep it

Following a lengthy process of considering the cruelty of steel-jaw traps and what should be done, the European Union adopted a historic measure (Regulation 3254/91) in 1991 that banned steel-jaw traps within member countries by 1995.[39] This regulation was the first-ever international agreement that comprehensively addressed animal welfare issues specific to wildlife.

Regulation 3254/91 also sought to exert economic pressure on countries using steel-jaw traps by prohibiting these countries from exporting fur from 13 species of animals to the European Union.[40] At the time the regulation passed, Europe imported more than 70 percent of wild-caught furs from the United States and Canada.[41] Animal advocates had hoped the EU regulation would provide the necessary impetus to finally end the use of steel-jaw traps within the United States, Canada, and Russia; the three nations that export the largest number of pelts from wild-caught animals.[42]

Those hopes were not realized. Before the regulation was finalized, the European Union bowed to pressure from Canada and the United States and added a clause to the regulation that permitted countries exporting fur to the European Union to either prohibit all use of steel-jaw traps *or* to use trapping methods for the 13 species that meet "internationally agreed humane trapping standards." At the time, no such standards existed, although they were under development (more on this later). However, the EU interpretation of the regulation[43] was that such humane trapping standards had to include a prohibition on steel-jaw traps for the 13 species listed in the regulation.[44]

The governments of Canada and the United States balked at this interpretation. These countries and the fur interests they represent were not prepared to end use of all types of steel-jaw traps for the 13 species, and they did not want their fur trade with the European Union curtailed. Canada, with support from the United States, responded by threatening a trade challenge under the General Agreement on Tariffs and Trade (GATT)—an international treaty originally signed in 1947 and revised in 1994 to coincide with the establishment of the World Trade Organization (WTO). The agreement's dispute settlement and enforcement procedures

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[38] *Id.* States that have explicitly banned the use of colony traps include Illinois (http://www.ilga.gov/legislation/ilcs/fulltext.asp?DocName=052000050K2.33a) and Wisconsin (http://www.fishwildlife.org/files/Summary-Trapping-Regulations-Fur-Harvesting.pdf). States that explicitly allow the use of colony traps are Colorado (https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=854), Iowa (muskrats only: https://coolice.legis.iowa.gov/Cool-ICE/default.asp?category=billinfo&service=IowaCode&ga=83&input=481A.92), and Michigan (muskrats only: http://www.mtpca.com/regulations.html).

[39] Council Regulation 3254/91 of 4 Nov. 1991, *available at* http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1500477936509&uri=CELEX:31991R3254) .

[40] *Id.*

[41] *Id.*

[42] *Id.*

[43] *Note for the File* prepared by Willem Wijnstekers, 24 November 1993 (an adapted version of a note of 8 October 1993 on this subject). Note that the document takes account of the comments and views of the legal division of DG XI and the Commission Legal Service.

[44] *Id.*

induced the European Union to buckle under pressure from Canada and the United States. Implementation of the fur import ban was delayed while negotiations dragged on for years.

In July 1997, an Agreement on International Humane Trapping Standards (AIHTS) was reached between the European Union, Canada, and Russia, which spared the latter two from a fur import ban. The agreement required Canada and Russia to end use of "conventional" steel-jaw traps for certain species within four years of AIHTS's ratification. Trapping standards are annexed to the agreement, trap testing must be conducted, and the parties must end use of traps that do not meet the standards. Steel-jaw traps that meet the standard can continue to be used.

In December 1997, the United States reached a separate understanding (a nonbinding "agreed minute") with the European Union.[45] "Standards for the Humane Trapping of Specified Terrestrial and Semi-Aquatic Mammals" (the same standards that are annexed to the European Union/Canada/Russia agreement) and a side letter from the United States are included in the understanding.

The agreed minute states that the United States and the European Union consider the standards to be "a common framework and a basis for cooperation" and that the parties "intend to encourage and support research, development, monitoring and training programs … to promote the use and application of traps and trapping methods for the humane treatment of such mammals." It emphasized that such agreement does not "alter the distribution of authority within the United States for regulation of the use of traps and trapping methods."

The side letter further affirms that trap regulation is primarily the responsibility of the states. The United States promised a 50-state initiative to develop best management practices (BMP) for traps and trapping methods and touted that this initiative would cover 29 species rather than the 19 annexed to the agreed minute. Not so widely touted was the fact that the agreement was *nonbinding* on the states and the BMP process, among its many flaws, was a *voluntary* program.

The side letter went on to assure the European Union that, "*pursuant to the standards,*" the United States would phase out use of steel-jaw *restraining* traps on ermine and muskrat within four years of the entry into force of the tripartite agreement between the European Union, Canada, and Russia. However, both species are commonly taken in steel-jaw traps set to kill the animals rather than restrain them. Muskrats are trapped in water sets where they are drowned. Ermine are not typically targeted, but are taken as incidental catch in steel-jaw traps set for other species. If steel-jaw traps are set for ermine, they are set in a manner intended to kill the ermine rather than restrain them. Notwithstanding the United States' assurances, therefore, the end result has been business as usual.

The United States further stated that regarding other species, "*pursuant to the standards* annexed to the Agreed Minute, the use of *conventional* steel-jawed leghold restraining traps is being phased out within six years of the entry into force" of the tripartite agreement (emphasis added). The United States did not acknowledge that there is no agreed definition of what constitutes a "conventional" steel-jaw trap. The language "pursuant to the standards" appears to suggest that the phase-out of conventional steel-jaw restraining traps would occur only if they failed to meet the weak standards annexed to the agreement.

Furthermore, the status of the tripartite agreement and the US-EU understanding has been difficult to discern. It appears that although the EU Regulation was adopted in 1991, the agreement between the European Union, Canada, and Russia was not ratified until July 22,

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[45] Office of the United States Trade Rep., European Union Humane Trapping Standards Agreement (Dec. 23, 1997) *available at* http://tcc.export.gov/Trade_Agreements/All_Trade_Agreements/exp_002820.asp.

2008.[46] Beyond these dates, there is little public record of what progress has been made toward compliance with either agreement.

3.1 History of the ISO process of developing “Humane Trapping Standards”

The seed for creating trap standards was planted before EU Regulation 3254/91 was even adopted. In the mid-1980s, the Canadian government brought together about 50 representatives from the Canadian fur industry to meet with a four-member Gray and Company public relations team to see what could be done to protect their trade. The seminar was titled, “The Animal Rights Movement, Trappers and the Canadian Fur Industry: Facing the Facts and Shaping the Message.”[47] \ The objective was “to develop an effective strategy to counter vocal critics of trapping and the fur industry.” Following the meeting a report was prepared, “Launching the Offensive,” and in this document the firm advised the industry to reach the general public—“uncommitted yet vulnerable to emotional issues and messages”—with a “positive” and “effective” message on behalf of Canadian fur interests. The industry was told that it is problematic to rally the public to “Save the Leghold Trap.” Instead, Canada was advised to adopt strong national standards, and the Fur Institute was told to make “humane trapping a key agenda item immediately.” An essential long-term goal was for Canada to label its fur products so as to assure the public that the animals are caught “humanely” and by a “caring and interested community.”[48] Canada was advised that “by not sitting this out and simply waiting for the next shoe to fall, Canada will be able to set the agenda on behalf of its fur interests. Assumptions made *about* the industry and trapping can be assumptions shaped *by* the industry.” (emphasis added)

The next year, Canada began the formal process of developing humane trap standards under the auspices of the International Organization for Standardization (ISO). The involvement of ISO—whose mission is to “promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services”—played into the hands of the fur industry.[49] Canada served as administrator of the process and a Canadian served as chair. The first meeting of ISO Technical Committee 191 to develop international humane trap standards was held in Quebec City in 1987. Ultimately, three separate standards were devised: for “humane” restraint traps, “humane” killing traps, and “humane” drowning traps, and the work was done by three working groups). [50] All three were chaired by Canadians. Representatives deliberating on appropriate text and requirements for the documents were trappers, trap manufacturers, game managers, and others involved with the industry. Animal protection representatives were present, though significant efforts were made to minimize their participation.

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[46] European Commission, Implementation of Humane Trapping Standard in the EU, http://ec.europa.eu/environment/biodiversity/animal_welfare/hts/index_en.htm (last visited March 31, 2017).

[47] Response from Department of External Affairs, Canada to Access to Information Request No. A-176 for a “discussion paper dated May 1985 prepared by Gray and Company…as well as copies of the minutes of meetings held where this report was tabled and discussed by government representatives,” dated 12 September 1985.

[48] *Id*.

[49] American National Standards Institute, International Organization for Standardization Overview, *available at* https://www.ansi.org/standards_activities/iso_programs/overview.

[50] *See Pro-Steel Jaw Leghold Trap “Experts” Meet Behind Closed Doors to Produce a Final Draft of “Humane” Trap Standards*, 42 ANIMAL WELFARE INST. Q. 12-13 (Spring 1993).

The standards process continued over many years without commanding much attention—until the stakes were raised when the Canadians secured "humane trap standards" language in EU Regulation 3254/91. As stated above, under the revised regulation, EU member states would end the use of steel-jaw traps but other countries wishing to import fur into the EU could either ban steel-jaw traps *or* meet "internationally agreed humane trapping standards for the thirteen species in the annex." Suddenly, the ISO standards became a vehicle to help Canadian and US fur traders slide in under the latter provision.

Once the standards were tied to the law, however, the process of agreeing upon what constituted humane trapping standards started to break down. The United States and Canada were vehemently opposed to the notion that if they adopted humane trapping standards they would also have to prohibit all steel-jaw traps for the 13 species of furbearer listed in the regulation. Meantime, countries participating in the ISO process were unable to agree on base criteria for what constituted a "humane" trap. How much injury was acceptable for a humane restraining trap? How much time was acceptable before an animal was irreversibly unconscious in a humane killing trap? How could fractured teeth exposing pulp cavity, broken tendons and bones, amputation of toes, and forcible drowning be considered "acceptable traumas" associated with a "humane" trap? The ISO process was also criticized internationally as lacking in transparency and being biased in its representation.

The pivotal point in the ISO trap standards process occurred at a meeting of TC191 in Ottawa in February 1994. Following four days of debate over whether or not the word "humane" should be deleted from the standards, it was removed from *all* of the trap standards. Countries voting to delete it were Belgium, Finland, Germany, the Netherlands, New Zealand, Norway, Sweden, and the United Kingdom. The United States and Denmark had voted to keep the term, while Argentina and Canada abstained. As soon as the word "humane" was removed, two of the three chairs resigned and left the meeting.[51]

Trap standards that did not include the word "humane" were of little use to the major users of steel-jaw traps and the fur industry, which had hoped to both secure continued use of steel-jaw traps and to place a "humane" label on wild-caught furs. The process soon devolved, and ultimately, no trap standards were adopted. Instead, the Canadians salvaged a protocol on methods for testing restraining traps and another for testing killing traps.[52] The testing protocols do not simply assess effects of the traps on animals; other data—such as safety to the trapper, practicality and efficiency—are included. These ISO standards are the basis for the methods of trap testing taking place under the IAHTS.

3.2 The United States' federal BMP trap-testing program

Pursuant to the above bilateral and trilateral agreements, the United States instituted a federally funded Best Management Practices trap-testing program.[53] One of the primary aims of the federal BMP trap-testing program is "to instill public confidence in and maintain public support

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[51] *See Friends of Furbearers: Delegations That Voted for Removal of the Word "Humane" from the Title of the Trap Standards*, 43 ANIMAL WELFARE INST. Q. 1, 11 (Winter 1994).

[52] *See* International Organization for Standardization, *Animal (Mammal) Traps*, ISO 10990-4:1999 & ISO 10990-5:1999, https://www.iso.org/committee/54422/x/catalogue.

[53] New York Dep't of Envtl. Conservation, Best Management Practices for Trapping in the United States (2006), *available at* http://www.dec.ny.gov/docs/wildlife_pdf/trapbmpsintro.pdf.

for wildlife management and trapping through distribution of science-based information."[54] Recreational fur trappers are paid to participate in the program. Trappers are given a set of standard testing procedures to follow as they trap coyotes, bobcats, martens, raccoons, badgers, muskrats, otters, and other furbearing animals on their trap lines. The trappers and their "technicians" (who can, by protocol, be the trapper's spouse, relative, or friend) are asked to set certain types of traps and aid in the evaluation of criteria that describe trap performance. The trappers submit an invoice to the AFWA and receive checks for their time and expenses for participating in the program.

BMP trap recommendations have been issued for 22 species in the United States.[55] Steel-jaw traps—the very device the European Union originally intended to prohibit—are included in the list of traps meeting the BMP criteria for 17 species, including coyotes, bobcats, beavers, lynx, and river otters. Although steel-jaw traps are permitted for select species, there is no requirement to monitor which species are actually caught in them. In addition, the steel-jaw trap is often used as the control device to which a different design—for example, a steel-jaw trap with a modification—is compared. More than 150 different types of commercially available traps have been tested on animals.[56]

The final BMPs issued are mere recommendations; neither state nor federal wildlife management agencies are required to adopt them as requirements. According to a national survey of licensed trappers in the United States, only 42 percent had heard of BMPs for trapping.[57]

3.3 BMPs legitimize the status quo

The United States' BMP trap-testing program has enabled the United States to assert that it has established a certification mechanism determined via a "scientific process," despite the fact that the process has focused on legitimizing steel-jaw traps. Former National Trappers Association President Craig Spoores assured trappers that "the scientific BMP process will discover that some steel-jaw traps will continue to be necessary and prove best for some American species."[58] Indeed, the first official BMPs recommend unmodified steel-jaw traps and neck snares for several species.[59]

The costs of the BMP trap-testing program have been substantial, both in dollars and animal suffering. Historically funded by federal tax dollars passed through the USDA to the AFWA, the BMP program has cost millions since its inception in 1996.[60] While the USDA was funding the program, the public was officially entitled to any documents associated with it. Once the USDA stopped funding the program some years ago, however, and it was funded by the AFWA, associated documents were no longer available through the federal Freedom of Information Act.

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[54] Association of Fish and Wildlife Agencies, Best Trapping Practices for Trapping in the United States, Introduction, at 3 (2006), *available at* http://www.dec.ny.gov/docs/wildlife_pdf/trapbmpsintro.pdf;

[55] Responsive Mgmt., *supra* note 2.

[56] *See* Minutes of the Agreement on International Humane Trapping Standards Joint Management Committee Meeting, Edmonton, Alberta, Canada 15 (October 4-5, 2011), http://www.fishwildlife.org/files/2011JMCReport.pdf.

[57] *Id.*

[58] Fox, *supra* note 6.

[59] *Id.*

[60] According to the minutes of the Agreement on International Humane Trapping Standards Joint Management Committee Meeting, Edmonton, Alberta, Canada, Oct 4-5, 2011, p. 15, about $9 million has been spent "including federal funds and state contributions, direct and in-kind." http://www.fishwildlife.org/files/2011JMCReport.pdf.

The BMP testing program is unquestionably subject to bias, subjectivity, and inaccuracy. The use of professional fur trappers—who have a strong interest in the outcome— as testers undermines the veracity and accuracy of the data and the scientific rigor of the process. Trappers well-versed at the setting and use of steel-jaw traps, neck snares, and Conibears are unlikely to be familiar with many of the alternatives and this can confound the data. Full disclosure is questionable: Trappers are loath to admit having trapped an endangered species or family pet, or that a trapped animal had struggled so excessively that it self-amputated a foot while trying to escape.

Indeed, the program has been criticized by independent scientists, wildlife professionals, and animal advocacy organizations as unscientific, self-serving, and rife with political agendas.[61] Moreover, program design and implementation has occurred with no public accountability, transparency, or oversight. The Animal Welfare Institute, in a letter to Donald MacLauchlan, international resource director of the International Association of Fish and Wildlife Agencies (later renamed the Association of Fish and Wildlife Agencies), dated February 5, 1998, requested membership on the Fur Resources Technical Subcommittee overseeing the BMPs. Although the subcommittee included two nongovernmental representatives from the National Trappers Association, AWI's request was denied.[62] In addition, public review of the research projects or monitoring of the BMP trap-testing process is virtually impossible.

Ultimately, the BMP trap-testing program has caused thousands of coyotes, bobcats, beavers, raccoons, and other furbearing animals to suffer unnecessarily in steel-jaw traps. The traps close with bone-crushing force on their victims, who struggle violently to be free. Injuries include amputation of digits, severed tendons and ligaments, joint luxation, and bone fractures. Teeth may be broken, sometimes right down to the jawbone, as animals bite at the trap. In their desperation, some animals will chew off their own limb to escape. In the trap studies being conducted (based on the agreement between the United States and the European Union), four of 20 animals caught in traps can experience these and other traumas, and the trap can still be approved. One does not find much of this information about the damage caused to animals by steel-jaw traps and other devices in the recent scientific literature because the vast majority of trap testing has not been published in any peer-reviewed journal. This process needs to be exposed for the farce that it is, and this needless trapping cruelty must end.

In practice, these agreements and associated trap testing programs have enabled all parties to sidestep the original intent of Regulation 3254/91 by allowing both continued use of steel-jaw traps outside of the European Union and unfettered trade in wild-caught fur from the United States, Canada and Russia to Europe.

4. The sources and causes of resistance to trapping reforms in the United States

The response of the United States government to EU Regulation 3254/91 indicates more than economic self-interest. A primary source of resistance to trapping reforms in the United States is wildlife agencies, at both the federal and state level.

Despite a rising tide of public opinion condemning cruel trapping, especially the use of steel-jaw traps and strangling neck snares, state wildlife departments as well as federal

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[61] *Id.*

[62] Personal communication from Cathy Liss to Mr. MacLauchlan, 5 February 1998.

agencies have made few changes to reduce animal pain and suffering from traps.[63] This is unsurprising, given their utilitarian wildlife use philosophy. Most state wildlife agency commissions (or boards or councils) are dominated, often as required under state law, by "consumptive wildlife users" (i.e., those who hunt, trap, and kill wildlife for recreation), making it both challenging and slow to achieve regulatory change through the administrative process. To members of these commissions and, in general, employees of these agencies, wildlife is seen as a resource to be stocked and managed for the benefit of consumptive wildlife users.

Moreover, state wildlife agencies depend heavily upon revenues and excise taxes directly connected to sales of hunting, trapping, and fishing licenses and gear. As a result, agencies largely ignore the opinions of other constituents who are opposed to these practices. Agency funds tend to be disproportionately invested in "game" animals, while "nongame" animals receive very little consideration.[64]

The conduct of both state and federal agencies reflects a regrettably common public attitude: the failure to see animals as having moral standing and intrinsic worth. Wildlife agencies, particularly at the state level, have generally been slow to respond to shifting public values and to demands for less invasive and lethal ways of managing wildlife, and have resisted innovative and participatory governance and ecosystem-based management.[65]

5. Ongoing and future reform efforts needed: Forums and issues

More than 100 countries have banned or severely restricted use of steel-jaw traps,[66] a device condemned as inhumane by the National Animal Control Association and the American Animal Hospital Association. In 1995, all member countries of the European Union banned steel-jaw traps and sought to ban the import of furs from countries still using these traps.

Yet, the United States lags far behind the rest of the world with regard to trapping reforms.[67] Despite increased opposition to the use of steel-jaw traps[68] and the availability of alternatives,[69]

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[63] Camilla Fox, *Trapping, Behavior, and Welfare, in* ENCYCLOPEDIA OF ANIMAL RIGHTS AND WELFARE 559 (Marc Bekoff ed., 2d ed. 2010); ANIMAL PROTECTION INST., *supra* note 10; Jones & Rodriguez, *supra* note 17.

[64] ANIMAL PROTECTION INST., *supra* note 8.

[65] R. Bruce Gill, *The Wildlife Professional Subculture: The Case of the Crazy Aunt*, 1 HUMAN DIMENSIONS OF WILDLIFE 60 (1996); Martin Nie, *State Wildlife Policy and Management: The Scope and Bias of Political Conflict*, 64 PUB. ADMIN. REV. 221 (2004); COEXISTING WITH LARGE CARNIVORES: LESSONS FROM GREATER YELLOWSTONE (Tim Clark et al. eds., Island Press 2005).

[66] *Laws on Leg-Hold Animal Traps Around the World,* THE LAW LIBRARY OF CONGRESS, http://www.loc.gov/law/help/leg-hold-traps/index.php (last updated December 12, 2016).

[67] Fox, *supra* note 63; Iossa et al., *supra* note 4; *Caught by Mistake: Pets Suffer Serious Steel-Jaw Leghold Trap Injuries,* ANIMAL WELFARE INSTITUTE (2016), https://awionline.org/awi-quarterly/2016-spring/caught-mistake-pets-suffer-serious-steel-jaw-leghold-trap-injuries. G. Iossa, C. D. Soulsbury & S. Harris. Mammal Trapping: A Review of Animal Welfare Standards of Killing and; G. Iossa et al., *Mammal Trapping: A Review of Animal Welfare Standards of Killing and Restraining Traps*, 16 ANIMAL WELFARE 335 (2007).

[68] Robert Muth et al., *Unnecessary Source of Pain and Suffering or Necessary Management Tool: Examining the Attitudes of Conservation Professionals toward Outlawing the Use of the Steel-jaw Trap*, 34 WILDLIFE SOC'Y BULL. 706 (2010); ANIMAL PROTECTION INST., *supra* note 9; Dena Jones & Sheila Rodriguez, *Restricting the Use of Animal Traps in the United States: An Overview of Laws and Strategy*, 9 ANIMAL L. 135 (2003); Stuart Harrop, *The Trapping of Wild Mammals and Attempts to Legislate for Animal Suffering in International Standards,* 12 J. ENVTL. L. 333 (2000); John Gentile, *The Evolution of Anti-Trapping Sentiment in the United States: A Review and Commentary,* 15 WILDLIFE SOC'Y BULL. 490 (1987).

[69] *See* Garrett, *supra* note 28.

brutal trapping devices remain legal in most of the United States, including for use on national wildlife refuges. Meanwhile, the United States government continues to defend commercial fur trapping and the use of steel-jaw traps.[70]

5.1 Types of reform efforts in the United States

5.1.1 Reform efforts using the ballot initiative process

In 26 states and Washington DC,[71] the initiative process allows citizens to gather petition signatures to place a proposed statutory or constitutional amendment before the voters. History has shown that when the public begins to distrust government, they seek redress through direct democratic processes.[72] Such processes "give voters a direct say in the law and circumvent special interests and unresponsive legislatures."[73]

In the last two decades, animal advocates have used the public initiative process to ban or to restrict certain traps and/or trapping practices at the state level.[74] As noted above, from 1994 through 2000, voters in five states (Arizona, California, Colorado, Massachusetts, and Washington) passed ballot initiatives restricting the use of body-gripping and/or steel-jaw traps for commercial and recreational trapping.[75] These successes reflect public concern that cruel traps such as these should not be permitted.

With heightened controversy and increased public awareness, efforts to restrict or reform trapping through ballot initiatives will likely continue.

5.1.2. Reform efforts using the judicial process

Animal advocates and wildlife conservationists have also used the courts to restrict trapping in order to protect endangered species from steel-jaw traps, body-gripping traps, and neck snares. Cases involving the incidental trapping of federally protected Canada lynx are illustrative of the effort.

In 2008, the Animal Welfare Institute and the Wildlife Alliance of Maine (WAM) filed a federal lawsuit against the Maine Department of Inland Fisheries and Wildlife (MDIFW) for failing to adequately protect Canada lynx from traps and snares set for other furbearing species by trappers licensed by the MDIFW.[76] AWI and WAM claimed that allowing and authorizing

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[70] Fox, *supra* note 63; ANIMAL PROTECTION INST., *supra* note 8; Jones & Rodriguez, *supra* note 16.

[71] Jones & Rodriguez, *supra* note 16; *see also states with initiative or referendum,* Ballotpedia.org, https://ballotpedia.org/States_with_initiative_or_referendum.

[72] Kenneth Jost, *Initiatives: True Democracy or Bad Lawmaking?, in* EDITORIAL RESEARCH REPORTS 1990, at 461 (1990).

[73] *Id.* at 463.

[74] ANIMAL PROTECTION INST., *supra* note 8; Jones & Rodriguez, *supra* note 16; Susan Cockrell, *Crusader Activists and the 1996 Colorado Anti-Trapping Campaign,* 27 WILDLIFE SOC'Y BULL. 65 (1999).

[75] Jones & Rodriguez, *supra* note 16.

[76] Animal Welfare Inst. v. Martin, 588 F. Supp. 2d 70 (D. Me. 2008); Keith Rizzardi, *Animal Welfare Institute v. Martin: Dispute over Canada Lynx Trapping Creates Factual Twists and Procedural Controversies*, ESA BLAWG (Dec. 24, 2008), http://www.esablawg.com/esalaw/ESBlawg.nsf/d6plinks/KRII-7MN4KB.

trappers to injure and sometimes kill Canada lynx—a species listed as threatened under the Endangered Species Act (ESA) — was a violation of Section 9 of the ESA's prohibition against "take" (causing serious injury or death) of such species.[77]

In December 2009, the US District Court for the District of Maine ruled that Maine's current regulatory scheme for trapping furbearing animals results in the trapping of Canada lynx in violation of the ESA. The court did not, however, enjoin trapping in Maine's lynx habitat. The court noted a pending decision by the US Fish and Wildlife Service (USFWS) to issue an incidental take permit (ITP) to the MDIFW, which would, according to the court, require the agency to implement mitigation measures to better protect lynx from indiscriminate traps and would thereby shield the state from liability for incidental trapping of Canada lynx.

However, once issued, the ITP failed to adequately protect Canada lynx. As a result, on 17 August 2015, AWI, WAM, and the Center for Biological Diversity filed a lawsuit against the USFWS for allowing trappers in Maine to take Canada lynx. The lawsuit requests that the court close down the state's trapping season in lynx habitat.[78] On February 15, 2017, the court denied plaintiffs' motion for summary judgment. To date, plaintiffs have not announced a decision regarding an appeal.

In a similar case, in March 2008, the US District Court for the District of Minnesota ruled that Minnesota's Department of Natural Resources (DNR) violated Section 9 of the ESA because the department's trapping program was the proximate cause of numerous lynx takings. The court noted that "government agencies cause a taking under ESA if such agency authorizes activities that result in said taking,"[79] Expanding on this, the Court stated:

> In order to legally engage in trapping in Minnesota … one must obtain a license and follow all governmental regulations governing trapping activities. Thus, for purposes of determining proximate cause, the DNR's licensure and regulation of trapping is the "stimulus" for the trappers [sic] conduct that results in incidental takings. Accordingly, the trappers [sic] conduct is not an independent intervening cause that breaks the chain of causation between the DNR and the incidental takings of lynx.[80]

As a result, the court ordered the state to restrict traps and snares to reduce the likelihood of lynx being captured in traps set for other species. In addition, the ruling required the state to obtain an ITP from the USFWS under Section 10 of the ESA. The ITP was to provide the state with a variety of alternatives and strategies to avoid, minimize, and mitigate the taking of lynx.

The cases in Maine and Minnesota were among the first lawsuits brought by wildlife advocates that specifically targeted state wildlife agencies for authorizing the use of traps and establishing trapping seasons for furbearers that capture, injure, and kill federally listed lynx and other species. These cases are important to protect listed species from intentional or incidental take in traps.

5.2 Problems with state trapping regulations and reforms needed

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[77] 16 U.S.C. § 1532 (2017) (defining the term "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct").

[78] Friends of Animals v. Phifer, 1:15-CV-00157-JDL, 2017 WL 617910 (D. Me. 2017).

[79] Ctr. For Biological Diversity v. Holsten, 541 F. Supp. 2d 1073, 1078 (D. Minn. 2008).

[80] *Id.* at 1079.

5.2.1 Trap check times and lack of enforcement

Even though numerous scientific studies indicate that short trap check intervals greatly reduce injuries to trapped animals,[81] a number of states still allow animals to languish in traps for days. In Montana and Alaska, for instance, there is no mandatory trap check time for most steel-jaw traps, while Wyoming trappers are directed to check steel-jaw traps just once every 72 hours. Where trap-check standards are in place, they are often weak and unenforced. In addition, where trap check times have been established for "furbearers" and other categories of animals, species classified as "nongame" or "predatory"—such as coyotes—may be excluded, allowing victims to suffer indefinitely. New Mexico, for example, excludes coyotes from existing trap check standards.[82] Moreover, there is generally a shortage of enforcement personnel to ensure compliance with existing trapping regulations.

Little attention is given to evaluating the impact of these trapping practices on wildlife populations, and relaxed licensing and record-keeping requirements compound this problem. For instance, New York law does not mandate reporting for furbearers other than bobcats, and a number of states from Nevada to Virginia do not require trapper education courses in order to obtain a permit.[83]

Many states, by their own admission, lack the enforcement personnel in the field to ensure compliance with state trapping (and hunting) regulations. Violations of trapping regulations, as well as poaching of protected species, are commonplace. These violations include (1) failure to check traps as frequently as state regulations require, (2) using traps without the personal identification that is required in most states, (3) trapping of species out of season, and (4) using traps that do not comply with state regulations.

5.2.2 New technologies that reduce suffering are ignored

New technologies are available and, if mandated and used by trappers, capable of greatly reducing the suffering of animals in live traps. One such technology is the use of remote trap monitors, which send a signal to let a trapper know when an animal has tripped and presumably been caught in a trap so that the animal can be promptly removed from the trap.[84] Another technology, albeit one that may come with a regulatory burden, is the use of tranquilizer tabs. Here, the device is equipped with a tab containing a tranquilizing agent; upon capture, the animal bites the tab and ingests the agent, thereby reducing his or her stress and injury.[85]

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[81] NOCTURNAL WILDLIFE RESEARCH PTY., *supra* note 4; Powell & Proulx, *supra* note 4.

[82] *While the World Moves On, US Still Caught in Its Traps*, ANIMAL WELFARE INSTITUTE (2013) https://awionline.org/awi-quarterly/2013-fall/while-world-moves-us-still-caught-its-traps.

[83] *Id.*

[84] Nat'l Wildlife Research Ctr., Evaluation of Remote Trap Monitors (2008), *available at* https://www.aphis.usda.gov/wildlife_damage/nwrc/research/predator_management/content/USDA%20Tech%20Note%20Remote%20Trap%20Monitors.pdf.

[85] Donald Balser, *Tranquilizer Tabs for Capturing Wild Carnivores*, 29 J. WILDLIFE MGMT. 438 (1965); Duane Sahr & Frederick Knowlton, *Evaluation of Tranquilizer Trap Devices (TTDs) for Foothold Traps Used to Capture Gray Wolves*, 28 WILDLIFE SOC'Y BULL. 597 (2000).

5.2.3 Omission of several species from trapping regulation protections

Some state trapping regulations cover only certain trapped species, such as those classified as "furbearer" or "small game." Species classified as "nongame" or "predatory" are often exempt from any protections or regulatory oversight. In some states, such species can be trapped and/or hunted at any time of the year, in any number, without a license, and without any requirement to report the number of animals killed to the state agency.[86] The impact of such unregulated trapping and hunting on mammal populations is unknown, but may be significant for some species, particularly at local levels.

5.2.4 Lack of oversight of "Nuisance Wildlife" trapping

With increasing urban sprawl in recent decades, encounters between humans and wildlife have escalated, and private "nuisance wildlife control" trapping businesses have grown exponentially in response.[87] This industry, which is based upon the removal, generally via lethal means, of animals deemed "pests" or "nuisances," has little regulatory oversight at either the state or federal level.[88] Although many nuisance wildlife control operators (NWCO) use the same traps used by fur trappers, few states require that NWCOs report the species or number of animals killed. State wildlife agencies have almost no oversight over private NWCOs, even though they kill wild animals subject to the management authority of state wildlife agencies. Some wildlife agency professionals, recognizing this problem, have recommended that the emerging industry be regulated.[89]

5.2.5 Unregulated methods for killing trapped animals

Most state regulations do not address how animals found alive in traps are to be killed. For example, in Georgia, trappers are required to carry a .22 caliber rim fire gun while tending traps, and to use that weapon to kill furbearers.[90] All other states that mention the killing of trapped animals, however, offer guidance rather than set requirements on the method of killing trapped furbearers. Alabama, for example, merely requires trappers to carry a choke stick, and trappers may use a standard .22 caliber rimfire firearm to kill furbearers.[91] New Jersey regulations state that except on Sunday, trappers with a valid rifle permit may carry a .22 caliber rifle and use short rimfire cartridges to kill legally trapped animals (other than

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[86] *See Oregon Big Game Hunting Regulations*, EREGULATIONS, http://www.eregulations.com/oregon/big-game-hunting/general-hunting-regulations/ (last visited March 11, 2017).

[87] Camilla Fox, *Wildlife Control: Out of Control*, 35 ANIMAL ISSUES 15 (2004); John Hadidian et al., *Nuisance Control Practices, Policies, and Procedures in the United States, in* WILDLIFE, LAND, AND PEOPLE: PRIORITIES FOR THE 21ST CENTURY 165 (Rebecca Field et al. eds., 2001).

[88] Thomas Barnes, *State Agency Oversight of the Nuisance Wildlife Control Industry,* 25 WILDLIFE SOC'Y BULL. 185 (1997); Hadidian et al., *supra* note 87.

[89] Barnes, *supra* note 88.

[90] *Trapping Regulations*, GEORGIA DEP'T OF NATURAL RES., http://www.georgiawildlife.com/Trapping (last visited March 11, 2017).

[91] ALA. CODE § 220-2-.30(2) (2017).

muskrat).[92] Arizona, Wisconsin, and South Dakota require trappers to either release or kill trapped animals, but they do not state the methods to be used.[93] In addition, allowing children to live-trap animals raises concerns over how the animals will be killed and how prolonged their suffering could be.

The common killing methods used by trappers are clubbing, suffocation (standing on the chest), and strangulation (with a "choke stick" or "catch pole").[94] Fur trappers do not like to shoot trapped animals because bullet holes and blood damage pelts and reduce the value of furs.[95] Trapper education manuals—which are difficult to find posted online—typically advise trappers to kill animals by suffocation, drowning, gassing, and/or hitting them with a club in order to preserve the pelt, as well as to stand on the animal's chest to compress its organs, which leads to death.[96] Some manuals suggest using a heavy object, such as an iron pipe or an axe handle, and striking the animal twice; once to render it unconscious and again to render it either dead or comatose.[97] One suggests that trappers "pin the head with one foot and stand on the chest (area near the heart) of the animal with the other foot for several minutes."[98]

5.2.6 Inaccuracy of state wildlife agency population data and trap-kill data

Many state wildlife agencies rely on furbearer "harvest" numbers (those animals killed through trapping and hunting) to estimate statewide populations of trapped and hunted species. Because "harvest" figures do not necessarily reflect species abundance and may be more influenced by external factors, such as pelt price and fur demand, such extrapolations are generally poor methods for accurately estimating species' populations.

Moreover, the majority of state wildlife agencies do not require trappers to report the number or species of animals they trap each season.[99] Instead, they rely upon fur dealer or buyer reports, which have little correlation to the actual number of animals trapped. Fur dealer or buyer reports only record those pelts purchased by licensed fur buyers within the state, and unsold and/or damaged pelts or pelts sold out of state are not recorded in these figures. Thus, these reports can drastically underestimate the total number of animals trapped statewide. Furthermore, states that *do* require seasonal trapping reports often obtain this information via mail or telephone

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[92] New Jersey Dep't Envtl. Prot., Trapping Regulations (2012), *available at* http://www.state.nj.us/dep/fgw/pdf/2012/dighnt70-73.pdf.

[93] Wisconsin Dep't of Natural Res., Wisconsin Trapper Education Manual, *available at* http://dnr.wi.gov/education/OutdoorSkills/documents/Unit3.pdf; *see also* Ass'n of Fish & Wildlife Agencies, Summary of Trapping Regulations for Fur Harvesting in the United States (2007), *available at* www.fishwildlife.org/files/Summary-Trapping-Regulations-Fur-Harvesting.pdf.

[94] ANIMAL PROTECTION INST., *supra* note 8.

[95] *While the World Moves On*, *supra* note 82.

[96] LISA KEMMERER, ANIMALS AND THE ENVIRONMENT: ADVOCACY, ACTIVISM, AND THE QUEST FOR COMMON GROUND 125 (2015).

[97] ANIMAL PROTECTION INST., *supra* note 8.

[98] New York Dep't of Envtl. Conservation, Trapping Furbearers: An Introduction to Responsible Trapping (2016), *available at* http://www.dec.ny.gov/docs/wildlife_pdf/trapedman.pdf.

[99] *Exposing the Myths: The Truth about Trapping*, BORN FREE USA, http://www.bornfreeusa.org/facts.php?p=53&more=1 (last visited March 11, 2017).

surveys.[100] Response rates to such surveys, however, may vary from 10 to 60 percent.[101] State wildlife agencies then extrapolate the total number of animals trapped each year from these partial reports to estimate total take from trapping. These data are then used to determine trapping "harvest" levels and season lengths for the subsequent trapping season.

5.2.7 Poor (or nonexistent) reporting of nontarget animals trapped

Very few states require that trappers report nontarget animals trapped. Some states regulate trap sets and specify methods for avoiding nontarget captures and recommend methods for handling instances in which a nontarget domestic animal is trapped.[102] However, because most trappers are not trained to assess the condition of trapped animals or the severity of any injuries sustained by trapping, it is unclear how a trapper can ensure that any nontarget animal is released "unharmed," and state agencies fail to provide any criteria or instruction to aid in determining harm. What regulations that exist do little to ensure an accurate tally of the numbers of nontarget animals trapped, and field research indicates that nontarget take can be significant.[103]

5.2.8 Exemptions of private landowners from trapping regulations

In a number of states, private landowners do not need a license to trap and kill certain species on their own property.[104] For example, in Wisconsin, landowners or occupants and their family members may (without a license) hunt or trap on their own property for coyotes, beavers, foxes, raccoons, woodchucks, rabbits, and squirrels year-round.[105] In Indiana, landowners may take coyotes at any time on the land they own, or provide written permission for others to do so.[106]

5.2.9 Insufficient regulation of trespassing by trappers

Every state recognizes a landowner's right to exclude trappers from his or her land by erecting "no trespassing" or "no hunting/trapping" signs. A few states even *require* that landowners who wish to exclude trappers/hunters post "no trespassing/ hunting/ trapping" signs. Conversely, other states require that trappers obtain permission from landowners even if the landowner has

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[100] ANIMAL PROTECTION INST., *supra* note 8 at 28.

[101] *Id.*

[102] *See, e.g.*, Maryland Dep't of Natural Res., Maryland Trapper Education Manual (2005), *available at* http://dnr.maryland.gov/Documents/Maryland_Trapper_Education_Student_Manual.pdf; Minnesota Dep't of Natural Res., Minnesota Trapper Education Manual (2012), *available at* http://www.mnforesttrappers.com/trapper_manual.pdf.

[103] Nocturnal Wildlife Research Pty., *supra* note 4; Iossa et al., *supra* note 4; BRIAN J. FRAWLEY ET AL., *supra* note 4; Powell & Proulx, *supra* note 4; Gary Bortolotti, *supra* note 4.

[104] *See, e.g.*, Wisconsin Dep't of Natural Res., Nuisance Wildlife Guidelines, *available at* http://dnr.wi.gov/topic/WildlifeHabitat/documents/nuswlguide.pdf; *Dealing with Nuisance Coyotes*, INDIANA DEP'T OF NATURAL RES., http://www.in.gov/dnr/fishwild/5688.htm (last visited March 11, 2017).

[105] *Id.*

[106] *Id.*

not posted prohibitory notices.[107] Alabama, Arizona, New Mexico, North Dakota, Oklahoma, Rhode Island, South Dakota, and Utah require written permission from landowners under some circumstances.[108] In several other states, verbal permission is allowed.[109] Trespassing by trappers remains an ongoing problem for private landowners.

5.2.10 Lack of trapper education as a condition of licensing

While there is no way to avoid animal cruelty when using steel-jaw traps, the lack of basic guidance—such as mandating that trappers avoid using bait that is attractive to companion animals or sets that may result in significant nontarget take, are familiar with the state's trapping requirements, and have reached a specified age before they can obtain a (mandatory) trapping license—contributes to the problem.

6. Conclusion

Trapping continues to be hidden from the public eye; most people are unaware of the extent to which it is even happening, and the United States continues to lag far behind the rest of the world in regard to trapping reforms. With more than 100 countries already having banned steel-jaw traps, a ban on steel-jaw traps is, arguably, *the* international standard. It is likely that global pressure will be needed to compel the European Union to rethink its weak trapping agreement with the United States and implement a strict prohibition on the import of pelts from animals captured using steel-jaw traps. Yet, without hope of overcoming trade agreements intended to facilitate such trade, there may not be a chance for the European Union to reconsider.

Ultimately, efforts need to be made at every level—local, state, national, and global—to seek a prohibition on the use of steel-jaw traps. It will be necessary to expose the various trap standards for the farce that they are, and to highlight their abysmal failure to actually protect furbearing animals. Meanwhile, additional measures can help, such as mandating a 24-hour trap check time in every state. This need is ever more apparent as the United States becomes increasingly isolated among a dwindling number of countries that sanction the horrific animal suffering caused by barbaric traps—traps that should be relegated to museums or melted down so the steel could be put to a better purpose.

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[107] *See, e.g.*, *Landowner Permission Requirements and Trapping on Private Property*, MAINE DEP'T OF INLAND FISHERIES & WILDLIFE, http://www.state.me.us/ifw/hunting_trapping/trapping/laws/landowner_privateproperty.htm (last visited March 11, 2017).

[108] Ass'n of Fish & Wildlife Agencies, *supra* note 93.

[109] *Id.*

References

Association of Fish and Wildlife Agencies (AFWA). 2001. New Hampshire Best Management Practices Trap Research Trapper Technician Report.

Association of Fish and Wildlife Agencies (AFWA). 2003. Best Management Practices for Trapping Coyotes in the Eastern United States. Available online at http://www.fishwildlife.org/pdfs/CoyoteBMP.pdf (accessed July 20, 2008).

Association of Fish and Wildlife Agencies (AFWA). 2005. Ownership and Use of Traps by Trappers in the United States in 2004. *A report produced by Responsive Management for AFWA*.

Barnes, T. G. 1997. State Agency Oversight of the Nuisance Wildlife Control Industry. *Wildlife Society Bulletin*, 25: 185–188.

Bortolotti, G.R. 1984. Trap and poison mortality of golden eagles *Aquila chrysaetos* and bald eagles *Haliaeetus leucocephalus*. Journal of Wildlife Management 48: 1173-1179.

Clark, T., M. Rutherford, and D. Casey (editors). 2005. *Coexisting with Large Carnivores: Lessons from Greater Yellowstone* 2005. Island Press, Washington, DC.

Cockrell, S. 1999. Crusader activists and the 1996 Colorado anti-trapping campaign. *Wildlife Society Bulletin* 27:65-74.

ESA Blawg. Animal Welfare Institute v. Martin: dispute over Canada lynx trapping creates factual twists and procedural controversies. Available online at http://www.esablawg.com/esalaw/ESBlawg.nsf/d6plinks/KRII-7MN4KB (accessed August 27, 2009).

Fox, C.H. 2010. Trapping, Behavior, & Welfare. In M. Bekoff (ed.). *Encyclopedia of Animal Rights & Welfare* (revised edition). Greenwood, Westport, CT.

Fox, C.H. 2008. *Analysis of the Marin County Strategic Plan for Protection of Livestock & Wildlife: An Alternative to Traditional Predator Control*. (Master's thesis). Prescott College, Prescott, Arizona.

Fox, C.H. and C.M. Papouchis. 2005. *Coyotes in Our Midst: Coexisting with an Adaptable and Resilient Carnivore*. Animal Protection Institute, Sacramento, California

Fox, C.H. 2004. Wildlife Control Out of Control. Animal Issues 35:15-18.

Fox, C.H. and C.M. Papouchis (eds.). 2004. *Cull of the Wild: A Contemporary Analysis of Wildlife Trapping in the United States*. Animal Protection Institute, Sacramento, California.

Frawley, B.J. et al. 2005. *Fox and Coyote Trapping Survey; Wildlife Division Report No. 3430*. Michigan Department of Natural Resources (February 2005).

Fur Institute of Canada (FIC). *Agreement on International Humane Trapping Standards: Canada's Objectives in Negotiating the AIHTS*. Available online at http://www.fur.ca/index-e/aihts/index.asp?action=aihts&page=index (accessed July 20, 2008).

Garrett, Tom. 1999. *Alternative Traps: The Role of Spring Powered Killing Traps in Modern Trapping, the Role of Cage and Box Traps in Modern Trapping, and the Role of Legsnares in Modern Trapping*. Animal Welfare Institute

Gentile, J. R. 1987. The evolution of anti-trapping sentiment in the United States: a review and commentary. *Wildlife Society Bulletin* 15:490–503.

Gerstell, R. 1985. *The Steel Trap in North America*, Stackpole Books.

Gill, R. B.1996. The wildlife professional subculture: The case of the crazy aunt. *Human Dimensions of Wildlife*. 1:21–32.

Hadidian, J., C.H. Fox, and W.S. Lynn. 2006. The ethics of wildlife control in humanized landscapes. Pp. 500-504 in: R.M. Timm and J. H. O'Brien (eds.), Proceedings*, 22nd Vertebrate Pest Conference*. Publ. Univ. Calif.-Davis.

Hadidian, John, Michele R. Childs, Robert H. Schmidt, Laura J. Simon, and Ann Church. 2001. Nuisance wildlife control practices, policies and procedures in the United States. *Wildlife, Land and People: Priorities for the 21st Century*, eds Rebecca Field, Robert J. Warren, Henryk Okarma, and Paul R. Sievert, Pp. 165-68. Proceedings of the Second International Wildlife Management Congress, Wildlife Society, Valko, Hungary.

Harrop, S.R. 2000. The trapping of wild mammals and attempts to legislate for animal suffering in international standards. *Journal of Environmental Law*, 12:333-360

Jones, D. M., and S. H. Rodrigues. 2003. Restricting the use of animal traps in the United States: an overview of laws and strategy. *Animal Law* 9:135–157.

Jones, D.M. 1997. Protecting animals at the ballot box. *Mainstream*. Spring: 24-27.

Jost, K. 1990. Initiatives: True democracy or bad law making? *Congressional Quarterly Editorial Research Reports*. August: 462-474.

Iossa, G., Soulsbury, C.D., Harris, S. 2007. Mammal trapping: a review of animal welfare standards of killing and restraining traps. *Animal Welfare* 16:335-352.

Marks, C.A. 2008. *Welfare Outcomes of Leg-hold Trap Use in Victoria*. Nocturnal Wildlife Research Pty Ltd.

Minnis, D. L. 1998. Wildlife policy-making by the electorate: an overview of citizen-sponsored ballot measures on hunting and trapping. *Wildlife Society Bulletin* 26:75–83.

Muth, R.M., R.R. Zwick, M.E. Mather, J.F. Organ, and J.J. Daigle. 2006. Unnecessary source of pain and suffering or necessary management tool: Examining the attitudes of conservation professionals toward outlawing the use of the steel-jaw trap. *Wildlife Society Bulletin* 34:706-715.

Nie, **M.** 2004**.** State wildlife policy and management: the scope and bias of political conflict**.** *Public Administration Review* 64**:** 221-233**.**

Nilsson, G. 1980. *Facts about Furs.* 3d ed., Animal Welfare Institute, Washington, D.C.

Powell, R.A. and G. Proulx. 2003. Trapping and marking terrestrial mammals for research: integrating ethics, performance criteria, techniques, and common sense. *ILAR Journal* 44: 259-276.

Proulx, G. and D. Rodtka. 2017. Steel-Jawed Leghold Traps and Killing Neck Snares: Similar Injuries Command Change to Agreement on International Humane Trapping Standards. *Journal of Applied Animal Welfare Science*, 1-6.

Robinson, M.J. 2005. *Predatory Bureaucracy*. University Press of Colorado.

Tomsa, T. N., and J. E. Forbes. 1989. Coyote depredation control in New York—an integrated approach. Proc. East. Wildlife Damage Control Conf. 4: 75-86.

Warburton B. 2009. International trapping standards. *Welfare Pulse*, Issue 01. Ministry of Agriculture and Forestry, Animal Welfare Directorate, Wellington, New Zealand. p. 16-17.

Wijnstekers, W. 1993. Note for the file: Implementation of Regulation 3254/91, leghold traps and fur imports (an adapted version of a note of 8 October 1993 on this subject and takes account of the comments and views of the legal division of DG XI and the Commission Legal Service, p, 1-5.

Beavers cutting tree to obtain smaller branches for food and building material

Until 2007, the largest known beaver dam in the world was near Three Forks, Montana, measuring 2,140 feet long, over 14 feet high, and 23 feet wide at the base. In 2007, a 2,800-foot-long dam, visible from space, was discovered near Wood Buffalo National Park, Alberta, Canada.

Social Behavior: Beavers are also well known for their ability and eagerness to dam up streams, creating beaver ponds. The sound of running water apparently serves as the stimulus for such construction activities. Their engineering skills are quite remarkable. Dams can be 75 to 98 feet (23–30 m) or more in length, although some may even exceed a distance of 0.31 mile (0.5 km). They are constructed from a foundation of rocks and mud upon which tree limbs are piled. Leaves and mud are then packed around the limbs as mortar. Standing water behind these dams provides the beavers with a pool of water around which to move, provides protection from predators, and serves as a storage site for winter food. The beavers often dig a series of intricate canals in association with the pond. Beavers use these aquatic waterways to float vegetation needed for construction of their lodge, the dam, or food cache.

A typical beaver colony consists of four to eight individuals; the adult male and female, their young (kits) from the previous year and, in the spring, kits from the current year. Second-year offspring are forced to leave before the birth of a new litter. Beavers become active toward late afternoon or evening, foraging and reconstructing dams and lodges throughout the night. In early morning, they retreat to their lodge to rest. During winter, beavers will leave the lodge to recover previously stored caches of branches under the ice. They can stay submerged for up to fifteen minutes, although three to four minutes is more common. They are somewhat slow and clumsy on land, so during winter when escape routes back to open water are limited, they rarely come out on land.

When frightened, a beaver will customarily slap its tail on the surface of the water. This behavior, referred to as a warning dive, not only startles a potential predator but warns other beavers of a possible threat. Other beavers respond to the sound by immediately swimming to deep water. The animal making the tail slap will resurface to swim around the intruder and continue to slap the water. Often beavers can be approached quite closely when this occurs.

Note the small feet of the bobcat

Lewis was describing a prime winter pelt at its fullest growth. In addition, both fore- and hind feet are small, with the hind feet the smallest. From a distance, bobcats could be confused with the other medium-sized felid in Montana, the lynx (*Lynx canadensis*). Up close, however, they can be distinguished by color (the lynx is predominantly gray), degree of spotting (spots on the lynx are far less numerous and distinct), ear tufts (those of the lynx are long and showy), and size of feet (those of the lynx are disproportionately large).

Total length	♂ 41 in (104.2 cm)/♀ 37.7 in (93.2 cm)
Tail length	♂ 6.6 in (16.7 cm)/♀ 6.1 in (15.6 cm)
Hind foot	♂ 7.6 in (19.3 cm)/♀ 7.1 in (18.0 cm)
Track size (l x w)	Front 2 x 2.1 in (5 x 5.3 cm) Hind 2.1 x 1.9 in (5.3 x 4.8 cm)
Ear	♂ 2.7 in (6.9 cm)/♀ 2.7 in (6.9 cm)
Weight	♂ 25.8 lb (11.7 kg)/♀ 18.7 lb (8.5 kg)
Status	Common; classified as a furbearer. In the 2009/2010 trapping season, an estimated 1,428 individuals were harvested.

DISTRIBUTION

Widely distributed across North America, extending from the southern regions of the Canadian provinces throughout the continental United States and Mexico; found throughout Montana.

ECOLOGY AND BEHAVIOR

Habitat Preference: The bobcat uses a wide variety of habitat types in Montana, from semidesert grasslands and short-grass prairies, with sagebrush and juniper thickets, to riparian zones characterized by cottonwoods and willows. Dense coniferous forest stands of Douglas-fir, ponderosa pine, lodgepole pine, and Engelmann spruce are also used. In all habitats, the bobcat needs cover and structural complexity not only for hunting but also for protection of nursery dens.

Diet and Foraging Activity: Rabbits and hares make up a majority of the diet, although other small mammals such as voles and mice (family Muridae) are eaten. Where prairie dogs (*Cynomys* spp.) are abundant in the north-central portion of the state, they are actively sought. Ground-nesting bird species, such as grouse and pheasant, are also eaten. The hunting strategy of this species is to wait patiently next to a game trail or a prairie dog colony for an animal to appear. A quick pounce is usually all that is required to dispatch the unsuspecting prey.

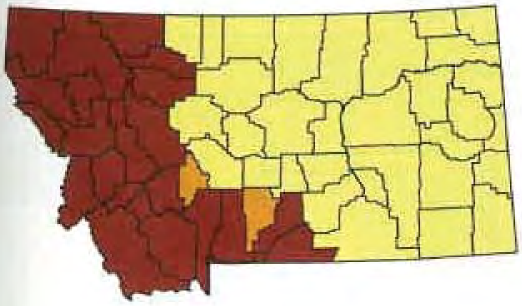
Most activity is nocturnal, although early morning and evening movements are common.

the long coat and bushy tail. Lastly, the fisher (*Martes pennanti*) is black in color with a white throat patch and is three to five times bigger than the American marten. Skull characteristics can also be used to separate these species.

DISTRIBUTION

Tightly associated with boreal forests and, as such, occurs across the northern region of North America from Alaska through the Canadian provinces, with southern extensions through Washington, Oregon, and California, and along the Rocky Mountains to Colorado and New Mexico. Populations also occur in northern regions of Maine, Vermont, New York, and Minnesota; reintroduction efforts are occurring in Wisconsin and Michigan, some using Montana individuals. Occurs in forested regions of western Montana.

Tail length ♂ 7.4 in (18.7 cm)/♀ 6.7 in (17.0 cm)
Hind foot ♂ 3.3 in (8.4 cm)/♀ 3.0 in (7.7 cm)
Track size (l x w) Front 2.1 x 2 in (5.3 x 5 cm)
Hind 2.3 x 2.1 in (5.8 x 5.3 cm)
Ear ♂ 1.6 in (4.2 cm)/♀ 1.3 in (3.4 cm)
Weight ♂ 1.9 lb (880 g)/♀ 1.3 lb (568 g)
Status Common; classified as a furbearer, with a trapping season in December. In 2009/2010, an estimated 962 individuals were harvested.



ECOLOGY AND BEHAVIOR

Habitat Preference: The American marten is one of the most common midsize forest carnivores in northern North America. Although populations have been reduced by loss of habitat and heavy trapping, the American marten is still common, particularly in western Montana. Mesic coniferous forests dominated by subalpine fir, Douglas-fir, and lodgepole pine support the American marten in Montana, particularly stands at late successional stages. Structural complexity at ground level is important for protection, thermal cover, and habitat for prey species. Such cover (shrubs and coarse woody debris that develops from forest decay) is more abundant in older stands. Martens live in talus fields above tree line, but these individuals probably need access to the forested interface.

Diet and Foraging Activity: Martens are dietary generalists, eating a wide variety of vertebrates and plant materials and having distinct seasonal preferences. In spring and summer, small mammals, birds (as well as nestlings and eggs), and insects make up most of the diet. Berries and fruits are eaten as they form in autumn (huckleberry and raspberry are especially preferred). In winter, foraging occurs under the snow in the space provided by complex ground cover. Here martens feed predominantly on voles and mice (in particular the southern red-backed vole [*Myodes gapperi*], montane vole [*Microtus montanus*], and meadow vole [*M. pennsylvanicus*], and the deer mouse [*Peromyscus maniculatus*]). Snowshoe hares (*Lepus americanus*) and red squirrels (*Tamiasciurus hudsonicus*) are also important winter prey. In Montana, nearly 74 percent of scats contained mice and voles, while 12 percent contained squirrels.

American martens are active throughout the year, with a diurnal pattern during summer months and a nocturnal pattern during winter. While foraging, animals investigate any structure that may hide prey. They move rapidly across their home range, using downed logs as runways and periodically stopping to poke into crevices and brush piles.

Dens: The physical structure of older-aged forested stands provides natal and maternal den sites as well as resting sites. Trees, logs, snags, and rock outcroppings are most commonly used. Natal sites, those in which birth occurs, are often in tree cavities in locations with more cover than those chosen for maternal sites. Maternal dens, where kits are raised, are generally

ity of their pelts. Commercial mink farms are still widely found throughout the United States, with several in Montana. Such operations often selectively breed and raise more than ten thousand animals per year, adjusting the pelt color of their stock to accommodate the commercial market. Most fur raised in this country supplies the European market.

Total length ♂ 23.3 in (59.2 cm)/♀ 18 in (45.7 cm)

Tail length ♂ 7.5 in (19.0 cm)/♀ 5.3 in (13.4 cm)

Hind foot ♂ 2.7 in (6.9 cm)/♀ 2.0 in (5.1 cm)

Track size (lxw) Front 1.7 x 1.8 in (4.2 x 4.4 cm)
Hind 1.8 x 1.9 in (4.5 x 4.8 cm)

Ear ♂ 0.9 in (2.2 cm)/ ♀ 0.8 in (2.0 cm)

Weight ♂ 2.4 lb (1.1 kg)/ ♀ 1.0 lb (0.45 kg)

Status Common and locally abundant; classified as a furbearer. Even with a reduced fur market, an estimated 584 animals were harvested in the 2009/2010 season.

HOME RANGES

Mink are not social, preferring to live alone except during the breeding season although home ranges may overlap. Males range more widely than females. Home range size is a function of habitat quality. Along the Madison River, males may travel up to 3 miles (4.9 km) across their home range. Minimum home ranges for two females were 0.03 and 0.09 mi^2 (0.08 and 0.24 km^2). Males from a wetland in Manitoba had an average home range of 2.5 mi^2 (6.5 km^2). Traveling from one end of a home range this large to the other end may require several days, and animals will shelter in dens throughout their home range. Populations may be locally abundant. One 13-square-mile (33.6 km^2) area near Three Forks, Montana, had 280 individuals.

and crayfish are heavily used, particularly during winter. In open prairie habitats, waterfowl may make up over 50 percent of the diet, and other birds, including grebes and coots, may be taken. Food is most often taken back to the den for consumption.

Mink, like other mustelids, remain active all year, foraging primarily at night. Frequent activity may also occur at dawn or dusk. The dense winter underfur of mink greatly enhances the trapping of air and provides increased insulation. During winter, foraging in water is limited to the pursuit of prey after detection from above water. Retention of an air layer, shunting of blood away from the surface, and elevated metabolic heat production help to maintain the animal's core body temperature during foraging.

Dens: Dens are located in log or rock piles, often close to ponds, streams, or marshes. Muskrat dens are used as well, often after the occupants are eaten. These dens have several entrances. Nests are constructed of leaves, grass, and the fur and feathers of prey.

REPRODUCTION

In Montana, breeding extends from late February through early April, with a peak in March. This variation is influenced by temperature, photoperiod, and the date of mating. Females often mate again with a different male six to eight days after their first mating, and the subsequent litter produced will have been sired by two males. Young are born in April or early May. Sexual maturity is attained the following spring, at ten months.

SCIENTIFIC DISCOVERY

First described by Johann C. D. von Schreber in 1777 from a type specimen obtained in eastern Canada. The scientific name applied at this time is still in use today. The genus, *Mustela*, is Latin for "weasel." The species, *vison*, is of either Icelandic or Swedish origin, a term also meaning "marten" or "weasel." The common name is thought to have originated from the Swedish word *maenk*.

Gestation length 40 days (up to 75 days if delayed implantation occurs)

Litters/year 1

Average litter size 3–5

Weaning 5–6 weeks

The muskrat constructs canals around its home range that connect its lodges and provide access to deeper water. The canals can breach dikes and drain farm ponds and other impoundments, requiring management and control of this species.

Total length	18.1–21.4 in (46.0–54.3 cm)
Tail length	8.7–9.3 in (22.2–23.7 cm)
Hind foot	3.0 in (7.5 cm)
Ear	0.6–0.8 in (1.6–2.1 cm)
Weight	2.0–2.1 lb (913–962 g)
Status	Common. Listed as a furbearer; an estimated 12,754 individuals were harvested in 2009/2010, down considerably from the more than 40,000 individuals trapped in 1987, when market prices for fur were higher.

Diet and Foraging Activity: Muskrats are primarily herbivorous, feeding both in late afternoon and late evening on the more common aquatic plants available at any given location. Roots and stems of cattails and bulrush are highly used, although many other plants such as sedges and arrowheads will suffice. Muskrats also eat a large variety of animals, including frogs, fish, freshwater clams, snails, and crayfish.

Nests and Dens: Houses, formed aboveground from available vegetation, typically cattail and bulrush, are of two common types. The most familiar is the dwelling lodge, much the same in appearance as the beaver lodge, although considerably smaller in size. In winter, these lodges are 3.3 to 6 feet (1–2.5 m) in length, 3 to 6 feet (0.9–2.5 m) in width, and 1.3 to 3 feet (0.4–1 m) high, with walls averaging 19 inches (48 cm) in thickness; summer lodges are 12 to 30 percent smaller, with walls half as thick. These lodges have one central chamber (although up to three chambers may be formed in the winter and up to seven in the summer) and are entered from below waterline by one or more tunnels. A second type of house, called the pushup, is typically constructed by pushing submerged aquatic vegetation such as pondweed up into ice cracks, forming a dome above the ice. These pushups and more elaborate feeder lodges are built around and radiate from the main dwelling lodge during winter. These foraging lodges are positioned at distances from the main dwelling lodge that approximate the optimal distance that the muskrat can swim under the ice pack. These way stations allow the animals to forage over a relatively large area during the winter, in relative safety from predation, with only short, periodic forays into cold water.

Muskrat foraging on bank

Tail length ♂ 10.2 in (26.0 cm)/♀ 8.5 in (21.5 cm)

Hind foot ♂ 4.7 in (12.0 cm)/♀ 4.6 in (11.9 cm)

Track size (l x w) Front 2.5 x 2.5 in (6.3 x 6.3 cm)
Hind 4 x 2.3 in (10 x 5.8 cm)

Ear ♂ 2.5 in (6.2 cm)/♀ 2.1 in (5.3 cm)

Weight ♂ 15.6 lb (7.1 kg)/♀ 11.9 lb (5.4 kg)

Status Common; classified as a furbearer. In the 2009/2010 trapping season, an estimated 2,626 individuals were harvested.

and grasslands of the east. In the east, they are found in rock coulees, wooded draws, upland croplands, and along hardwood riparian zones of the Yellowstone and Missouri rivers.

Diet and Foraging Activity: The raccoon is omnivorous and will eat berries and nuts, commercial crops such as corn and orchard fruits, aquatic invertebrates (crayfish, snails, and clams), fish, birds, small mammals, and insects. Foraging begins at sunset and continues throughout the night, with animals retreating to resting dens at sunrise. Predation by raccoons on waterfowl, their eggs, and nestlings, may account for significant mortality on refuges such as Ninepipe National Wildlife Refuge in western Montana. Raccoons do not have a strong social structure but will accommodate one another and move together when visiting locally abundant food sources.

Raccoons may wash their food before they eat it, although this behavior may also serve to identify various parts of prey, such as the claws of crayfish. Four digits are highly dexterous and finger activity occurs even when no food is being manipulated.

Dens: Den sites, several in number, may occur in rock crevices, abandoned marmot burrows, caves, or hollow trees. When threatened, raccoons seek refuge in trees. Individuals most often den alone during summer and autumn but may share dens in winter. In fact, twenty-three individuals shared the cellar of an abandoned house. Sharing dens enhances winter survival by allowing individuals to share body heat. Raccoons do not undergo torpor and maintain high body temperatures while resting for extended periods during severe cold spells.

REPRODUCTION

Breeding in Montana probably extends from January into late spring. Young are born from March into early summer.

Gestation length 63 days

Litters/year 1

Average litter size 2-5

SCIENTIFIC DISCOVERY

First described by Carl Linnaeus in 1758 from a type specimen obtained in Pennsylvania. Originally identified as *Ursus lotor* because it resembles a bear, this species was reassigned to the genus *Procyon* by Gottlieb C. C. Storr in 1780. The genus, *Procyon*, is from Greek *pro*, meaning "before," and *kyon*, meaning "like a dog," an origin not clearly understood. The species, *lotor*, is Latin for "a washer," referring to its perceived habit of washing its food before eating.

Baby raccoon navigating its new environment mals were reintroduced by the Blackfeet Nation on the Blackfeet Indian Reservation (Glacier County) and additional animals were reintroduced on the Fort Peck Reservation between 2006 and 2010.

ECOLOGY AND BEHAVIOR

Total length 31 in (78.2 cm)

Tail length 10.6 in (27.0 cm)

Hind foot 4.9 in (12.6 cm)

Track size (l x w) Front 1.1 x 1.6 in (2.7 x 4.0 cm)
Hind 1.1 x 1.3 in (2.5 x 3.3 cm)

Ear 2.5 in (6.3 cm)

Weight 5.3 lb (2.5 kg)

Status Species of Concern; rare. The decline of the swift fox had multiple causes: extermination programs oriented toward coyotes and wolves using indiscriminate poison bait sets, heavy trapping pressure in the 1800s, loss of habitat with human westward expansion, and coyote-swift fox incompatibility. Recent changes in coyote control programs and return of the land to native habitat, with the decline of homesteads and small ranches, may be responsible for the observed increases. Swift fox probably survived in isolated pockets in many parts of its historical range. The swift fox is just now making a comeback as a result of reintroductions in Canada, Montana, and South Dakota.

Habitat Preference: When Meriwether Lewis first observed the swift fox on July 6, 1805, he was quite impressed: "There is a remarkable small fox which associate in large communities and burrow in the praries something like the small wolf [coyote] but we have not as yet been able to obtain one of them; they are extremely watchfull and take reffuge in their burrows which are very deep; we have seen them now where except near these falls [the Great Falls of the Missouri in Great Falls, Montana]" (Moulton 1987b:364). Two days later, on July 8, Lewis provided a more detailed description, saying: "they are very delicately formed, exceedingly fleet, and not as large as the common domestic cat. their tallons appear longer than any species of fox I ever saw and seem therefore prepared more amply by nature for the purpose of burrowing" (Moulton 1987b:367). Lewis was remarkably perceptive, recognizing not only that this was a new species unknown to science at the time, but that it was an adept burrower closely tied ecologically to the prairies.

Exposed sites on hilltops and slopes in cultivated fields or short-grass prairies are preferred, although heavily grazed sites devoid of shrubs are also used. Dominant vegetation is buffalo grass and blue grama and cultivated fields of winter wheat and alfalfa.

Diet and Foraging Activity: The diet consists of small mammals, birds, reptiles, and invertebrates heavily weighted toward small mammals. Analyses of stomach contents identified lagomorphs, such as the black-tailed jackrabbit (*Lepus californicus*) and cottontail (*Sylvilagus* spp.), most frequently. Deer mice (*Peromyscus maniculatus*), western harvest mice (*Reithrodontomys megalotis*), and pocket mice (*Perognathus* spp.) were also significantly represented, as were songbirds and quail. Most activity is nocturnal, although during cold periods swift foxes are active at midday, sunning themselves at the den entrance.

As the common name implies, this species is indeed very swift, appearing to float across the prairie as it runs. This swiftness is needed to capture its prey and to avoid being preyed upon by hawks and coyotes.

Den Sites: No other North American canid is as strongly subterranean. Elaborate dens are constructed with up to nine entrances and a tunnel system often greater than 3 feet (1 m) in depth and 3 feet (1 m) in length. One report describes a tunnel over 15 feet (4.6 m) long, although most are shorter. Entrances are 7.9 inches (20 cm) in diameter, suggesting that the swift fox does not take over abandoned badger (*Taxidea taxus*) or coyote dens. Dens are often clustered together in groups of three to as many as thirteen. They are used throughout the year, may be maintained by an individual for extended periods, and are often further modified by successive generations.

and voles (family Muridae), and porcupines (*Erethizon dorsatum*). Insects and numerous plant materials have also been found in scat samples. As deepening snows reduce food abundance at higher elevations, wolverines move down in search of carrion. Scat analyses from populations in Montana and Idaho showed that 80 percent and 74 percent, respectively, contained ungulate material, primarily elk (*Cervus elephus*), deer (*Odocoileus* spp.), and caribou (*Rangifer tarandus*).

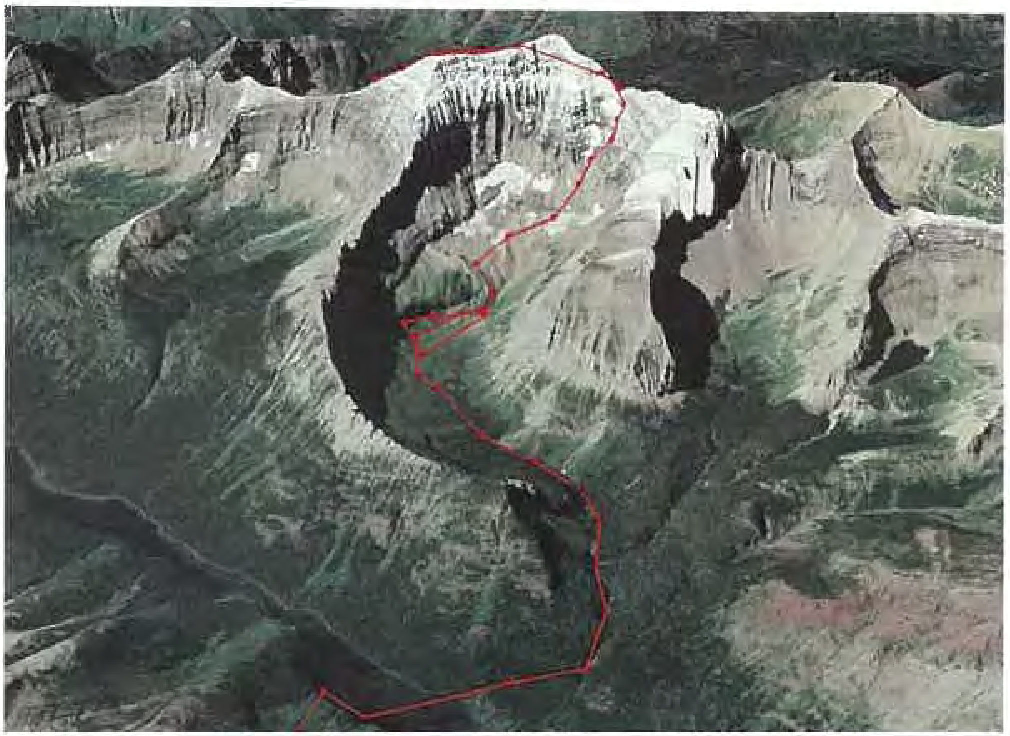
Wolverines are nomadic in behavior, traveling widely across the landscape in search of food or, during the breeding season, potential mates. Activity may be primarily nocturnal, or more irregular, with animals alternating between rest and activity throughout the day. Use of remote sensing cameras by the author documented wolverines in the Bitterroot Mountains twice and at the base of the Rattlesnake Mountains once, all three incidents occurring during daylight hours.

HOME RANGES

Movement patterns and home range sizes are influenced by terrain, weather, season, and habitat quality. Average daily movements in central Idaho ranged from 2.1 to 4.9 miles (3.4–7.9 km). Maximum movements over a three-day period in western Montana were 39.8 miles (64 km) for males and 23.6 miles (38 km) for females. Male wolverines in Glacier National Park routinely travel more than 93 miles (150 km) in a week. Mean yearly home range size for males was 163 mi^2 (422 km^2) in western Montana, 201 mi^2 (521 km^2) in Glacier National Park, and 803 mi^2 (2,079 km^2) in Idaho; for females these values were 150 mi^2 (388 km^2), 54 mi^2 (139 km^2), and 163 mi^2 (423 km^2), respectively.

Dens: Females use two types of den, natal dens where kits are born and maternal dens where kits are reared. Both are formed by natural cavities created by downed trees (whitebark pine or subalpine fir) or within boulder fields. Both den types are always under a layer of snow 6.5 to 10 feet (2–3 m) deep that persists until late spring. Natal dens are entered in late February; young may be moved to several different maternal dens over the next nine to ten weeks.

Social Structure: Though, as with most mustelids, the wolverine has been considered solitary, recent research in Idaho and Glacier National Park suggests that it may be more social. Siblings may travel with their mother, and once juveniles separate from their mother they may come in contact with their father and travel together. Adult males and females only associate during the breeding season; females will remain with their kits during the first summer following their birth. No well-defined pattern of territoriality occurs. On the contrary, the wolverine's foraging strategy (scavenging) and requisite large home range preclude its ability to maintain a strict territory.



The path of a radio-collared male wolverine that climbed out of the Mokowanis River valley and summited Mt. Cleveland in Glacier National Park in ninety minutes, an elevational change of nearly 5,000 feet (1,524 m)

Incidental Captures in Montana 2009-2014 license years.

	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Bobcat	2	2	3	7	4	1
Domestic Dog					28	30
Deer				1	1	
Elk					1	
Fisher	2	1		1		1
Grizzly					3	
Wolf				2	1	
Lynx				1	1	1
Marten		1	2			
Mountain Lion	9	8	8	26	26	15
Otter	8	1	7	9	11	2
Raptor				1	2	2
Swift Fox		2		2		1
Wolverine					2	2
Total	**21**	**15**	**20**	**50**	**80**	**55**

Table G. Animals Taken by Component/Method Type and Fate by Wildlife Services in Montana - FY2014

Capture / Restraint Method ^	Intentional / Unintentional	Species	Killed / Euthanized	Removed/ Destroyed	Freed / Released / Relocated	Dispersed
Drc-1339-Feedlots						
	Intentional					
		Starlings, European	40			
Drc-1339-Livestock/Nest/Fodder						
	Intentional					
		Ravens, Common	189			
Drc-1339-Pigeons						
	Intentional					
		Pigeons, Feral (Rock)	50			
Firearms						
	Intentional					
		Badgers	1			
		Bears, Black	5			
		Coyotes	876			
		Crows, American				5
		Doves, Mourning	50			1,180
		Ducks, Mallards	4			16
		Falcons, American Kestrels				9
		Foxes, Red	1			
		Geese, Canada	2			4
		Geese, Snow, Lesser				7

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^About Capture/Restraint Method: This column reports the primary method or tool used to capture, restrain, or identify/target the animals addressed. This MAY NOT have been the method or tool used to kill, euthanize, or free/relocate, the animal captured. When animals are captured and/or restrained, WS employees use methods or tools to euthanize, and approved handling and transport are used to free or relocate.

Table G. Animals Taken by Component/Method Type and Fate by Wildlife Services in Montana - FY2014

Capture / Restraint Method ^	*Intentional / Unintentional*	*Species*	*Killed / Euthanized*	*Removed/ Destroyed*	*Freed / Released / Relocated*	*Dispersed*
Firearms						
	Intentional					
		Gulls, Ring-Billed	4			1
		Hawks, Harrier, Northern (Marsh Hawks	1			33
		Hawks, Red-Tailed	1			89
		Hawks, Swainson`s	2			26
		Herons, Great Blue				2
		Larks, Horned				18
		Lions, Mountain (Cougar)	2			
		Magpies, Black-Billed	10			192
		Meadowlarks, Western	2			125
		Pigeons, Feral (Rock)	228			
		Rabbits, Cottontail	2			
		Ravens, Common	5			8
		Robins, American				3
		Sparrows, House/English	1			
		Squirrels, Ground, Richardson`s	868			396
		Starlings, European	55			1,545
		Vultures, Turkey				13
		Wolves, Gray/Timber	13			
Fixed Wing						

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Capture / Restraint Method ^	Intentional / Unintentional	Species	Killed / Euthanized	Removed/ Destroyed	Freed / Released / Relocated	Dispersed
	Intentional					
		Coyotes	604			
		Wolves, Gray/Timber	3			
Gas Cartridge, Large						
	Intentional					
		Coyotes	1			
		Coyotes (Burrow/Den)		24		
		Foxes, Red (Burrow/Den)		13		
Helicopter						
	Intentional					
		Coyotes	2,180			
		Foxes, Red	11			
		Wolves, Gray/Timber	25		2	
M-44 Cyanide Capsule						
	Intentional					
		Coyotes	418			
		Foxes, Red	11			
	Unintentional					
		Foxes, Red	1			
Pyrotechnics (All)						
	Intentional					
		Falcons, American Kestrels				4

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Pyrotechnics (All)						
	Intentional					
		Hawks, Red-Tailed				14
Snares, Foot/Leg						
	Intentional					
		Bears, Black	5			
		Bears, Grizzly			4	
		Lions, Mountain (Cougar)	2			
Snares, Neck						
	Intentional					
		Badgers	3			
		Bobcats	1			
		Coyotes	539			
		Foxes, Red	41			
		Lions, Mountain (Cougar)	2			
		Rabbits, Cottontail	4			
		Raccoons	4			
		Skunks, Striped	2			
	Unintentional					
		Badgers	1			
		Deer, White-Tailed (Wild)	1			

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Table G. Animals Taken by Component/Method Type and Fate by Wildlife Services in Montana - FY2014

Capture / Restraint Method ^	*Intentional / Unintentional*	*Species*	*Killed / Euthanized*	*Removed/ Destroyed*	*Freed / Released / Relocated*	*Dispersed*
Snares, Neck	Unintentional	Foxes, Red	1			
		Porcupines	1			
		Pronghorns (Antelope)			1	
		Skunks, Striped	1			
Traps, Cage	Intentional	Lions, Mountain (Cougar)	2			
		Skunks, Striped	1			
	Unintentional	Bears, Black			1	
Traps, Culvert	Intentional	Bears, Black	1			
		Bears, Grizzly			2	
Traps, Decoy	Intentional	Vultures, Turkey	22			
Traps, Foothold	Intentional	Badgers	2			

^About Capture/Restraint Method: This column reports the primary method or tool used to capture, restrain, or identify/target the animals addressed. This MAY NOT have been the method or tool used to kill, euthanize, or free/relocate, the animal captured. When animals are captured and/or restrained, WS employees use methods or tools to euthanize, and approved handling and transport are used to free or relocate.

Table G. Animals Taken by Component/Method Type and Fate by Wildlife Services in Montana - FY2014

Capture / Restraint Method ^	Intentional / Unintentional	Species	Killed / Euthanized	Removed/ Destroyed	Freed / Released / Relocated	Dispersed
Traps, Foothold						
	Intentional					
		Cats, Feral/Free Ranging	1			
		Coyotes	128			
		Foxes, Red	21			
		Lions, Mountain (Cougar)	4			
		Porcupines	1			
		Skunks, Striped	16			
		Wolves, Gray/Timber	6		13	
	Unintentional					
		Badgers	1		1	
		Bears, Black			2	
		Domestic Animal (Pet Or Livestock)			1	
		Lions, Mountain (Cougar)			1	
Vehicles (All)						
	Intentional					
		Eagles, Bald				7
		Total Take for MT	6,480	37	28	3,697

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^About Capture/Restraint Method: This column reports the primary method or tool used to capture, restrain, or identify/target the animals addressed. This MAY NOT have been the method or tool used to kill, euthanize, or free/relocate, the animal captured. When animals are captured and/or restrained, WS employees use methods or tools to euthanize, and approved handling and transport are used to free or relocate.

Trapper Education Manual

A Guide for Trappers in the United States

Safety - Animal Welfare - Responsibility - Furbearer Conservation

Acknowledgements

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Hundreds of individuals have contributed to the development of the IAFWA Trapper Education Program. Most state and provincial wildlife agencies provided copies of their trapper education materials for review. Many agency personnel provided comments on materials, answered questions, ran pilot courses, or helped in other ways. Many trappers, including members of the National Trappers Association and the Fur Takers of America also contributed. Special thanks go to the Ohio Division of Wildlife, the Ohio State Trappers Association, Hal Sullivan, Pat Howard, and Doug Wilson.

Members of the steering committee spent many hours reviewing documents, attending meetings, and providing advice as the program developed over two years. Committee members include: Tom Decker, Vermont Fish and Wildlife Department; Steve Hall, Texas Parks and Wildlife Department; Susan Langlois, Massachusetts Division of Fisheries and Wildlife; Eric Nuse, International Hunter Education Association; John Organ, U.S. Fish and Wildlife Service; Judy Stokes, New Hampshire Fish and Game; and Rick Tischaefer, Trapper Education Consultant, North Dakota.

Samara Trusso, Program Manager of the IAFWA, coordinated the development of the Trapper Education Program. The materials were developed through a contract with Silvertip Productions, Ltd. Jim Wentz of Silvertip served as the primary author of the documents.

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Trapper Education Manual

Table of Contents

Chapter 1

Introduction to Trapper Education

Content Standard - *Students demonstrate an understanding of the purpose of trapping and trapper education in today's society*

Ohio DOW Photo

Introduction

Trapping is part of our North American heritage. First-time trappers in many states and Canadian provinces must complete a trapper education program covering skills, regulations, and trapping's role in scientific wildlife management. Trapper education programs teach basic techniques with a strong focus on the responsible treatment of animals, legal methods, safety, selectivity, and ethical trapper behavior.

This Trapper Education Program was developed by the International Association of Fish and Wildlife Agencies (IAFWA). The Association represents professionals from the fish and wildlife agencies of the states, provinces, and federal governments of the U.S. and Canada. The program was developed to:

Trapping benefits Society

- protect the health, safety, and welfare of people, wildlife, and domestic animals
- support wildlife conservation programs that sustain species and ecosystems for the benefit of future generations
- increase the benefits society currently receives from regulated trapping activities

Trapping is highly regulated

Recognize that the decision to become a trapper represents a serious commitment of time and dedication to responsible behavior

Trapping is a highly regulated activity because the public is concerned about wildlife conservation and the welfare of wild animals. Regulations are designed to help manage furbearing animals using safe and selective equipment and techniques.

Trapping is a highly engaging, year-round activity

Trapping takes a lot of time and dedication. Trappers spend time studying wildlife, scouting, preparing traps, working with landowners, setting traps, running traplines, and preparing pelts. When trapping season starts, trappers must check the traps every day until they are removed.

Society, trappers and non-trappers alike, will not accept illegal or unethical behavior. This course can teach you the basics. You must be willing to spend the time and effort to trap responsibly.

Illegal or unethical behavior is not acceptable. Show respect for wildlife, people, and property

Ohio DOW Photo

List five positive or negative values of furbearers including ecological, biological, cultural, aesthetic, and economic values

Today fur products and trapping are still of cultural and economic importance. Furbearers continue to be used and managed as valuable, and renewable, natural resources.

Values associated with furbearers:

- Economic - Positive values includes furs, meat, and by-products such as perfume and fishing lures. Examples of negative values include crop depredation, property damage, and flooded roads.
- Ecological - Furbearers have positive value as predators and prey in functioning ecosystems. Excessive numbers of furbearers can have negative values if they harm habitats or prey on endangered animals.
- Cultural - Trapping is valued by many people as part of their cultural heritage. Trapping involves outdoor skills, knowledge and respect for wildlife, and family activities. Some people look to nature or the land to provide vegetables, firewood, venison, and furbearers. Trapping provides these people with needed food and clothing.
- Biological - Furbearers have positive values that help us understand human health and the effects of environmental pollutants. Negative biological values include human exposure to disease and parasites.
- Aesthetic - Furbearers have many positive aesthetic values for fur and wildlife watching.

Farmers who have crop damage will often give you permission to trap

Trapping is a way of life for many people

Silvertip Productions

Rabies and tularemia are two of the diseases humans may get from furbearers

Wetland habitats are home to hundreds of species of wildlife

FWS Photo

Whooping Crane

When voters restricted trapping in Massachusetts in 1996 landowner beaver complaints doubled

Trappers have helped restore river otter populations in 19 states - visit www.convservewildlife.org

A US Fish and Wildlife Service survey revealed 487 wildlife management programs that involved trapping on 281 National Wildlife Refuges

FWS Photo

List a minimum of four benefits regulated trapping provides to society

Responsible trappers provide these benefits to society:

- Disease Control - When trappers reduce local furbearer populations it helps reduce the spread of diseases among animals and people.
- Habitat Protection - When furbearers overpopulate they can destroy habitat. For example, the harvest of nutria in Louisiana helps protect 3.6 million acres of coastal wetlands.
- Endangered Species Protection - Foothold traps help protect many rare and endangered species from predators. Examples include the desert tortoise, sea turtles, whooping cranes, black-footed ferrets, and piping plovers.
- Property Protection - Farmers and other landowners benefit when trappers remove excess furbearers that threaten property and crops.
- Wildlife Restoration - Trappers use foothold traps to harmlessly capture species such as river otters in states where they are plentiful so they can be released in other states to re-establish populations.
- Wildlife Research - Foothold traps and cable devices are the only effective means for catching elusive species such as wolves, coyotes, and foxes. Wildlife biologists depend on traps and trappers to help study many species of wildlife.

Choose correctly that trapping is an individual privilege, not an individual right

In most states, trapping is an individual privilege available to all citizens who choose to follow regulations and behave responsibly. Trappers who violate laws can lose their privilege to trap. If trappers as a group do not behave responsibly, citizens could decide to stop all trapping.

Some states have made it a collective right to hunt, fish, and trap. This protects the activity of trapping for future generations. It does not protect trapping privileges for people who violate trapping regulations. Judges can, and do, suspend trapping privileges for serious violations.

Identify a minimum of two state or national trappers associations that provide materials and continuing education for trappers

Trappers have formed state and national organizations to help address issues related to trapping and furbearer management. Two national groups include the National Trappers Association and the Fur Takers of America.

The National Trappers Association (NTA) has the following purpose statement:

- To promote sound conservation, legislation, and administrative procedures;
- To save and faithfully defend from waste the natural resources of the United States;
- To promote sound environmental education programs; and
- To promote a continued annual fur harvest using the best tools presently available for that purpose.

The Fur Takers of America (FTA) has the following purpose:

- To promote interest in and accumulate and disseminate knowledge concerning the trapping of fur bearing animals among persons interested therein.

You can find out more about the NTA and FTA at their Web sites:

- http://www.nationaltrappers.com/
- http://www.furtakersofamerica.com/

The Web sites also link to state trapping associations, online bulletin boards, and other helpful organizations.

Write the name of your state trapping association here:

____

There are many benefits to membership in trapping organizations. You will learn new techniques to become more successful, be invited to meetings and other activities, gain a greater understanding of wildlife management, and learn about issues affecting trapping.

Organized trappers, hunters, and anglers have supported fish and wildlife conservation programs for more than 100 years

Membership in state and national trapping organizations will help you become a more successful and responsible trapper

FWS Photo

Arctic Fox

Online bulletin boards for trappers are a good way to learn new techniques and solve problems. Post a question, and get answers from friendly, experienced trappers.

Introduction to Trapper Education

Know the legal types of traps that may be used in your state

In other chapters you will learn more about trap types and trapping techniques. Foothold traps, for instance, are live-restraining devices, but they can be used in “submersion” sets to kill aquatic furbearers

Each state regulates the types of traps that are legal. States consider animal welfare, efficiency, selectivity, and safety when they select legal traps.

Deadfalls and many types of traps, including traps with teeth, are prohibited. Legal traps fall into two categories known as kill-type, and live-restraining devices. Put a check mark beside the traps that are legal to use in your state.

State: __________________ Year: ___________________

Submarine or Colony Trap trap for multiple muskrats

Ohio DOW Photo

Basic Trap Types	Legal
Foothold Traps	
Body-gripping Traps	
Cable Devices	
Cage traps	
Traps with teeth	
Deadfalls	
Other	

Trapping technology and techniques have shown continuous improvement for nearly 200 years

Name the species of furbearers that inhabit your state

Raccoons and coyotes are widely distributed in the U.S.

Eyewire.com

Raccoon

FWS Photo

Coyote

The following species are known as furbearers in North America. Some of these species will not be present in your state. Even if a species is present there may be no open trapping season for it in your state.

Place a check in the box on the following chart to indicate if a species is present, and if there is an open trapping or hunting season for it in your state. Use your state hunting and trapping regulations brochure to find this information.

Species	Present	Open Season
Coyote		
Red Fox		
Gray Fox		
Gray Wolf		
Swift/Kit Fox		
Arctic Fox		
Beaver		
Muskrat		
Nutria		
Bobcat		
Canada Lynx		
Mink		
River Otter		
Fisher		
Marten		
Weasels		
Striped Skunk		
Badger		
Opossum		
Raccoon		
Ringtail - Bassarisk		
Wolverine		
Other:		

Nutria FWS Photo

Gray Fox FWS Photo

Even though a furbearer is present within your state, it may be restricted to specific habitats within a certain range

State wildlife agencies prohibit the taking of any species if it would harm the long-term sustainability of the population

Responsible trappers care about wildlife conservation and animal welfare

Nutria were introduced from South America. They are found in the gulf coast states, parts of the east coast, Washington and Oregon.

The gray fox is common in many parts of the country

Introduction to Trapper Education

Know that the Trapper Education Course is based on Best Management Practices developed by wildlife biologists, trappers, and researchers

State fish and wildlife agencies, trapping organizations, veterinarians, and university researchers help develop Best Management Practices (BMPs) for regulated trapping in the United States.

FWS Photo

River Otter

Trapping BMPs are documents that provide information to help trappers practice safe, humane, and efficient techniques. BMPs describe different types of traps, how they work, how traps should be set, and what training may be needed for people who use BMP traps.

Five criteria are considered when developing BMPs:

- Animal welfare
- Trap efficiency
- Trap selectivity
- Trapper & public safety
- Practical application

Silvertip Productions

Opening Day

BMPs provide guidance to wildlife agencies and help responsible trappers make decisions in the field.

Chapter 5

Best Management Practices

Content Standard - *Students understand Best Management Practices for Trapping are needed to address animal welfare, trapping efficiency, selectivity, and safety in furbearer management programs*

Trapping BMPs

Sustaining the Future of Trapping

Eyewire.com

Raccoon

Introduction

In 1996, the International Association of Fish and Wildlife Agencies began a program to develop Best Management Practices (BMPs) for trapping as a way to improve the welfare of captured animals, and to document improvements in trapping technology. This project is one of the most ambitious in the history of the conservation movement.

BMPs are necessary to sustain regulated trapping as a wildlife management tool, and to maintain the integrity of wildlife conservation programs throughout the United States.

All 50 state fish and wildlife agencies support the development of best management practices

State the name of the organization that coordinates development of best management practices for trapping

32 state fish and wildlife agencies have been actively involved with the BMP program

The International Association of Fish and Wildlife Agencies (IAFWA) coordinates the development of BMPs for trapping. IAFWA's membership includes all 50 state fish and wildlife management agencies, federal agencies, and conservation organizations.

Trappers, veterinarians, and university researchers helped wildlife agencies evaluate more than 70 types of traps

State furbearer biologists, veterinarians, trappers, and scientists from the University of Georgia and the University of Wyoming cooperated on the development of BMPs. The United States Department of Agriculture provided most of the funding for Trapping BMP research and development.

Explain that BMPs are based on scientific information and professional experience about current traps and trapping technology

BMPs are based on the most extensive research effort of animal traps ever conducted in the United States. Traps tested were selected based on knowledge of commonly used traps, previous research, and input from expert trappers.

Wildlife veterinarians examined thousands of trapped furbearers for different types of injuries

Eyewire.com

Recognize that the Trapping BMP Project is designed to provide wildlife management professionals in the United States with the data necessary to assist in improvements to animal welfare in trapping programs

Trapping BMPs were developed to give wildlife professionals information they need to improve animal welfare. State fish and wildlife agencies will use BMPs to continue the improvement of trapping systems throughout the United States.

More than 150 teams of trappers and technicians participated in field testing

Each state wildlife agency decides how to incorporate Best Management Practices into trapper education and furbearer management programs

Recognize that trapping BMPs are intended to be a practical tool for trappers and wildlife biologists to use for decision-making in the field

Trapping BMPs include suggestions on practices, equipment, and techniques that will provide trappers and wildlife biologists with practical information to use in the field. These suggestions will improve animal welfare, help avoid the unintended capture of other animals, and increase public support for trapping,

BMPs are valuable tools for biologists and trappers

BMP recommended traps resulted in no, little, or moderate injury to at least 70% of the animals trapped

Identify BMP criteria for the evaluation of trapping devices including animal welfare, efficiency, selectivity, practicality, and safety

BMP traps were evaluated using criteria to measure the effects on animal welfare as well as trapping efficiency, selectivity, practicality, and safety.

Traps that failed to capture and hold at least 60% of the species targeted did not qualify for recommendation

Animal Welfare - Researchers tested live restraining traps for injuries to furbearers using two methods. One system evaluated specific injuries, and the other grouped the injuries into categories from mild to severe. BMP approved traps must have a low rate of injuries to the furbearing animals being studied.

Recommended traps resulted in moderate, low, or no injury to at least 70% of the animals trapped.

Traps and sets must be selective

Efficiency - Traps meeting BMP criteria must be able to capture and hold at least 60% of the furbearers that spring the trap.

Experienced trappers evaluated cost, ease of use, trap weight, reliability, and other factors

Selectivity - Traps must be set and used in a fashion that limits the risk of capturing non-furbearing species while increasing the chances of capturing the desired furbearer.

Practicality - Each recommended live restraining trap was evaluated by experienced trappers and wildlife biologists for practicality. Criteria used to measure practicality include cost, ease of use, ease of transport, storage, weight and size, reliability, versatility, and the expected life-span of the trap.

Safety - Each recommended live restraining trap was evaluated for safety to the user and other people who might come into contact with the trap.


Eyewire.com

Canada Lynx

Identify where to find detailed BMP information for each furbearer

State fish and wildlife agencies have access to Trapping BMP publications as they are developed. Trappers can find all current information on Trapping BMPs at the following Web site:

- http://www.furbearermgmt.org

As new BMP information is published it is distributed by wildlife agencies, IAFWA, and trapping associations in print and online

The Furbearer Management Web site is maintained by the International Association of Fish and Wildlife Agencies on behalf of state fish and wildlife agencies, trappers, and trapping organizations.

Best Management Practices for Trapping in the United States

INTRODUCTION

ASSOCIATION of
FISH & WILDLIFE
AGENCIES

Acknowledgements

Best Management Practices (BMPs) for Trapping in the United States was written by the Furbearer Conservation Technical Work Group of the Association of Fish & Wildlife Agencies. Development of this document would not have been possible without the cooperation and participation of many state wildlife agencies, expert trappers and trapper organizations. State agency personnel provided on-the-ground coordination and supervision in those states where BMP trap testing occurred, and many agency staff members provided constructive comments on earlier drafts of this document. We thank the wildlife veterinarians at the University of Georgia, the University of Wyoming and Wildlife Health Associates who completed evaluations of captured animals.

We thank the members of trapper associations, individual trappers and technicians who took part in field-testing that supported the development of these BMPs. Their hard work and commitment to the continued improvement of trapping in the United States was an essential contribution to the success of this project. We also appreciate the involvement of the National Trappers Association from the inception of the BMP process and would like to acknowledge their continuing assistance and support.

We are indebted to the Fur Institute of Canada (FIC) for providing valuable information on the animal welfare of furbearers captured in bodygrip traps and the mechanical attributes of both bodygrip and foothold traps. Their research has provided the information needed for inclusion of many important trapping devices in the respective BMPs and would have been practically impossible to obtain otherwise.

We also extend our appreciation to the many cooperating landowners who permitted BMP trap testing to be conducted on their property. They have made a significant contribution to the future of furbearer management in the United States.

The U.S. Department of Agriculture (USDA) provided funding for trapping BMP research and development. The International Fur Trade Federation provided additional funding, and many state agencies made substantial in-kind contributions.

Mission Statement

The Furbearer Conservation Technical Work Group is composed of wildlife biologists from state fish and wildlife agencies throughout the United States. Regional representation is from the Northeast, Southeast, Midwest, West and Alaska.

The mission of the Furbearer Conservation Technical Work Group of the Association of Fish & Wildlife Agencies is to maintain the regulated use of trapping as a safe, efficient and acceptable means of managing and harvesting wildlife for the benefits it provides to the public, while improving the welfare of trapped animals.

The Association of Fish and Wildlife Agencies (AFWA), formerly the International Association of Fish and Wildlife Agencies (IAFWA), was founded in 1902. It is an organization of public agencies charged with the protection and management of North America's fish and wildlife resources. The 50 state fish and wildlife agencies, as well as provincial and territorial governments in Canada, are members. Federal natural resource agencies in Canada and the United States are also members. The Association has been a key organization in promoting sound resource management and strengthening state, provincial, federal, and private cooperation in protecting and managing fish and wildlife and their habitats in the public interest.

Credits:
Editing and Design-
Devaney & Associates, Inc.
Illustrations-Joe Goodman and
Natalene Cummings

Introduction

The purpose of the BMP process is to scientifically evaluate the traps and trapping systems used for capturing furbearers in the United States. Evaluations are based on animal welfare, efficiency, selectivity, practicality and safety. Results of this research are provided as information to state and federal wildlife agencies and trappers.

The goals of this document are:
- To promote regulated trapping as a modern wildlife management tool
- To identify practical traps and trapping techniques that continue to improve efficiency selectivity, and the welfare of trapped animals
- To provide specifications for traps that meet BMP criteria for individual species in various regions of the United States
- To provide wildlife management professionals with information to evaluate trapping systems in the United States
- To instill public confidence in and maintain public support for wildlife management and trapping through distribution of science-based information

BMPs serve as a reference guide to wildlife management agencies, conservation organizations, tribal nations, researchers, trapper organizations, individual trappers and others interested in the continued improvement of traps and trapping systems.

BMPs are intended to inform people about traps and trapping systems considered to be state of the art in animal welfare and efficiency. Through the use of BMP guidelines, trappers can continue to play an important role in furbearer management programs across the United States.

Benefits of Trapping

Trapping is a highly regulated activity. Anyone who traps must follow strict rules established and enforced by state fish and wildlife agencies. Restrictions on species that may be harvested, harvest seasons, trap types, trapping methods and areas open to trapping are some examples of the guidelines and regulations that state agencies regularly review, implement and enforce.

Trapping is an element of many wildlife management programs. In some cases, local populations of furbearers are controlled, thereby helping to minimize human-wildlife conflicts and mitigate habitat changes brought about by certain furbearer species. Similarly, trapping contributes to the protection of threatened and endangered species by controlling predators. Trapping also is used to relocate animals to and restore populations in areas where conditions are suitable for the species to thrive.

Scientists collect important ecological information about wildlife through the use of trapping. Preferred habitats, migration patterns and population indices for some species of wildlife are determined through mark and recapture programs and by monitoring regulated harvest levels. In addition, trapping can help reduce the exposure of humans and pets to rabies and other diseases. Trapping is widely recognized by the wildlife conservation community as a beneficial outdoor activity, providing food, clothing, cosmetic items, artists' supplies and other products.

Best Management Practices

Wildlife professionals, trappers and trapper associations historically have worked to improve trapping. Most of the advancements used today come from the efforts of trappers. Wildlife agencies have a long history of regulating trapping to assure that the traps and trapping systems being used are the best available. State fish and wildlife agencies must continue to take a lead role by establishing a practical and effective plan for the improvement of trapping systems in order to maintain trapping as a valuable wildlife management practice.

The BMP framework provides a structure and criteria for identifying and documenting trapping methods and equipment that will continue to improve trapping. The trapping BMP project is intended to provide wildlife management professionals in the United States with the data necessary to ensure improved animal welfare in trapping programs. Trapping BMPs are based on scientific research and professional experience regarding currently available traps and trapping technology. Trapping BMPs identify both techniques and traps that address the welfare of trapped animals and allow for the efficient, selective, safe and practical capture of furbearers.

Trapping BMPs are intended to be a practical tool for trappers, wildlife biologists, wildlife agencies and anyone interested in improved traps and trapping systems. BMPs include technical recommendations from expert trappers and biologists and a list of specifications of traps that meet or exceed BMP criteria. BMPs provide options, allowing for discretion and decision making in the field when trapping furbearers in various regions of the United States. They do not present a single choice that can or must be applied in all cases. The suggestions contained in this document include practices, equipment and techniques that will continue to ensure the welfare of trapped animals, avoid unintended captures of other animals, improve public confidence in trappers and wildlife managers, and maintain public support for trapping and wildlife management.

Trapping BMPs are recommendations to be implemented in a voluntary and educational approach. The trapping BMPs are the product of ongoing work that may be updated as additional traps are identified in the future. BMPs are intended to compliment and enhance trapper education programs. It is recommended that all trappers participate in a trapper education course. Trapping BMPs provide additional technical and practical information to help trappers and managers identify and select the best traps available for a given species and provide an overview of methods for proper use.

Criteria for Evaluation of Trapping Devices

For the purpose of developing trapping BMPs, thresholds were established by the Furbearer Conservation Technical Work Group of AFWA for several trap performance criteria. These thresholds were derived from reference standards annexed to the 1997 understanding reached between the United States of America and the European Community and with input from wildlife biologists and wildlife veterinarians involved in this effort. These thresholds provide a common framework for evaluating progress toward the use of more humane traps and trapping methods. Assessments of injury were undertaken in the furtherance of such common framework.

BMPs are based on the most extensive study of animal traps ever conducted in the United States. Test traps were selected based on knowledge of commonly used traps, previous research findings and input from expert trappers. Statisticians from universities and federal and state agencies developed rigorous study designs. Experienced wildlife biologists and trappers developed study procedures, supervised or participated in field research and provided insight and expert technical advice on trapping methods to ensure the completion of each project. Data collection, including safety evaluations, was undertaken following widely accepted international standards for testing traps specified in the International Organization for Standardization (ISO) Documents 10990-4 and 10990-5. Wildlife biologists and statisticians assisted in data analysis and interpretation during the development of this document.

Although many details of trap testing procedures and results are available in other documents, some understanding of the procedures is important and can be gained by reading this document.

Restraining Devices

All types of traps used on land to hold live animals were evaluated using five performance criteria: animal welfare, efficiency, selectivity, practicality and safety. Live restraining devices included cage traps; foothold traps; enclosed foothold devices, such as the EGG trap™; and powered and non-powered cable devices, including modified designs like the Belisle™ foot snare.

Animal Welfare

Trauma scales used to determine a level of animal welfare performance for restraining traps are presented as guidelines in ISO (International Organization for Standardization) Document 10990-5. One scale allocates points to specific injuries, including a zero score for uninjured animals. The other scale groups specific injuries into classes ranging from none to severe. A combination of both systems was used in this evaluation process. The primary species captured in traps that meet BMP performance criteria must have an average cumulative score of 55 points or less according to one scale. According to the other scale, 70% or more of those in the sample must have no injuries or only have trauma described as mild or moderate.

Efficiency

Traps meeting BMP criteria must be able to capture and hold at least 60% of the primary species of interest that activate the trap. An activated trap is one that has been sprung. An activated cable device is one that has the cable loop closed.

$$\text{Efficiency} = \frac{\text{Number of primary species captured}}{\text{Number of activations by primary species}} \geq 60\%$$

Selectivity

Traps should be set and used in a fashion that limits the risk of capturing non-furbearers, including domestic animals, while increasing the chances of capturing desired furbearer species. Data concerning selectivity were collected in field studies and used to identify those traps that have features that influence selectivity. These features and any special considerations are provided in the Mechanical Description and Attributes section for each BMP-designated trap.

Practicality

Traps should be practical for use in the field under trapline conditions. After a particular BMP trap test, each trapper was asked for information regarding practicality. These comments were then reviewed to detect any traps with consistently poor scores. In addition, a panel of experienced trappers and wildlife biologists evaluated each trap and considered the following:

- Cost of initial purchase and maintenance
- Replacement of parts, ease in setting and resetting
- Ease of transport and storage
- Weight and dimensions
- Reliability
- Versatility
- Expected usable life span
- Need for specialized training prior to use

Any special considerations are described in the Mechanical Description and Attributes section for each BMP designated trap.

Traps were selected for testing based on their relative use among trappers surveyed by IAFWA (now AFWA) in 1992 and 2004 and in consultation with wildlife biologists and expert trappers. Commonly used trap models and modifications and new, readily available designs that may improve animal welfare were given priority for testing. Experienced local trappers tested traps during regulated trapping seasons using daily trap checks to provide for consistent, repeatable and reliable data for the most accurate analysis possible. Technicians accompanied trappers and recorded data. Teams worked under field conditions throughout the United States during regulated trapping seasons. Wildlife veterinary pathologists examined captured animals for trap-related injuries using full-body necropsies following international trap testing guidelines. A minimum of 20 specimens were examined for each trap evaluated.

The development of trapping BMPs is an ongoing work that is flexible and adaptable as existing trap models are improved and additional models are tested. Criteria to identify BMP traps are standardized. Trap models that were tested and met these criteria are included in the BMPs for individual furbearers.

Other commercially available traps, modified traps, or other capture devices not yet tested may perform as well as or better than the listed BMP traps. Recommendations to wildlife agencies, biologists and trappers may be updated as additional devices are identified in the future. The listing of specific commercially available BMP traps is not an endorsement by the Association of Fish and Wildlife Agencies or that of any of our member agencies.

Safety

Traps should not present a significant risk to the user, and if necessary, should have appropriate safety features, safety tools, or a combination of the two that can be used easily under normal trapline conditions. Each trapper testing traps for the BMP project was asked to judge whether tested traps posed an unreasonable risk to the user or others who might come into contact with the trap. A panel of experienced trappers and wildlife biologists then evaluated each trap. Safety issues, if any, are described in more detail in the Mechanical Description and Attributes section for each BMP-designated trap.

Mechanically Powered Killing Devices

Mechanically powered killing traps, commonly called bodygrip or rotating-jaw traps (e.g., Conibear™ traps), are designed to kill an animal when two rotating jaws close on either side of the animal's neck or chest. Most of the mechanical testing and research on killing traps has been conducted at the Alberta Research Council facility in Canada. Field-testing of killing traps has been conducted throughout the United States. Killing traps are evaluated with the same five criteria as restraining traps (animal welfare, efficiency, selectivity, practicality and safety), but killing traps must meet different performance standards for animal welfare and safety.

The animal welfare performance standard for killing traps set on land is that the trap must cause irreversible loss of consciousness in 70% of the sample animals within 300 seconds. Killing traps must meet two additional performance standards for safety. First, a trapper must be able to release him/herself from an accidentally fired trap without assistance and second, the forces generated by the trap should not be likely to cause significant human injury. Performance standards for commonly used killing devices are comparable to those described for restraining devices.

Submersion Trapping Systems

Submersion trapping systems are frequently used for furbearers that are found in or near waterways. These systems consist of traps, equipment and techniques that allow or cause furbearers, when trapped, to quickly and irreversibly submerge until death occurs. Submersion systems can employ bodygrip traps, cage traps, cable devices or foothold traps of the appropriate size and weight. Traps are either set underwater at a depth that prevents the captured animal from reaching the surface, or they are set in shallow water near shore and attached with a one-way sliding lock to a cable anchored in deep water.

The animal welfare performance standard for submersion trapping systems is that the equipment must prevent the animal from surfacing once it has submerged. Performance standards for submersion trapping systems are comparable to those used for restraining and killing devices.

Capture Devices

Foothold Traps

Longspring and coil-spring traps (Figures 1a and 1b) are the most commonly used trap types, as they can be used in a myriad of set types on land and in water. The basic design of foothold traps has two jaws attached to a baseplate with a pan-trigger device. Longspring traps are powered by either one or two springs while the standard coil-spring trap is fitted with two small springs. Many modifications can be made to affect the performance of these traps, as described in the next section. Some coil-spring traps are designed to encapsulate the animal's foot, and some have a bar trigger that is either pulled or pushed for activation. These foot-encapsulating traps (Figure 2) are highly species selective by design.

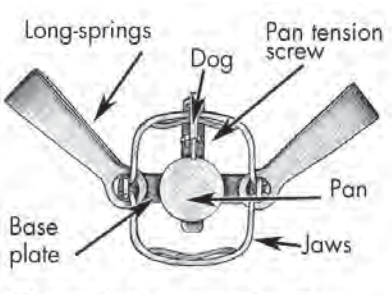

Figure 1a. Longspring trap

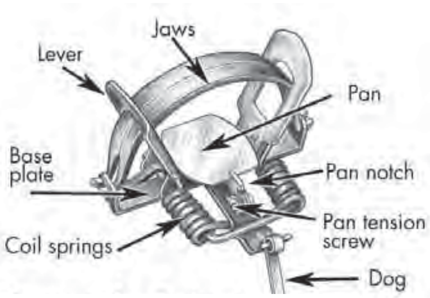

Figure 1b. Coil-spring trap

Cable Devices

A cable device is made of stranded steel cable set in a manner so that a loop of cable encircles the animal's body or limb. Like foothold traps, they can be used in a variety of set types on land and in water. Modern cable devices are made from stranded steel cable. Various sizes are used, three examples of which are: the 7 x 7 design that has 7 bundles of 7 wires each, the 7 x 19 design that has 7 bundles of 19 wires each (Figure 3a), and the 1 x 19 single-strand design that consists of 7 wires (twisted right) wrapped by 12 wires (twisted left) (Figure 3b). These cable types can be used effectively as cable devices.

A non-powered cable device uses the forward movement of the animal to place and close the loop on its body or limb. The powered cable device uses a mechanical feature, such as a spring, to place or close the loop of the cable on an animal's body or limb. An example of a powered cable device is the coil-spring activated Belisle™ Foot Snare (Figure 4a), which employs a foothold-like pan system to activate springs that throw a cable around the animal's foot.

Figure 2. Enclosed foothold trap

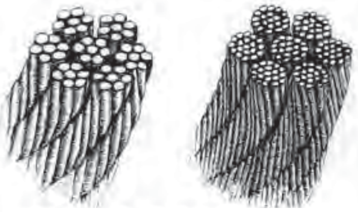

Figure 3a. 7 x 7 and 7 x 19 Cable strands

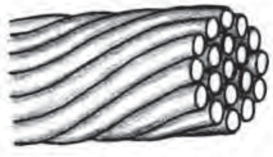

Figure 3b. 1 x 19 Single-strand cable

Each region of the country may have conditions that affect trapping, and BMPs are developed with this in mind. An example is the difference in coyotes (i.e. behavior, size, habitat and management programs across the U.S.), resulting in two coyote BMPs (Eastern and Western). Both trappers and governmental agencies are encouraged to use BMP traps that are best suited for their purposes. All trappers should consult state trapping regulations to be sure the devices and techniques recommended in the BMPs are permitted in their state.

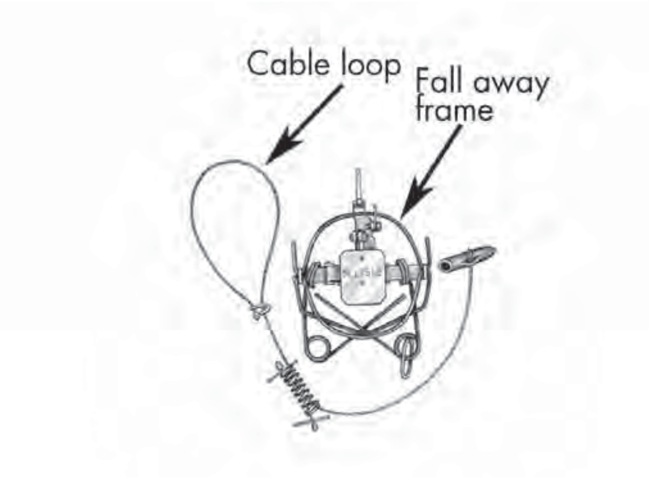

Figure 4a. Belisle foot snare

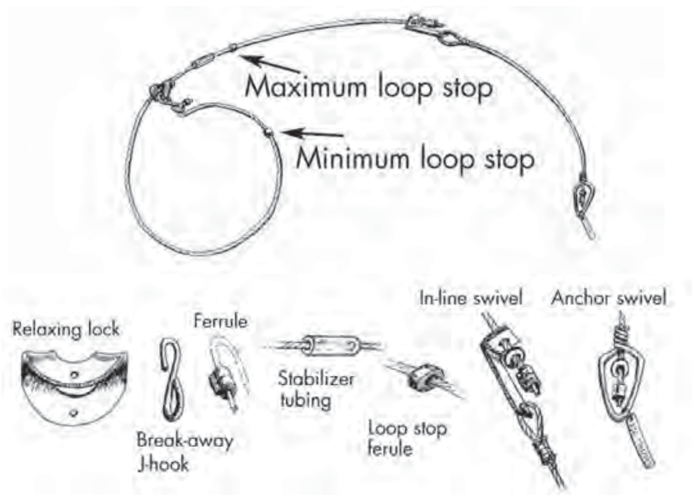

Figure 4b. Non-powered cable device components

Figure 4c. Relaxing lock (example)

Figure 4d. Typical break-away

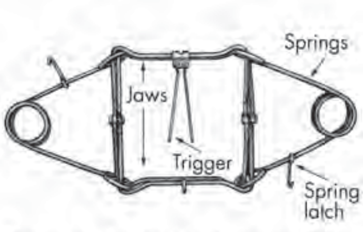

Figure 5. Standard bodygrip trap

Cable devices can be designed in several ways and may have one or more of the following components: relaxing lock; break-away J-hook S-hook, or ferrule; stabilizer tubing; loop stop ferrule, in-line swivel; and/or anchor swivel (Figure 4b). Relaxing locks allow the loop of the cable device to draw smaller as the animal pulls against it but does not continue to close when the animal stops pulling (Figure 4c). Many types of relaxing locks are available. Ferrules are used for several purposes, such as to hold the lock or swivel on the cable or as a breakaway device. Ferrules can be made from many materials, including a steel nut, wire or aluminum cylinders. Break-away devices are components that allow an animal to escape from the cable device if it pulls against it with sufficient force (Figure 4d). Ferrules and J-hooks are two examples of breakaway devices. Loop stops may be made from heavy gauge wire, steel nuts or crimped ferrules and may be used to maintain the cable loop at a minimum or maximum diameter, or both (Figure 4b). The maximum loop stop prevents larger animals from entering the cable loop, while the minimum loop prevents the cable loop from closing around an animal's foot.

Bodygrip Traps

Bodygrip traps (Figure 5) are designed to kill an animal quickly when one or two rotating jaws strike the animal's neck or chest. These traps may be powered by one or two springs. Bodygrip traps operate in a manner similar to the common mouse trap.

Cage or Box Trapping Systems

A cage trap or box trap is designed in such a manner that the animal enters the trap through a door that closes, preventing the animal from exiting (Figure 6). These traps can be used for multiple species, limited by the door size and length. They are difficult to conceal and may be avoided by some animals. Some of these traps can be used to transport animals where permitted by law.

Components of Foothold Trap and Cable Device Systems

Swivels

Proper swiveling is the key to preventing the chain or cable of an anchoring system from binding at the stake, drag or grapple. This is important because it minimizes injury to the captured animal, reduces fur damage and may prevent cable breakage. On a foothold trap, the anchoring system should be attached with a swivel to the center of the base plate of the trap. The anchoring system of most restraining devices should include one or more swivels along the length of the anchoring system, including one at the anchor point. At least two or more swivels are recommended along the anchoring system of a foothold trap (Figure 7a). For cable device systems, at least one swivel at the anchor point and one in-line swivel along the cable are recommended (Figure 7b).

Trap Anchoring Systems

The anchoring system should always be strong enough to hold the largest furbearer that might be captured. When stakes are used to anchor traps, they must be of sufficient length to prevent the captured animal from pulling the stake. If there is doubt that a stake will hold (e.g. in sandy soils), use two stakes with a cross-staking method to ensure the stakes will not move after the catch (Figure 8). Cable stakes are also effective. Drags or grapples may be used effectively in some terrain and may also allow the captured animal to find cover. Similarly, when using a submersion system, the chain length must be short enough and the terminal end of the anchoring system deep enough to keep the animal underwater.

The use of in-line shock springs on anchoring systems, whether they are stakes or drags, may reduce injury and/or prevent escape (Figure 9). Shock springs should be of high quality and adequate strength to resist a captured animal's ability to destroy the spring. By cushioning lunges of a captured animal, shock springs may minimize the chance of cuts and joint injuries. This cushioning action may also decrease "stake pumping," reducing the chances that the captured animal will escape.

Foothold Trap Modifications

Several BMP traps are conventional models that have been modified. Examples of modifications include: laminating and/or offsetting the jaws, adding extra coil spring, using pan-stops or reinforcing the base plate. Most trap manufacturers and suppliers now offer modified traps or will modify traps upon request. Trappers also can modify their own traps to replicate the BMP trap models in this document. In any case, sturdy materials should be used to ensure durability in the field.

Figure 6. Cage trap

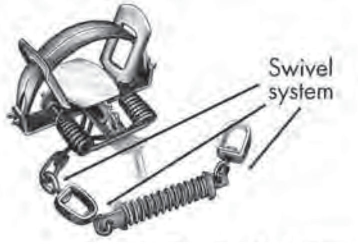

Figure 7a. Foothold trap

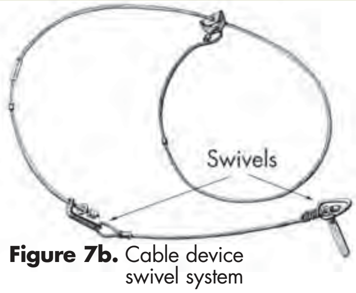

Figure 7b. Cable device swivel system

Figure 8. Cross-staking

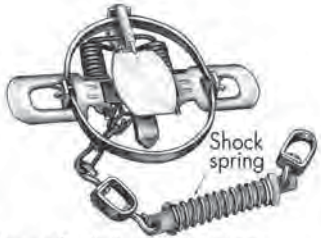

Figure 9. In-line shock spring

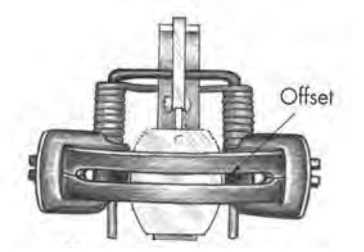

Figure 10. Offset jaws

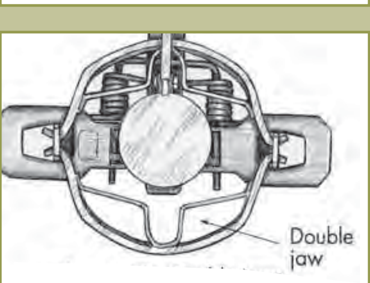

Figure 11. Double jaws

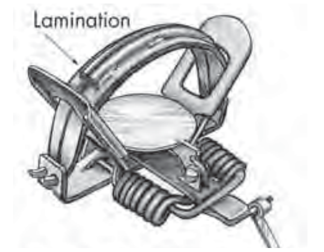

Figure 12. Laminated jaws

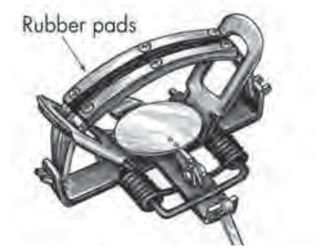

Figure 13. Padded jaws

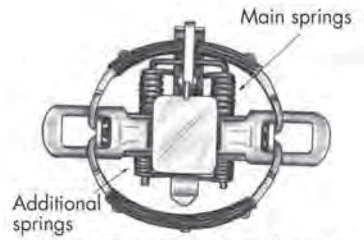

Figure 14. Additional springs (four coiling)

Offset Jaws

Offset jaws contain a space between the gripping surfaces on the closed jaws of a foothold trap. Typically, the offset ranges from ⅛ to ¼ inch (Figure 10). Offset jaw models allow spring levers on coil-spring traps and spring eyes on longspring traps to close higher upon capture, thereby reducing the chance that the captured animal will escape. In addition, clamping pressure is slightly reduced when levers are fully raised which may improve animal welfare under some conditions.

Double Jaws

Using a foothold trap with a double jaw configuration improves animal welfare for some species. The double jaw configuration decreases the distance between the jaw and trap pan, limiting access to the restrained foot. Single jaw traps of the appropriate size can be modified to this configuration by adding a second jaw below the primary jaw (Figure 11).

Lamination and Padding

Expanding the trap jaw thickness with lamination or the addition of rubber pads will increase the surface area of the jaw on a trapped animal's foot and may influence both animal injury and capture efficiency. Lamination may be attached above and/or below the trap jaws, to expand the jaw thickness by welding on an additional strip of metal rod (Figure 12). Lamination typically is an after-market addition, though some trap suppliers provide this service. Padded traps are usually prefabricated. Replacement or repair of rubber pads is periodically required, especially after captures (Figure 13).

Additional Springs

Sufficient trap strength is needed to hold an animal by the foot. Some coil-spring traps may perform better with the addition of two extra coil springs, commonly referred to as "four-coiling." Four-coiling also makes the trap more stable when bedded. Recommended spring wire diameters are provided in the Mechanical Description and Attributes section for each trap meeting BMP criteria (Figure 14).

Pan Stops

The use of a pan stop assembly decreases the distance between the trap jaw and pan after the trap is sprung, limiting access to the restrained foot and reducing the chance of injury (Figures 15a and 15b). Pan stops also prevent the animal from stepping too far into the trap, ensuring optimal jaw placement on the restrained foot.

Reinforced Base Plates

Trap base plates can be reinforced by welding a piece of flat steel to the bottom of the trap frame, thereby strengthening the trap frame and preventing it from bending. The reinforcement plate also can be used as a point of attachment for center swiveling.

Trap Tuning, Preparation and Maintenance

Inspection of Foothold Traps

Most new traps require some minor adjustments to operate correctly. New traps may have sharp edges or burrs that must be removed to avoid injuries to the trapped animal. The upper and lower corners of jaw faces should be filed to remove sharp, squared edges. On offset jaw models, jaw contact points also should be rounded as necessary, though not so much as to reduce the width of the offset. Similarly, used traps and attachments should be inspected for wear before each season (Figure 16).

- Weak coil springs should be replaced
- Trap components, such as swivels, J-hooks, and S-hooks, must be of sufficient strength, must operate freely without binding, and must not be damaged
- J-hooks should be welded shut when trapping large, strong animals such as coyotes
- Sharp edges on jaws or any part of the trap should be smoothed with a file

Leveling Trap Pans

A level pan is important because it optimizes the angle of capture of the animal's foot. When the trap is set, the trap pan should be level with the jaws. If the pan rests too high or too low, it should be adjusted (Figure 17).

Short Pan Throw

The amount of space where the trap dog (trigger) fits into the pan notch determines how far the trap pan must drop before the trap activates (Figure 18). A file can be used to "square" the trigger slot and the end of the dog to produce a short pan throw and crisp action. A short pan throw, used in conjunction with the correct pan tension for the target species, will result in desired capture positions on the animal's foot.

Inspection of Cable Devices

Cable devices and all components should be inspected before use for kinks or other imperfections that may keep them from closing smoothly. After capturing an animal, discard the used cable and inspect the other parts of the cable device for damage or weakening before using them again.

Treating and Handling Traps and Cable Devices

New foothold traps, bodygrip traps, and cable devices are often coated with oil that must be removed before use. A good method to remove the oil is to boil the devices in water mixed with baking soda (for cable devices), or mixed with detergent (for traps). This process will dull the finish, remove unnatural odors, and allow traps to begin forming a light coat of rust. Rusted traps can then be dyed and waxed, with the exception of bodygrip traps and cable devices, which should never be waxed. Some trappers also boil cable in water a second time with logwood crystals or other plant materials to darken the wire and add some natural scent. Cage or box traps are sometimes spray painted to help with concealment. After treatment, handle cable and traps with gloves that are free of scent and store them in a dry place where no unnatural odors will be absorbed. Many techniques for treating traps and cable are available and are best learned from trapper education materials or experienced trappers.

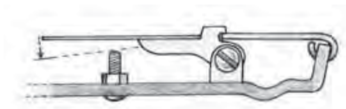

Figure 15a. Pan stop, set position

Figure 15b. Pan stop, closed position

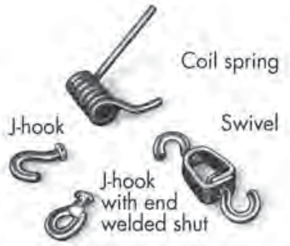

Figure 16. Trap components

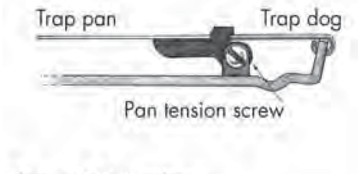

Figure 17. Level pan

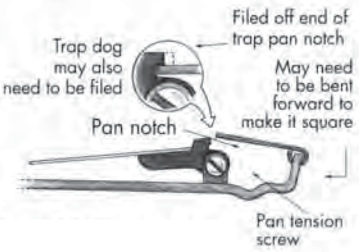

Figure 18. Short pan throw

Figure 19. Pan tension measuring device

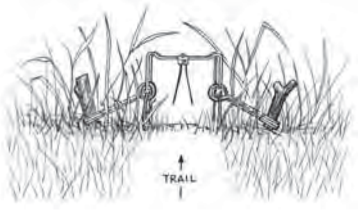

Figure 20a. Bodygrip, blind trail set

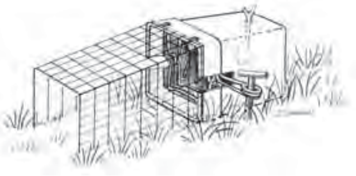

Figure 20b. Bodygrip, cubby set with restricted entry

Figure 20c. Bodygrip, pole set

Trapping Techniques

Using the correct size and type of restraining trap is essential to achieving a high level of efficiency and minimizing the risk of injuring the captured animal. How an individual trapper chooses to use a trap also is critical. Likewise, the correct size and type of bodygrip trap or cable device will allow for efficient capture while meeting animal welfare criteria.

Presented here are techniques and practices recommended by experienced trappers and wildlife biologists that provide for improved animal welfare, selectivity, efficiency and user safety. These suggestions may be familiar to some but new to others.

All trappers are strongly encouraged to use as many of these techniques as practical. More detailed information on recommended techniques is available through various trapper education manuals, manufacturer's documents, instructional videos and trade publications.

Set Location for Traps

Careful choice of trap location can influence animal welfare, efficiency and selectivity of trap sets. Trappers should choose set locations that:

- Prevent entanglement with fences or other objects that might result in injury
- Minimize the chance that objects or debris will prevent swivels from functioning properly
- Minimize the capture of non-furbearers
- Minimize the captured animal's exposure to domestic animals and human activities (e.g. avoid trails used by people)

Lure, Bait and Attractants

Careful placement and selection of baits, lures, and other attractants can greatly increase capture efficiency and selectivity. Certain baits or lures (e.g. meat-based attractants) may be more attractive to pets and hunting dogs and should be used cautiously.

Many states prohibit setting traps near large carcasses, or using exposed baits or fur or feather attractants. Be sure to comply with state regulations concerning the use of baits and attractants. Consult trapper education materials to learn how to use baits, lures, and attractants to improve the selectivity and efficiency of your sets.

Proper Pan/Treadle Tension – Foothold and Cage Traps

Pan tension influences trap selectivity. Most new traps have pan tension bolts and those that do not can typically be fitted with commercially available or homemade pan tension devices. Pan tension can be adjusted so certain weights are required to depress the pan and trigger the trap, thereby affecting trap selectivity. The pan likely will need readjustment after each capture. Devices for measuring pan tension are commercially available or may be easily constructed (Figure 19). To test pan tension with the type of device shown in Figure 19, the proper amount/weight of material (sand, water, etc.) should be added to the jug to depress the pan at the desired pan tension weight (e.g. 2 pounds., 4 pounds., etc.). Recommendations for appropriate pan-tension are given in the species chapters.

Bodygrip Trap Considerations

Different species have different shapes and behaviors that influence how they approach bodygrip traps. Trigger systems on bodygrip traps can be configured to improve trap efficiency and animal welfare (time to irreversible unconsciousness) by affecting strike locations. The selectivity of bodygrip traps also can be impacted by trigger configurations, as the shape and location of the trigger can be modified to avoid certain species while capturing others.

Bodygrip traps on land are sometimes used in blind trail sets (Figure 20a) or in conjunction with cubbies (Figure 20b) or in above-ground sets (Figure 20c) to avoid capture of certain species either because of species size or behavior. Further, many states prohibit setting bodygrip traps on land unless they are used in conjunction with one or more of these techniques. Be sure to comply with state regulations concerning the use of these traps. Consult trapper education material to learn how to use cubbies and trap placement to improve the selectivity and efficiency of your sets.

Avoiding Entanglements

Foothold traps and cable devices when staked should be set so the captured animal cannot entangle the anchoring system in any object. These devices should not be set near fences or farm equipment. Trap sites should be cleared of all objects (e.g. rocks, logs, and rooted, woody stems) that could be reached by the captured animal and become entangled in the anchoring chain or cable. This usually means some clearing work with pruning shears, a hatchet, or a saw. The area that needs to be free of entangling objects depends on the size of the target animal and the length of the anchoring system (Figure 21). If the trap anchoring system becomes entangled with objects at the set, the swiveling system may become inoperable.

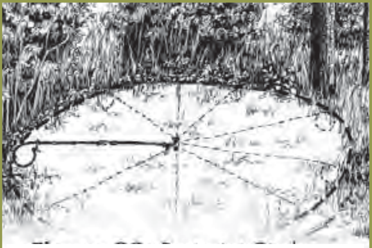

Figure 21. Restraint circle

Figure 22. Spring latches

Figure 23. Bodygrip safety gripper

Trap Safety

Restraining foothold devices have excellent safety records, but as with any tools, precautions should be taken in handling them. Use of available safety equipment, such as gloves and safety glasses, should be considered while setting traps.

Personal safety is more of an issue when handling bodygrip traps, especially the larger sizes. Bodygrip traps must close with considerable force to meet animal welfare performance standards. Trappers should be familiar with the safe and efficient use of bodygrip traps. We recommend the use of spring latches (Figure 22) on both springs and a safety gripper on trap jaws (Figure 23) when setting bodygrip traps. Most bodygrip traps are equipped with spring latches, and these should be engaged when the springs are compressed. A variety of safety locks are available for the jaws, and one should be attached when the jaws are moved to the set position. These safety devices protect the trapper and make it easier to position and anchor the trap. Safety devices should be disengaged only when the set is completed. It is also recommended that trappers carry one of the commonly available setting tools to help free oneself if accidentally caught.

Checking and removing the set should always be done carefully. Spring the trap or engage the safety latches before removing sets. Never reach under the ice to check bodygrip traps, particularly if the hole in the ice is too small to pull the trap through. Never use your hands or feet to locate a bodygrip trap that is underwater, under ice or out of sight.

Releasing or Dispatching Captured Animals

Restraining devices give trappers the option of either releasing or dispatching captured animals. A capture pole is one of several tools that a trapper can use to release animals. Using these devices, animals can be safely released from restraining traps. Techniques for release and dispatch are best learned from a trapper education program or from experienced trappers.

Trapping & Furbearer Management in Montana

What's New:

- **News Release:** FWP puts mandatory trapper education on hold (March 6, 2018)
- Center Swivels for 2019 Season (PDF 107 KB)

Fur trapping is highly regulated, biologically sustainable, and an important part of Montana's cultural history and outdoor lifestyle.

FWP is responsible for the conservation of furbearers and for regulating the responsible use of this public resource. FWP and its citizen commission continually refine furbearer trapping regulations to ensure sustainability, selectivity, and ethical harvest.

Regulated trapping can provide many benefits to society, including:

- Reducing wildlife damage to crops and property,
- Reducing threats to human health and safety,
- Population monitoring information including trends, distribution, reproductive data, presence of toxins, etc.

Best Management Practices for Trapping

- Modern Snares for Capturing Mammals (PDF 594 KB)
- Introduction: Best Management Practices for Trapping in the United States (PDF 686 KB)
- Bodygrip Traps on Dryland (PDF 10.9 MB)
- American Marten (PDF 4.2 MB)
- Badger (PDF 2.9 MB)
- Beaver (PDF 1.8 MB)

National
Trappers
Association

6. HSUS Statement: Commercial trapping is not a "wildlife management tool". There are no bag limits and no limits on the number of traps that can be set. Trapping activity is driven by the price of pelts, not by the need to manage wildlife populations. Some fur-bearers (coyotes for instance) have natural fertility and breeding controls when not disturbed by humans, while others (such as muskrats) experience natural boom-and-bust cycles.

Factual Rebuttal: The professional wildlife conservation community universally endorses traps and trapping as critical and essential wildlife management tools. The Wildlife Society and the International Association Of Fish and Wildlife Agencies are the largest international organizations representing professional wildlife conservation employees and governmental wildlife agencies. Both organizations have issued policy statements that strongly support the role commercial trapping plays in achieving wildlife management objectives.

Harvest season length, bag limits, permissible size and types of traps, and total number of traps permissible per trapper, are all considered during the development of management strategies for individual species. Population growth characteristics of some species require strict harvest regulations that include bag limits and limiting the number of traps per individual. Conversely, harvest and population characteristics of other species require liberal regulations to meet prescribed furbearer management objectives.

All wildlife populations possess inherent bio-feedback mechanisms that eventually limit population densities. Most species can exhibit classic 'boom and bust cycles'. The reproductive capabilities of coyotes, muskrats and many other furbearers allow non-regulated populations to increase at exponential rates until they approach and/or surpass the carrying capacity of their respective ecosystems (boom). When this occurs, competition for limited resources compromises the health of the entire population. At that time, the weakened condition of these animals allow density-dependent mortality factors such as starvation, disease, and social strife, to decimate entire populations (bust). Oftentimes, the health of the entire ecosystem including all aligned wildlife species and the public are also negatively impacted by these inflated furbearer populations.

Regulated commercial trapping manages populations by moderating the extremes of 'boom and bust' cycles. This results in stable populations of healthy animals that are in balance with the biological carrying capacity of their ecosystems and the cultural carrying capacity accepted by the general public.

Journal of Mammalogy, 92(1):235–253, 2011

Guidelines of the American Society of Mammalogists for the use of wild mammals in research

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Guidelines for use of wild mammal species are updated from the American Society of Mammalogists (ASM) 2007 publication. These revised guidelines cover current professional techniques and regulations involving mammals used in research and teaching. They incorporate additional resources, summaries of procedures, and reporting requirements not contained in earlier publications. Included are details on marking, housing, trapping, and collecting mammals. It is recommended that institutional animal care and use committees (IACUCs), regulatory agencies, and investigators use these guidelines as a resource for protocols involving wild mammals. These guidelines were prepared and approved by the ASM, working with experienced professional veterinarians and IACUCs, whose collective expertise provides a broad and comprehensive understanding of the biology of nondomesticated mammals in their natural environments. The most current version of these guidelines and any subsequent modifications are available at the ASM Animal Care and Use Committee page of the ASM Web site (http://mammalsociety.org/committees/index.asp).

Key words: animal capture, animal care, animal housing, animal marking, animal use ethics, federal regulation, Institutional Animal Care and Use Committee, trapping

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ORGANIZATION OF GUIDELINES

INTRODUCTION

Advances in the study of mammals, from exploring physiological functions to understanding evolutionary relationships and developing management strategies, are predicated on responsible use of mammals in research. Founded in April 1919, the American Society of Mammalogists (ASM) has long been concerned with the welfare of mammals, and in particular, natural communities. In 1928 one of the founders of the ASM, Joseph Grinnell, instructed administrators of Yosemite National Park to maintain the park as a natural mammalian community without unnecessary or destructive development. Grinnell (1928:76) described various management tactics for park managers to follow, but in particular he advised that to address an unwanted increase in the bear population, park officials needed to ''devise [some] means whereby troublesome individual bears could be discouraged from raiding food-stores, without doing them serious bodily harm. But I recommend that exceeding care be taken in such procedure, not to rouse, unnecessarily, adverse public opinion, and not to drive away the bears altogether, for they constitute a particularly valuable element in the native animal life of the valley.'' Thus, Grinnell made informed management recommendations and also advocated animal care and use with sensitivity toward public opinion. The same is true today because mammalogists care deeply about the sentient organisms they study.

Differences between medical research and basic research on mammals frequently pose problems for field researchers because regulations developed for laboratory environments and domesticated taxa are increasingly and inappropriately extrapolated to the field and to wild taxa even though conditions and context are dissimilar. In medical research artificially selected, domesticated strains are used to reduce differences among individuals. In this research the mammalian model (usually *Mus* or *Rattus*) frequently is considered more the vessel, vehicle, or source of tissue for the drug study or neuroscience investigation. In contrast, field researchers usually are interested in the mammals themselves as the focus of study, and variation among individuals and natural behaviors are of fundamental interest and importance. Guidelines for animal protocols have become more important with increasing use of native animal models in research. The Animal and Plant Health Inspection Service (APHIS) within the United States Department of Agriculture (USDA) unit has amended the Animal Welfare Act (AWA—USDA 2005; http://www.access.gpo.gov/uscode/title7/chapter54.html) to oversee field studies, which are defined as studies conducted on free-living wild animals in their natural habitat.

The ASM publication *Guidelines for the Use of Animals in Research* (*ad hoc* Committee for Animal Care Guidelines 1985) was the 1st effort to codify the expertise and philosophy of experienced, professional mammalogists on use of mammals in research. This single-page statement broadly listed considerations, such as concern for number of animals used, and highlighted laws that regulated use of animals (including Convention on International Trade in Endangered Species). It stated that the investigator should exercise good judgment and prudence when using animals in research. More complete guidelines were published by the ASM in 1987 with *Acceptable Field Methods in Mammalogy*: *Preliminary Guidelines Approved by the American Society of Mammalogists* (*ad hoc* Committee on Acceptable Field Methods in Mammalogy 1987), 1998, and again in 2007. Resources for the various editions of these guidelines included information from the United States, other governments (e.g., Canadian Council on Animal Care—Olfert et al. 1993), other professional societies, such as the Society for the Study of Animal Behaviour (2006), the American Veterinary Medical Association (AVMA 2007) *AVMA Guidelines on Euthanasia*, and various publications on trapping methods. In essence, earlier versions of the ASM guidelines provided highlights of more complete information available from either the *Guide for the Care and Use of Laboratory Animals* (hereinafter *Guide*—National Research Council [NRC] 1996) or the AWA; these were, minimize numbers taken, reduce pain or distress of captive animals, and provide humane euthanasia where death was the endpoint. An overview of the development of the ASM guidelines through their various iterations is provided in the 2007 publication (Gannon et al. 2007) and is not repeated here.

These newly revised guidelines are intended to provide investigators and those charged with evaluating animal use in research (institutional animal care and use committees [IACUCs], reviewers and editors of research manuscripts, management agency personnel, graduate committees, and the public) with up-to-date general and specific guidance on ethical care and use issues and health, safety, and environmental concerns particular to nondomesticated mammals. We emphasize that these guidelines are not intended to constrain ingenuity in meeting research demands but rather to bring relevant safety, regulatory, and ethical concerns regarding animal use to the attention of investigators. It is the responsibility of the principal investigator of a project to justify deviations from federal guidelines during submission of a protocol to an IACUC. Institutions have various requirements for animal use and care, but as scientists we have developed an ethos toward animal use. ''Ethics'' typically is defined as a study of moral values, that is, expectations about beliefs and behaviors by which we judge ourselves and others (Macrina 2005). All research procedures commonly used today must be considered and discussed by IACUCs as to whether they cause even momentary pain and distress.

This document was prepared and approved by the ASM, whose collective expertise provides a broad and comprehensive understanding of the biology of nondomesticated mammals in their natural environments. It is intended to be a resource for investigators, educators, and oversight bodies regarding use of wild mammals in research and teaching, particularly in those instances where difficulties might arise in defining what is appropriate when dealing with nondomesticated mammals and field procedures. We emphasize that this document is not intended to be an exhaustive catalog of procedures and that final approval of any protocol rests with the IACUC.

GENERAL GUIDELINES

Fieldwork with Mammals

Fieldwork is arguably the most difficult issue for IACUCs and others who typically evaluate use of animals in laboratory-based studies. Fieldwork in mammalogy involves designing and conducting research to address scientific questions by working with mammals in their natural habitats. This process might involve capturing an animal to obtain reproductive and other data and subsequently releasing it to obtain additional information on population dynamics, movements, and habitat relationships. In some cases the investigator might bring a wild-caught animal into an animal resource facility for further study. In the United States field and laboratory researchers who receive federal support must comply with relevant provisions of the United States Public Health Service policies on humane care and use of laboratory animals (Office of Laboratory Animal Welfare, National Institutes of Health—Office of Laboratory Animal Welfare 2002a). Use of sedatives, analgesics, and anesthetics often is under federal and state control. Investigators must consult with federal and state drug enforcement agencies and obtain appropriate licenses during the design stage of a study. Some drugs (e.g., narcotics) must have strict inventory logs and be stored in doubly locked areas to prevent unauthorized access.

Training, especially in the rapidly changing area of compliance, is extremely important for all individuals handling vertebrate animals. Some training is available online or is organized by IACUCs at universities and other institutions. Other training is provided by laboratory-animal veterinarians or technicians experienced in research-oriented procedures. Training provides the investigator with experience in acceptable methods of restraining, marking, monitoring vital signs, administering injections, taking blood samples, and assessing stress or signs of pain or distress. The investigator is responsible for knowing how to perform procedures in the appropriate setting (field, laboratory, etc.) for which their protocol was approved. In this document we outline issues associated with research involving mammals and provide a framework for addressing those issues based on animal welfare regulations, scientific studies, and our experiences as mammalogists.

The IACUCs are urged to recognize the investigator as a cooperator versed in the biology of the taxa used in their research. Wild vertebrates, particularly mammals, are vastly different in physiology and behavior from their usually highly inbred conspecifics used in biomedical research. Wild vertebrates do not inhabit antiseptic, stress-free environments with ad libitum food. With these differences in mind, investigators should serve as resources to their IACUCs and institutional veterinarians.

Compliance with Laws and Regulations

Mammalogists conducting research associated with a college, university, or museum that receives federal grant funding are advised to seek approval from their IACUCs and to obtain proper permits from local and federal agencies before conducting any procedure involving live animals. These permit requirements apply whether the principal investigator is working within the United States or elsewhere. The AWA authorizes the USDA/APHIS to regulate vertebrates used (or intended for use) in research, testing, experimentation, or exhibition purposes, or as pets, regardless of whether animals are maintained in a laboratory or farm setting. However, the USDA/APHIS does not regulate animals used for food or fiber (or for improving quality of food or fiber), or for improvement of animal nutrition, breeding, management, or production efficiency.

The United States Fish and Wildlife Service defines a mammal as any member of the class Mammalia, including any part, product, egg, or offspring, or the dead body or parts thereof (excluding fossils), whether or not included in a manufactured product or in a processed food product (Office of Laboratory Animal Welfare 2002a). In this context, ''permit'' is any document designated as a ''permit,'' ''license,'' ''certificate,'' or any other document issued by the United States Fish and Wildlife Service to authorize, limit, or describe an activity and signed by an authorized official of the United States Fish and Wildlife Service. Although the focus of this section is on federal and state regulations in the United States, investigators, regardless of their nationality or location of their research, should understand that local, state–provincial, federal–national, or international laws or regulations likely exist that pertain to scientific collecting, transport, possession, sale, purchase, barter, exportation, and importation of specimens or parts thereof, or other activities involving native or nonnative species of mammals. Therefore, each investigator must have knowledge of, and comply with, all relevant laws and regulations pertaining to field collection of mammals. Federal regulations exist in the United States that pertain to collection, import, export, and transport of scientific specimens of mammals, and ignorance of the law or even inadvertent violation of regulations could result in prosecution. Researchers living in or conducting research in the United States must obtain permits issued by federal agencies to import or export specimens of nonendangered species through a nondesignated port of entry; import or export endangered wildlife through any port; import injurious wildlife; import, export, ship interstate, take, or possess endangered species or parts thereof for research or propagation; take, harass, possess, or transport marine mammals; import or transfer etiological agents or vectors of human disease and living nonhuman primates; collect scientific specimens on national wildlife refuges; import ruminants and swine, including parts, products, and by-products; and import organisms or vectors, tissue cultures, cell lines, blood, and sera.

When moving specimens of mammals into or out of the United States, researchers are required to file United States Fish and Wildlife Service Form 3–177—currently the electronic declaration form (e-Dec) available at www.fws.gov is preferred and may be mandatory at the regional office or port of entry—and any necessary permits from the Convention on International Trade in Endangered Species if species are listed in Convention on International Trade in Endangered Species appendices I–III. Investigators working outside the United States should expect similar regulations in other countries and ensure compliance with all applicable regulations dealing with species of special concern. Investigators also must ascertain whether additional permits are needed when they review state–provincial and federal–national laws and regulations that relate to their planned field investigations. Further, investigators must be familiar with current lists of mammalian species deemed threatened or endangered by appropriate state–provincial or federal–national governments and comply with all laws and regulations pertaining to capture of these and other categories of protected mammals. A list of threatened or endangered species and subspecies under the United States Endangered Species Act is available from the Office of Endangered Species, Fish and Wildlife Service, United States Department of the Interior, Washington, D.C. 20240 (http://www.fws.gov/endangered/wildlife.html). Regulations relevant to these taxa are published in the *Code of Federal Regulations*, Title 50, Chapter 1; amendments to regulations under Title 50 also are published in the *Federal Register* (USDA 2005).

Most states and provinces require scientific collecting permits, and investigators must comply with this requirement and other regulations imposed by agencies in the states or provinces in which they conduct fieldwork as well as international regulations. International Union for the Conservation of Nature, United States Fish and Wildlife Service, and Convention on International Trade in Endangered Species status is indicated in Wilson and Reeder (2005), but investigators should check for updates. Lists of all mammals (and other animals and plants) that are regarded as endangered, threatened, or species of special concern, along with other pertinent information, are maintained by the United States Fish and Wildlife Service. Additional information is available on the International Union for the Conservation of Nature *Red List* (http://www.iucnredlist.org/) and from Convention on International Trade in Endangered Species (http://www.cites.org/). States, national and state parks, or other organizations might have additional regulations regarding scientific uses of wildlife on lands under their jurisdiction. Compliance with these regulations is essential. Finally, the investigator should obtain permission of the owner, operator, or manager of privately owned land before commencing fieldwork thereon.

Many institutions, and state, provincial, and federal governments, have regulations or recommendations concerning handling and sampling rodents or other mammals that might be carriers of zoonotic diseases. Investigators must ensure their own safety and that of employees or students by understanding the disease-carrying potential of the mammals they study. Additionally, as part of their charge of reducing institutional liability, most IACUCs have adopted some form of occupational health screening for all persons involved with animal research. Screening might involve completion of a check-off form inquiring about allergies or other health conditions of investigators, students, and employees, or even a more detailed examination.

Categorization of Animal Use for USDA Compliance

[Note: In 2010 the ASM, in conjunction with the Ornithological Council, reviewed guidance documents available to institutions and developed a joint position regarding categorization of animal use for USDA compliance. This text was 1st disseminated as a position statement and addendum to the 2007 version of these guidelines in 2010. The portions of this joint position relevant to work with mammals are included here.]

Two aspects of animal usage classification can cause confusion where activities involving wild animals are concerned: classification of the capture of free-ranging animals within the USDA reporting categories of pain and distress; and identification of field studies for the purpose of determining when IACUC protocol review and IACUC site inspection are required.

*United States Department of Agriculture reports: pain and distress categories.—*The AWA (7 USC 2143(b)(3)(A)) and the implementing regulation (9 CFR 2.36) require that research facilities in the United States subject to these laws file an annual report with the USDA Animal Care Regional Office documenting their research and teaching activities that used live animals covered by the AWA and its implementing regulations. A component of this report is classification of animal usage into categories intended to describe the absence, presence, or extent of pain or distress and the use of drugs to alleviate these conditions.

United States Department of Agriculture descriptions for animal reporting categories as defined on the reporting form (APHIS Form 7023) are:

C—Animals upon which teaching, research, experiments, or tests were conducted involving no pain, distress, or use of pain-relieving drugs.

D—Animals upon which experiments, teaching, research, surgery, or tests were conducted involving accompanying pain or distress to the animals and for which appropriate anesthetic, analgesic, or tranquilizing drugs were used.

E—Animals upon which teaching, experiments, research, surgery, or tests were conducted involving accompanying pain or distress to the animals and for which the use of appropriate anesthetic, analgesic, or tranquilizing drugs would have adversely affected the procedures, results, or interpretation of the teaching, research, or experiments, surgery, or tests. (An explanation of the procedures producing pain or distress on these animals and the reasons such drugs were not used must be attached to the report.)

Guidance for classifying painful procedures is provided in Policy 11 of the *Animal Care Resource Guide: Animal Care Policy Manual* published by the Animal Care Program of the USDA, APHIS (1997). However, this minimal guidance and the examples given therein pertain to procedures conducted in a laboratory setting, usually in the context of biomedical research.

Classification becomes especially problematic when institutions are faced with applying regulations intended primarily for laboratory settings to the very different context of free-ranging animals. The 2 critical terms in these descriptions are ''pain'' and ''distress.'' According to the *Animal Care Resource Guide: Animal Care Policy Manual* (Animal Care Program, USDA, APHIS 1997), Policy 11, a painful procedure is defined as one ''that would reasonably be expected to cause more than slight or momentary pain and/or distress in a human being to which that procedure is applied, that is, pain in excess of that caused by injections or other minor procedures.'' Distress is not defined in current policy except by example: ''Food or water deprivation beyond that necessary for normal presurgical preparation, noxious electrical shock that is not immediately escapable, paralysis or immobility in a conscious animal.'' The principal investigator and the institution must then contend with the task of determining the appropriate classification of captured mammals.

*United States Department of Agriculture classifications as applied to animal capture and noninvasive field procedures.—*Mammal capture devices are designed either to hold the animal unharmed (live traps) or to kill the animal outright upon capture. Barring mechanical malfunctions and with appropriate placement and trap checking frequency, animals captured in live traps or nets are simply held without injury until removal. Appropriate training is essential for setting capture devices and for removing animals from those devices. Pain or distress, as described in the *Animal Care Resource Guide: Animal Care Policy Manual* (Animal Care Program, USDA, APHIS 1997), is unlikely to result from the simple capture of free-ranging mammals using most live traps or capture techniques approved by the ASM, so animal usage in these instances is consistent with USDA Category C.

Most tissue sampling and marking techniques in the field also are consistent with USDA pain Category C provided that procedures are not more invasive than peripheral blood sampling. Support for this classification is provided in the *Guidelines for Preparing USDA Annual Reports and Assigning USDA Pain and Distress Categories* (National Institutes of Health, Office of Animal Care and Use 2009). This document is distributed by the National Institutes of Health Office of Animal Care and Use, which is the oversight office for intramural research. This guidance expressly states that Category C includes most blood-collection procedures and tissue-collection procedures that involve no or only momentary or slight pain. Based on these same National Institutes of Health guidelines, USDA Category C is also appropriate in instances where protocols requiring peripheral tissue sampling or tagging and release of free-ranging animals necessitate chemical immobilization to conduct the procedures, provided that immobilization is performed only to facilitate the procedure and protect the animal and the researcher from injury rather than to alleviate pain or distress induced by the procedure.

Free-ranging mammals captured in live traps and subsequently euthanized as part of the research study or that are taken in properly functioning kill traps meet the standards for either USDA Category C or Category D; the distinction between these reporting categories depends upon how the animal is killed. Category C appropriately applies to animals taken in live traps if the animals show no obvious signs of pain or distress. The same category applies to animals trapped and then subsequently euthanized using accepted methods that avoid inducing pain or distress and those taken in properly functioning kill traps. These conclusions are consistent with example 4 in the *Animal Care Resource Guide: Research Facility Inspection Guide* (Animal Care Program, USDA, APHIS 2001), Section 14.1.10, except that death is intentional rather than unexpected. The *Research Facility Inspection Guide* pertains to laboratory animals rather than free-ranging wildlife, but euthanasia following a live capture that does not result in pain or distress is analogous to this example.

The *Guidelines for Preparing USDA Annual Reports and Assigning USDA Pain and Distress Categories* (National Institutes of Health Office of Animal Care and Use 2009) make clear that assignment of animals to a reporting category is retrospective. Even though a trapping method ordinarily might comprise Category C, if a problem occurred in the field that resulted in pain or suffering necessitating pain alleviation, Category D is the appropriate reporting category for that particular animal. If livetrapping brings about pain or suffering that necessitates euthanasia, or if kill-trapping fails to bring about swift death and leaves a conscious animal in pain or distress, Category D is the appropriate reporting category. These situations are analogous to example 3 in *Animal Care Resource Guide: Research Facility Inspection Guide* (Animal Care Program, USDA, APHIS 2001) depending upon trap type, trap specificity, and trapping technique.

Field studies.—Considerable misunderstanding has surrounded the application of the AWA to field studies. Regulations promulgated by the USDA under the AWA exempt field studies from IACUC review (9 CFR 2.31(d)), where field study is defined as ‘‘any study conducted on free-living wild animals in their natural habitat that does not harm or materially alter the behavior of the animal under study’’ (9 CFR 1.1). None of these terms is defined in the regulation or in guidance documents issued by the Animal Care Program. The same regulation exempts from the inspection requirement of 9 CFR 2.31 ‘‘animal areas containing free-living wild animals in their natural habitat.’’

With regard to IACUC protocol review, the *Public Health Service Policy on Humane Care and Use of Laboratory Animals* (Office of Laboratory Animal Welfare 2002a) makes no distinction between laboratory and field studies. Guidance from the National Institutes of Health, Office of Laboratory Animal Welfare (http://grants.nih.gov/grants/olaw/faqs.htm#ab) states, ‘‘If the activities are PHS-supported and involve vertebrate animals, then the IACUC is responsible for oversight in accordance with PHS policy. IACUCs must know where field studies will be located, what procedures will be involved, and be sufficiently familiar with the nature of the habitat to assess the potential impact on the animal subjects. Studies with the potential to impact the health or safety of personnel or the animal's environment may need IACUC oversight, even if described as purely observational or behavioral. When capture, handling, confinement, transportation, anesthesia, euthanasia, or invasive procedures are involved, the IACUC must ensure that proposed studies are in accord with the *Guide*.’’ Other federal agencies have voluntarily adopted these same rules. For instance, the *National Science Foundation Award and Administration Guide* (http://www.nsf.gov/pubs/policydocs/pappguide/nsf10_1/aagprint.pdf) states, ‘‘Any grantee performing research on vertebrate animals shall comply with the Animal Welfare Act (7 U.S.C. 2131 *et seq.*) and the regulations promulgated thereunder by the Secretary of Agriculture (9 CFR 1.1–4.10) pertaining to the humane care, handling, and treatment of vertebrate animals held or used for research, teaching, or other activities supported by federal awards. The awardee is expected to ensure that the guidelines described in the National Academy of Science publication *Guide for the Care and Use of Laboratory Animals* (NRC 1996) are followed and to comply with the *Public Health Service Policy* and *Government Principles Regarding the Care and Use of Animals* (included as Appendix D to the NAS *Guide*).’’

How the definition of field study corresponds to the USDA reporting categories is unclear. In most instances protocols involving only procedures classified as Category C are consistent with the regulatory definition of a field study. However, lack of definition of key terms in the definition of field study—harm, material alteration of behavior, and invasiveness—introduce sufficient ambiguity in application of the definition that further guidance from the Animal Care Program would benefit the research community.

Numbers and Species (Including Endangered Taxa)

The *Guide* (NRC 1996) requires that protocols include details concerning the numbers of animals to be used. These details are relevant during IACUC discussions. The ‘‘3 Rs’’ outlined in the *Guide* (Reduction, Refinement, and Replacement—NRC 1996) direct IACUC committee members to determine if the smallest number of animals necessary to accomplish research goals is being used. Further, oversight agencies such as the USDA focus on clear association of animal numbers with procedures or research aims. Frequently, field researchers do not know how many individuals will be needed or sampled; this is especially true in the case of surveys or other exploratory work common in mammalogy. Statements in protocols such as ‘‘it is unknown how many animals we will capture’’ are generally not well received by the IACUC. For IACUC protocols the investigator can provide generalized statements such as: ‘‘In this survey we expect to collect different species of *Oryzomys* and will sample an estimated 25 localities. We will not exceed 20 specimens/species of *Oryzomys*/locality. It is anticipated that the total number of specimens collected during this study will not exceed 500 individuals/year.’’

The numbers of animals required in field studies will vary greatly depending on study design, species' life-history characters, and questions posed. Behavioral studies might involve capture of only a few animals where the focus is on a specific behavior, or an entire population to mark all individuals. In the latter case the investigator can provide a statement that ''all animals in the population will be captured, marked, and released, and it is estimated that this will not exceed 200 individuals/year.'' Genetic, taxonomic, ecological, and other studies require a minimum sample size for statistical analyses. Too few animals might not allow the investigator to address research questions with sufficient scientific rigor and, subsequently, will result in a waste of animals if the results cannot be applied to test a hypothesis. A power analysis might be performed to estimate the number of animals required to obtain statistical significance for a given level of variance and a minimum difference between samples. The NRC (2003) provides guidelines for determination of sample size and estimation of animal numbers for laboratory studies.

Institutional animal care and use committees also are charged with approving the particular species of mammals involved in a project. Again, medically oriented protocols commonly use laboratory rats (*Rattus norvegicus*) and mice (*Mus musculus*) bred for many generations by animal resource facilities. Recent additions to laboratory mice and rats are these same species bred as ''knockouts'' or transgenics (NRC 2003). Laboratory animals are bred for genetic manipulations that produce disease conditions upon which treatments can be tested. In addition to laboratory mice and rats, more than 5,400 species of mammals occur globally that field investigators might study scientifically (Wilson and Reeder 2005). For such studies the IACUC will require a protocol in which the investigator provides an adequate description of the study methods, experimental design, and expected results and a summary of related, previous studies. The IACUC might query investigators about planned methods of euthanasia even if the proposed study involves only observing or catching and releasing animals. ''We are not killing any animals'' is a frequent, but unsatisfactory, response to an IACUC because it indicates that the investigator has not considered methods of treatment or euthanasia in the event of an unexpected injury.

The investigator must provide assurance to the IACUC that permits necessary for use of wild mammals have been issued for the proposed project; copies of permits might be requested by the IACUC. Although most IACUCs usually do not focus on scientific merit, it is required by federal regulations in the United States that the IACUC ask that scientific merit has been assessed. IACUCs that deal primarily with biomedical protocols sometimes have difficulty evaluating the merit of protocols of field studies. Peer review of scientific proposals, approval of project permits by resource agencies, and support from academic departmental chairs can provide assurance to the IACUC that the project is sound and use of animals justified. Although rare, the IACUC might seek an outside assessment or request evidence of peer review to evaluate scientific merit.

TRAPPING TECHNIQUES

Oversight of Field Studies

Field studies not involving invasive procedures that harm or significantly alter behavior of an animal are exempt from IACUC review (Section 2.31 (d) IACUC review of activities involving animals (1) ''field studies … are exempt.''—USDA 2005), but many institutions interpret AWA in a broader sense and require IACUC review of all laboratory, classroom, and fieldwork involving vertebrate animals. For those studies that require review and approval by the IACUC, many field procedures for mammals are available (e.g., Kunz and Parsons 2009; Martin et al. 2000); these sources should be consulted by the investigator during protocol preparation and referenced as needed. Further, some institutions may have standard procedures available to all investigators preparing protocols.

Considerations for Capturing Mammals

A variety of methods and devices are available for trapping wild mammals. Techniques for capture of specific species of mammals are detailed in summary sources (Wilson et al. 1996), Internet sites devoted to specific subsets of mammals (http://www.furbearermgmt.org/resources.asp#bmps), and especially in articles from the primary literature. Trapping can include live traps (e.g., Sherman, box, mist nets, snares, Tomahawk, Hav-A-Hart, pitfall, nest box, and artificial burrow), kill traps (Museum Special, rat traps, and pitfalls), and other specialty traps for particular species or purposes. Shooting might be necessary to obtain specimens of some species. Sometimes physical capture of animals is not essential, and investigators can use devices to obtain acoustic signatures (ultrasonic detectors), visual data (still or video cameras), or sticky devices to remove hair from free-ranging mammals. Common reasons to capture mammals include livetrapping to tag (with radiotransmitters, necklaces, ear tags, or passive integrated transponder tags), mark (number, band, hair color, freeze brand, ear tag, or toe clip), or collect tissue. Regardless of the approach, potential for pain, distress, or suffering must be considered. When livetrapping, adequate insulation and food must be provided, and temperature extremes avoided. Kill-trapping methods must provide an efficient and quick death that minimizes pain. In general, observational techniques are not of concern to IACUCs unless they involve capture (e.g., capturing bats in mist nets to identify species before animals are released or use of artificial burrows or nest boxes to facilitate capture), harassment, or visiting nest sites during critical times in a species' life cycle (e.g., bat nursery roost or seal pup nursery). Individual IACUCs and institutional policies vary widely regarding exemptions for observational studies, so investigators should become familiar with their institutional policies before beginning any work with mammals.

Live Capture

Investigators conducting research requiring live capture of mammals assume the responsibility for using humane methods that respect target and nontarget species in the habitats involved. Methods for live capture include those designed for small mammals (Sherman, Tomahawk, and Hav-A-Hart traps, pitfalls, artificial burrows, and nest boxes), medium-sized to large mammals (Tomahawk, Hav-A-Hart, and foothold traps, snares, corrals, cannon nets, culvert traps, and darting), bats (mist nets, harp traps, and bags), and fossorial mammals (Baker and Williams 1972; Hart 1973). Methods of live capture should not injure or cause excessive stress to the animal. Adequate measures should be taken to ensure that the animal is protected from predation and temperature extremes and has food and water available, as needed, until it is released. For permanent trapping grids or webs the investigator might provide shelters over traps to protect captured animals from extreme temperatures and precipitation (Kaufman and Kaufman 1989).

Use of steel foothold traps for capturing animals alive must be approached cautiously because of potential for injury or capture of nontarget species (Kuehn et al. 1986). For some taxa foothold traps, including leg snares, might present the only means of capture available and might be most effective (Schmintz 2005; see also http://www.furbearermgmt.org/resources.asp#bmps for specific techniques). When their use is appropriate, investigators have an ethical obligation to use steel foothold traps of a sufficient size and strength to hold the animal firmly. Traps, other than snares, with rubber padded or offset jaws should be used to minimize potential damage to bone and soft tissue. Snares or spring foothold traps must be checked frequently (perhaps twice daily or more often depending upon target species and potential for capture of nontarget species) and captured animals assessed carefully for injury and euthanized when necessary. Nontarget species, if uninjured, should be released immediately, but their release, as with target species, might require chemical immobilization to prevent injury to the animal or researcher.

The number of traps set at a particular time and location should not exceed the ability of the investigator to monitor them at reasonable intervals. Because prompt and frequent checks of traps is the most effective way to minimize mortality or injury to animals in live traps, the investigator should consider staking or visibly flagging a trapline (or otherwise devising some effective system) to ensure that all traps are recovered and removed reliably and efficiently. Regular monitoring ensures that target animals remain in good condition while in traps and allows prompt release of nontarget species with no ill effects caused by capture. Examination intervals vary and are dependent on target species, type of trap, weather, season, terrain, and number and experience of investigators. Generally, live traps for nocturnal species are set before dusk and checked at dawn. Traps are then retrieved or closed during the day to prevent capture of diurnal, nontarget taxa. However, live traps for small mammals, particularly shrews, should be checked more frequently (e.g., every 1.5 h—Hawes 1977) to minimize mortality due to higher metabolism of these animals. Similarly, species of larger size with high metabolic rates (e.g., *Mustela*) also require shorter intervals between checking traps. Live traps for diurnal species should be set at dawn or early morning in areas that remain shaded or under trap shelters (Kaufman and Kaufman 1989) and checked every few hours in warm weather. Traps then should be retrieved or closed at dusk to prevent unintended capture of nocturnal taxa.

Thermoregulatory demands, especially for small mammals, can induce stress even if duration of captivity is short. Thermoregulatory stress can be minimized by providing an adequate supply of food and nesting material in the live trap. Because most live traps for small mammals are constructed of metal and conduct heat readily, it might be necessary to insulate traps to minimize hypo- and hyperthermia in captive animals. Insulation can be accomplished by using such items as cotton or synthetic fiber batting, leaves, or twigs to provide dead air space between the animal and conducting surface and to provide escape from the temperature extremes. Critical temperature tolerance limits vary with species and environmental conditions. Investigators must be responsive to changing conditions and modify trapping procedures as necessary to minimize thermal stress.

If disturbance (removal of animal or trap damage) of live traps for small mammals by larger species of carnivores, birds, and others is problematic, trap enclosures (Getz and Batzli 1974; Layne 1987) or other methods to secure traps might be required. Pitfall traps can be fitted with raised covers to minimize capture of nontarget species, provide cover from rain and sun, and prevent predation from larger animals. Pitfall traps used for live capture might require small holes in the bottoms to allow drainage in rainy weather, or enhancements such as small sections of polyvinyl chloride pipe to provide escape from other captured animals.

Traps used for live capture of larger mammals include box traps, Clover traps, and culvert traps. Some large mammals (e.g., ungulates and kangaroos) can be herded along fences into corrals or captured with cannon nets or drop nets projected from helicopters using net guns. These methods require immediate attention to the animals by trained personnel to prevent injury and can cause substantial distress in some species. With a large-scale capture it could be useful to contract with a veterinarian to assist with any injured or stressed animals. Depending on the nature of the activity, individuals captured using these techniques might need to be sedated or have their eyes covered until the investigator's work is completed (Braun 2005).

Large mammals also can be captured by delivering a sedative into the hip or shoulder musculature using a dart gun. Chemical immobilization, whether for capture or sedation, requires training by a wildlife veterinarian and thorough knowledge of proper dosage, antidote, and sedative effect. An excellent reference for chemical immobilization of mammals is Kreeger (1996). Local and national regulations may restrict use of certain drugs (e.g., narcotics). Location of the animal within the habitat should be considered in light of time necessary for sedation and recovery to avoid injury or drowning of the sedated mammal. Further, sedated mammals must be monitored closely during procedures and observed after release until they regain normal locomotion. In no instance should sedated animals be left in proximity to water or exposed to potential predators while under the influence of immobilizing drugs. Baits laced with tranquilizer have been described (Braun 2005), but these should be used with caution to prevent sedating nontarget species.

Bats can be captured effectively and humanely with mist nets, harp traps, bag traps, or by hand (Kunz and Parsons 2009). Mist nets should not be left unattended for >15 min when bats are active. Captured bats should be removed from nets immediately to minimize injury, drowning, strangulation, or stress. Bats must be removed carefully from mist nets to minimize stress and avoid injury to delicate wing bones and patagia. If a bat is badly tangled, it can be removed by cutting strands of the net. Mist nets should not be used where large numbers of bats might be captured at once (e.g., at cave entrances) because numbers can quickly overwhelm the ability of investigators to remove individuals efficiently and safely. In these situations harp traps or sweep nets are preferred (Wilson et al. 1996). Although harp traps do not require constant attention, they should be checked regularly, especially when a large number of captures is expected in a short period of time. Investigators using harp traps should guard against predators entering the trap bag or biting captured bats, predation of 1 bat species on another, rabies transfer, or suffocation due to large numbers of bats caught in a short time (Kunz and Parsons 2009).

To minimize stress on captured bats the number of mist nets operated simultaneously should not exceed the ability of investigators to check and clear nets of bats. Nets should not be operated in high winds because these conditions can place undue stress on bats entangled in nets. Mist nets should be operated only at night or during crepuscular periods and closed during the daytime to prevent capture of nontarget taxa (e.g., birds).

Roosting bats sometimes can be removed by gloved hand. Gloves should offer protection from bites but still allow the investigator to feel the body and movements of the bat to prevent injury to the animal. Long, padded tissue forceps might be used to extract bats from crevices, but extreme care should be taken to avoid injury to delicate wing bones and membranes (Kunz and Parsons 2009).

Investigators should consider that the time of year that bats are studied can impact their survival. Large or repeated disturbance of maternity colonies can cause mortality of offspring and colony abandonment (O'Shea and Bogan 2003). Also, repeated arousal of hibernating bats can lead to mortality because of depletion of critical fat stores (Thomas 1995).

Captured small and medium-sized mammals should be handled by methods that control body movements without restricting breathing. Covering an animal's eyes might reduce its struggle to escape. Restraint by a mesh or cloth bag allows the investigator to mark, measure, or otherwise sample an individual through mesh or the partially opened end of the bag (e.g., *Cynomys gunnisoni*—Davidson et al. 1999). Some small mammals also can be transferred directly from a trap to a heavy-duty plastic or cloth bag for transport. The design of some traps (e.g., box-type traps such as Sherman or Tomahawk live traps) also allows them to be used as a temporary cage for easy and safe transport.

Kill-trapping and Shooting

When study design requires that free-ranging mammals be euthanized to collect specific types of data or samples, individuals may be live-trapped (and then euthanized humanely), trap-killed, or shot (AVMA 2007). When this type of sampling is required the investigator must 1st consider the goals of the study and the impacts that removing a number of animals will have on the natural population. Animals should be euthanized as quickly and as painlessly as possible (see methods below) without damaging materials needed for research.

Traps suitable for kill-trapping include snap traps (e.g., Victor and Museum Special) for rat- and mouse-sized mammals, kill traps (e.g., Macabee) designed for subterranean species, harpoon traps for moles, snares for carnivores and furbearers, and Conibear or similar body-grip traps for medium-sized mammals. Some trapping techniques that use drowning as a means of euthanasia have been described as inhumane or unethical because time to unconsciousness exceeds 3 min (AVMA 2007; Powell and Proulx 2003). However, submersion trapping systems might be quite effective for furbearers found in or near waterways. Such systems rely on equipment (e.g., steel foothold traps with 1-way cable slides and locks) or techniques that cause the furbearer, upon capture, to quickly and irreversibly submerge until death (http://www.furbearermgmt.org/resources.asp#bmps).

Pitfall kill traps can be the best trapping option for some small mammals because the smaller species of rodents and shrews are much more effectively captured with pitfalls than by other means. These traps are particularly efficient where trapping must be continuous or extensive in a way that cannot be achieved with live traps or snap traps that need continual resetting. Pitfalls used with drowning fluids add a measure of preservation and thus can have added utility for scientific collections and detailed study of organs. Additional instances where pitfalls are optimal are outlined in Beacham and Krebs (1980) and Garsd and Howard (1981). Ethical use of pitfall kill traps should minimize struggling and suffering. The pitfall designed by Howard and Brock (1961) does this by using 70% ethanol (or similar alcohol) as the main ingredient of a drowning fluid. Evaporation of the alcohol is retarded by a thin layer of light mineral oil and hexane (2:1) added to the solution. Small mammals falling into the trap and hence into the drowning fluid lose buoyancy almost immediately due to the surfactant action of hexane and mineral oil and thus their ability to swim effectively so that submergence and death occur rapidly. Alcohol then infuses the body and acts as a preservative. As long as the solution is deeper than the head–body length of the animals, they cannot struggle by standing on the bottom and quickly drown. Using pitfall traps as kill traps by placing formalin or ethylene glycol in the bottom, however, is not approved or acceptable to the ASM. Pitfalls used as kill traps should have covers or other means of excluding nontarget species. If the traps will not be operational for extended periods, they should be constructed such that the kill jar and its fluid can be removed to prevent unwanted captures. As with any procedure or experimental protocol, an IACUC might find submersion trapping systems, including pitfalls with drowning fluids for small mammals, acceptable with justification.

Investigators should strive to use the trap that will inflict the least trauma and result in a clean, effective kill. Most traps should be checked at least once a day, and in the event an animal is still alive, it should be immediately dispatched according to AVMA guidelines (AVMA 2007). The AVMA offers these recommendations regarding kill traps (AVMA 2007:16): ''Mechanical kill traps are used for the collection and killing of small, free-ranging mammals for commercial purposes (fur, skin, or meat), scientific purposes, to stop property damage, and to protect human safety. Their use remains controversial, and the panel recognized that kill traps do not always render a rapid or stress-free death consistent with criteria for euthanasia found elsewhere in this document. For this reason, use of live traps followed by other methods of euthanasia is preferred. There are a few situations when that is not possible or when it may actually be more stressful to the animals or dangerous to humans to use live traps.''

An effective way (sometimes the only way) to collect certain species of mammals is by use of a firearm. Investigators using this method must be experienced in safe handling of firearms and adhere strictly to laws and regulations related to their possession and use. The firearm and ammunition should be appropriate for the species of interest so that the animal is killed swiftly without excessive damage to the body. A .22-caliber rifle loaded with bullets or shotguns loaded with appropriate shot sizes are suitable for medium-sized mammals. Generally, small mammals (chipmunk size or smaller) can be taken with .22-caliber rifle or pistol loaded with #12 (dust) shot, whereas animals the size of rabbits can be taken with shotguns loaded with #6 shot. Large mammals should be taken with a high-velocity rifle, where legal, or shotguns using appropriate ammunition (e.g., rifled slugs or larger shot). After the animal has been shot, it should be retrieved quickly.

Marine Mammals

All marine mammals in United States territorial waters are protected by the Marine Mammal Protection Act of 1972. Some species also are protected by the Endangered Species Act of 1973. The latest versions of both acts can be found at the United States Marine Mammal Commission Web site (http://www.mmc.gov/legislation/). These acts prohibit any form of ''take,'' including terminal capture, live capture, and tagging, of marine mammals without appropriate federal permits. Exceptions are made for certain aboriginal or traditional harvests of marine mammals and for commercial fisheries that might take marine mammals incidental to normal fishing operations. Permit application forms and instructions can be found on the National Marine Fisheries Service Web site (http://www.nmfs.noaa.gov/prot_res/overview/permits.html) and at the United States Fish and Wildlife Service Web site (http://permits.fws.gov/).

Methods of live capture for marine mammals include nets (ranging from purse seines to small, handheld hoop nets) and mechanical clamps with lines that are placed over an animal's peduncle while it rides the bow pressure wave of a vessel. Many live-capture techniques for smaller cetaceans are reviewed by Asper (1975). Some dolphin or small whales (e.g., *Phocoena* and *Delphinapterus*) can be captured by hand in shallow water (Walker 1975). Although polar bears (*Ursus maritimus*) and some species of pinnipeds (e.g., northern elephant seal [*Mirounga angustirostris*]) might be captured using remotely injected chemicals, chemical immobilization of marine mammals for capture risks losing animals by drowning or overdose (Dierauf and Gulland 2001). Euthanasia for marine mammals was reviewed by Greer et al. (2001). Additionally, the Society for Marine Mammalogy has developed guidelines for the treatment of marine mammals in field research. The most current version of these guidelines is available at http://marinemammalscience.org/images/stories/file/ethics/ethics%20guidelines.pdf.

Holding of marine mammals in captivity is regulated by the Marine Mammal Protection Act, the Endangered Species Act, and the AWA. The latter is administered by USDA APHIS. The AWA regulations include species-specific criteria for pool and pen sizes and construction, water quality, food storage and handling, and routine health care. The most current AWA regulations can be found on the APHIS Web site (http://www.aphis.usda.gov/ac/cfr/9cfr3.html#3.100).

TISSUE SAMPLING AND IDENTIFICATION

Tissue Sampling

The collection of small amounts of tissue from wild mammals is often required for studies involving DNA, various proteins (e.g., hemoglobins, albumins, and enzymes), or physiological assays (e.g., hormonal levels and antibody titers). Tissue samples frequently are obtained in conjunction with some marking procedures (e.g., toe clips or wing or ear punches). Even where these techniques are not required for identification, small external tissue samples are frequently taken from unsedated animals with little difficulty. Where blood is required, many procedures do not require anesthesia of the animal and can be conducted in the field by appropriately trained personnel. After tissue collection and prior to release, individuals should be observed to ensure that no trauma or adverse reaction has occurred as a consequence of capture, handling, or tissue or blood removal.

Multiple factors must be considered when determining the most appropriate method for obtaining blood samples. Various morphological attributes (e.g., size of the orbit, absence of tail, or presence of cheek pouches) characteristic of the species can limit potential sites of blood collection. The size of the animal also might restrict collection sites and limit the quantity of blood ($\leq$1.5% of body mass) that can be removed. The training and experience of the individuals performing the procedure is important, because unskilled personnel can cause significant trauma with some techniques. The procedures for blood collection and the qualifications of study personnel must be reviewed by the principal investigator's IACUC.

Obtaining blood from the facial vein.—This technique, which has been used on laboratory mice for many years, allows collection of 4–10 drops of blood with minimal discomfort to the animal (see USDA news release at www.ars.usda.gov/is/pr/2005/050921.htm). The procedure is described (in text, photos, and video) at www.medipoint.com/html/directions_for_use1.html. [Note: No endorsement of this particular commercial product is intended by the ASM.]

Obtaining blood from the caudal vein.—Extracting blood from the caudal vein is a relatively simple procedure that involves the use of a needle (more difficult in small rodents) or nicking of the caudal vein with a lancet. Alternatively, excising the distal 1–2 mm of the tail can yield a small amount of blood and can be used for DNA extraction.

Obtaining blood from the retro-orbital sinus.—Retro-orbital bleeding should be used when less-invasive blood-collection methods have been considered and are not suitable. To minimize the chances of damage to the eye, this technique should be performed by trained and experienced individuals. The use of very short-acting anesthesia (e.g., isoflurane or sevoflurane) in a plastic bag will immobilize rodents in 15–20 s, thereby making the procedure safer for the rodent and the handler.

External Marks

Individual identification of mammals is necessary for many types of studies, both in the laboratory and field. Identification marks can be natural (stripe pattern, color, or mane patterns) or those applied by the investigator. Of primary concern is the distance from which the animal must be identified. On large species cataloging natural variations in fur or whisker patterns (West and Packer 2002), or previously sustained injuries on body parts (such as to wing, ears, or flukes), often suffices for permanent identification at a distance.

Where naturally occurring identifying marks are not available, external dyes, freeze brands, or paint marks might provide the degree of longevity required. Dye marks on juveniles or subadults are of more limited duration because of rapid molting. Identification marks can be made with nontoxic hair dyes or paint. Care should be taken to ensure that substances used for external marks are nontoxic and otherwise do not alter the behavior of animals or subject them to increased predation. Freeze branding is an effective means of marking bats and other species, and marks might last several years (Sherwin et al. 2002). Tattooing and ear punches provide a permanent means of identification but require handling of individuals for individual recognition.

Metal or plastic tags and bands or collars are cost-effective and might be suitable for identification at appreciable distance on large terrestrial species. Tags typically are applied to the ears of terrestrial mammals and to flippers of seals and sea lions. Use of individually numbered tags on small mammals necessitates handling the animal each time an individual is to be identified. Although they frequently are used with a high degree of success, ear tags might inhibit grooming of ears and promote infection by parasites in some rodents (Ostfeld et al. 1996), although potential for infection likely varies with species and environment. Further, unless carefully sized, tags might snag, either during grooming or by vegetation in free-ranging animals, and can be lost (Wood and Slade 1990). Ear tags also might affect the Preyer reflex in free-ranging animals. Many of the problems associated with ear tags are reduced in laboratory settings where ear tags might be especially useful for long-term identification. Ear tags are not an option for species with greatly reduced pinnae (e.g., shrews). Wing bands for bats should be applied so that they slide freely along the forelimb, which may necessitate cutting a slit in the wing membrane in some cases. Another external marking option for bats is a carefully sized bead-chain necklace (Barclay and Bell 1988).

Individuals of some taxa might be identified by unique patterns of ear punches (where a small amount of tissue is removed from external pinnae using some type of hole punch) or toe clips. Toe clipping involves removal of 1 or more digits (generally only 1 per foot) or terminal phalanges and provides a permanent identifying mark. These marking methods necessarily involve recapture because neither is generally suitable for identification at a distance. Further, ear punches might become unidentifiable through time in free-ranging individuals because of healing, subsequent injuries sustained in the field, or being obscured by hair. Because both of these methods involve removal of a small amount of tissue, they might be especially appropriate in studies where tissue samples also are required.

Because it is more invasive and addressed specifically in the *Guide* (NRC 1996), toe clipping requires justification to the IACUC. Justification for toe clipping as a means of identification should include consideration of the natural history of the species, how the feet are used in the animal's environment, and the size of the toe. Digits generally should not be removed from the forefeet of subterranean or fossorial taxa where they are used for digging, nor should primary digits be removed from arboreal or scansorial taxa where they are used for climbing. Toe clipping in species with fleshy digits should be avoided. Toe clipping might be especially suitable for permanent identification in small species (e.g., *Chaetodipus*, *Perognathus*, *Peromyscus*, *Reithrodontomys*, and *Sorex*) and in neonates of larger taxa. Toe clipping and ear punches should not be used for marking bats; bats can be wing punched or freeze branded effectively. Toe clips and ear punches should be performed with sharp, sterilized instruments. Anesthetics and analgesics generally are not recommended because prolonged restraint of small mammals to administer these substances and consumption of the analgesic substances (e.g., creams) via licking likely cause more stress and harm than conducting the procedure without their use.

Radiotransmitters provide a mechanism to monitor movements and survival of individuals and, therefore, also serve to identify an individual. Transmitters can be attached externally with surgical or skin glue or a collar, or implanted into the body cavity. External attachment often can be accomplished in the field (Munro et al. 2006; Rothmeyer et al. 2002), whereas more-invasive implantation might require transport to a laboratory where sterile conditions can be arranged. Investigators using collars should take into account potential for growth of an animal or seasonal changes in neck circumference (e.g., male cervids) and use devices designed to accommodate such changes (Strathearn et al. 1984). If external transmitters are attached using glue, individuals of some species will groom each other excessively to remove adhesive from their fur (Wilkinson and Bradbury 1988). Surgical implantation and more invasive procedures, which should be performed by a veterinarian or individuals who have received specialized training, usually require a suitable recovery period before the animal can be released. Before using radiotransmitters, an investigator should consider the mass of the transmitter relative to the body mass of the target species or individual. Generally, the transmitter should represent <5–10% of the individual's body mass (Wilson et al. 1996). As an alternative to radiotransmitters, light-emitting diodes, or similar markers might be fastened externally to some species.

Internal Tags

Passive integrated transponder tags are electronic devices encased in glass or resin capsules. They do not emit constant signals but can be interpreted with a remote reader in much the same way that bar codes are scanned. Tags are injected subcutaneously by using a modified large-bore hypodermic syringe and are suitable for many field and laboratory identification needs. Tags should be massaged away from the point of insertion subdermally to prevent loss. Even the smallest passive integrated transponder tags (about the size of a grain of rice) can be too large for some individuals, so their use in very small individuals should be approached cautiously. Currently available passive integrated transponder tag readers must be in reasonably close proximity to the tag (~10 cm) for reading, so their use with large, aggressive taxa (e.g., *Procyon* and *Lynx*) might require anesthesia both for application of the tag and for subsequent reading to prevent injury to the animal and investigators. Because of stress for both subject and investigator, other methods of tagging large mammals, such as using radiotransmitters or naturally occurring markers, might be preferable. Ingestion of colored plastic particles or radioactive isotopes (such as ^{32}P) in bait can be used to mark feces for studies of movements of individuals or groups of individuals but is of limited use for uniquely marking a large number of individuals.

Chemical Immobilization for Application of Marks and Tissue Sampling

Depending on the biology of the target species, its size, and goals of the study, captured animals might require chemical immobilization for handling. Investigators should bear in mind that stress and restraint associated with immobilization might be greater than applying or reading a particular mark or taking noninvasive tissue samples without immobilization. Whether immobilization is required must be considered on a case-by-case basis. If pain is slight or momentary, anesthesia is not recommended so that the animal can be released immediately. Procedures that can cause more than momentary or slight pain or distress should be performed with appropriate sedation, analgesia, or anesthesia (Article V, *United States Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training*—http://grants.nih.gov/grants/olaw/references/phspol.htm). In these instances field-portable anesthetic machines allow use of isoflurane and similar inhalants to provide a reliable anesthetic and rapid recovery after the animal is no longer exposed to the gas. Use of anesthesia for blood sampling will depend on data needed and species requirements. Some anesthetics (e.g., ketamine) depress blood pressure and make blood collection lengthier and potentially dangerous. Anesthesia also might alter the blood component (e.g., cortisols) under investigation. Use of anesthesia should be weighed against risk of mortality because some species are very sensitive to anesthesia (e.g., felids—Bush 1995; Kreeger 1996). Selection of anesthetics and analgesics for specific mammals should be based on evaluation by a specialist, such as a wildlife veterinarian, knowledgeable about the use of anesthesia in species of mammals other than standard laboratory or pet taxa. The investigator should conduct a literature review for alternatives and anesthetics and analgesics used in related species (Kreeger 1996). Physiological measurements required for experimental purposes also can affect the choice of anesthesia. Sedatives, anxiolytics, and neuromuscular blocking agents are not analgesic or anesthetic and hence do not relieve pain; these substances must be used in combination with a suitable anesthetic or analgesic (NRC 1996).

MAINTENANCE OF WILD-CAUGHT MAMMALS IN CAPTIVITY

Procurement and Holding Conditions

Any time wild-caught individuals are to be held or transported the investigator must consider the transport or holding cage, appropriate and sufficient food and moisture for the captured animal, ambient environment, ecto- or endoparasites potentially present, and safety of the investigators (see section on ''Human Safety''). Cages must be constructed to minimize possibility of injury, provide adequate ventilation, allow for protection from wastes, and generally should be of sufficient size to permit the captive individual to make appropriate postural adjustments (NRC 1996). Some types of live traps (e.g., Sherman traps and Tomahawk traps) can be used as holding or transport cages for short periods of time for appropriate species.

Captive mammals held for any length of time (>12 h for USDA regulated species and >24 h for all others) must be provided with suitable sources of food and moisture. Food can be provided at the time of capture. For many small mammals, especially rodents, fruits or vegetables (e.g., grapes, celery, cabbage, lettuce, or slices of apple or potato) with high moisture content will suffice during transport or short periods of captivity until more-permanent housing, food, and water provisions can be provided. Water bottles generally should be avoided during transport because they will leak and dampen bedding.

Care must be taken in transporting captive animals to prevent their exposure to temperature extremes or precipitation, provide adequate ventilation, and keep them calm. Regardless of cage construction, the more quietly the animal can be maintained in appropriate caging, the better. Minimizing disturbance and placing transport cages in cool, darkened settings is best. In some instances these conditions can be achieved simply by placing a drape over the cage, provided air flow is sufficient and temperatures are not extreme.

Free-ranging mammals might carry diseases and almost certainly harbor ecto- and endoparasites. Some facilities require treatment for ectoparasites before transport, and most will require quarantine of newly captured individuals before entering an animal resource facility. Even if these are not required, the investigator should take appropriate steps to minimize potential impacts to other captive species and humans. Most ectoparasites can be controlled by dusting with commercial flea and tick powder. Treatments for endoparasites are more involved and generally should be pursued after consultation with a veterinarian. Investigators should contact the local institutional occupational health office for information on risks to humans from species of mammals under consideration before transport.

Maintenance Environments

When individuals of wild species are to be maintained in captivity for >12 h, the caging and holding environment must be selected carefully to accommodate species-specific requirements and to minimize stress. Cages or pens of an appropriate size and construction must adequately contain animals for their health and safety and that of investigators and animal care personnel. Because of the great variety of mammalian species that might be maintained, no specific guidelines for cage materials or size are possible, but considerations should be given to all aspects of ecology, physiology, and behavior of target species. Guidelines developed for husbandry of domesticated species might not be appropriate for wild-caught individuals and might even constitute inhumane treatment. Because of their capture as free-ranging individuals, nondomesticated species might perform better in larger cages or pens than those used for similar-sized domesticated species (Fowler 1995). Temperature, humidity, lighting, and noise levels also must be within appropriate limits. An excellent source of information on the specific needs of wild-caught species is the ASM's *Mammalian Species* series (http://www.amsjournals.org). Additional valuable information usually can be obtained directly from investigators or animal-care staff familiar with particular species. Investigators proposing to maintain wild-caught mammals in captivity are encouraged to contact other researchers or institutions experienced with the taxa in question and to consult with the IACUC's attending veterinarian before submitting a protocol; however, investigators should realize that departures from the *Guide* (NRC 1996) or the Public Health Service policy on use of laboratory animals (Office of Laboratory Animal Welfare 2002a), even if optimum for the proper maintenance of nondomesticated taxa, will require justification to the IACUC.

Careful selection of bedding materials and substrate is critical to meet the needs of the target species. Materials used should simulate as closely as possible the natural environment. Appropriate materials might include sand or fine wood chips for desert species, soil and leaf litter for shrews and fossorial forms, and hay or straw for other species of rodents. The quantity of bedding also might be important if a dense covering (e.g., straw) allows establishment of runways that are components of the natural environment of the target species. Refuges should be provided where captive individuals can remain concealed when possible because the availability of refuges influences behavior (Rusak and Zucker 1975).

Olfactory cues are a fundamental component of the natural environment of most mammals, and the design of husbandry practices should incorporate the maintenance of familiar scents to maximize animal comfort. Individuals frequently scent mark to establish possession and boundaries of a territory. Regular changing of bedding and washing of the cage and associated equipment eliminates normal scent cues and places captive individuals in a novel and potentially stressful environment. Investigators can reduce stress that accompanies cleaning by changing bedding and cage equipment on a less-frequent cycle than typically used for domesticated species (often 1 or 2 times weekly). Investigators also can mix a small amount of the old bedding with fresh bedding. Species adapted to arid conditions (e.g., *Onychomys*) likely will perform best when bedding changes occur every 10–14 days, or even less frequently, whereas others (e.g., *Sigmodon*) might require weekly changes. Because scent marks often are deposited on watering devices or cage lids, disturbance associated with being placed into a novel environment can be reduced by changing these devices on a schedule different from that of the cage and bedding so that captive individuals are not regularly placed in an environment completely devoid of familiar scents. The importance of establishing and maintaining familiar surroundings, especially as identified by olfactory cues, cannot be overemphasized.

All species of mammals require some source of water in captivity, although water sources and requirements vary widely among species. Most mammals are best maintained with liquid water provided in various containers or via lickable watering systems. However, kangaroo rats (*Dipodomys*) and pocket gophers of various genera live without free water in the wild because they get water directly from their food and retain metabolic water (Boice 1972). These taxa can be maintained in captivity by periodically feeding small amounts of cabbage, lettuce, celery, or apple. The frequency of these supplemental feedings is dependent upon the ambient humidity in their environment. Adult heteromyids (e.g., *Dipodomys*) seldom even require these. If provided with ad libitum access to free water, xeric-adapted species can become dependent upon these sources (Boice 1972), which can result in changes in physiological functions that might confound some studies.

Because the lack of stimulation in a captive environment can result in development of stereotypic behaviors that confound research interests, environmental enrichment can be a critical component of husbandry for nondomesticated mammals. Enrichment might be as simple as increasing structural complexity in the cage or providing additional materials for manipulation. For example, the captive environment of woodrats (*Neotoma*) kept in false-bottom cages can be improved by providing rodent chow directly in the cage rather than in a feeder attached to the cage front. This allows these natural hoarders to regularly rearrange food within their cage. Their environment can be improved even more by providing strips of cardboard that will simulate the woody debris they use to construct nests in the wild. Other species of rodents also can benefit from inclusion of fibrous materials from which to construct nests. Chipmunks (*Tamias*) and red squirrels (*Tamiasciurus*) are very active and can be difficult to maintain in captivity, but they can be housed by using cages that incorporate 3-dimensional structures (e.g., hanging branches and perches) along with a substrate sufficient for digging and caching food. For some species hiding food in cardboard boxes allows the animal to ''forage.''

Social structure of the target species also must be taken into account when housing captive mammals. Captive situations that permit an approximation of the natural social structure of the target species are likely to be most successful and minimize distress. Individuals of species that are social or gregarious should be housed with other individuals. Of course, investigators must be aware of seasonal changes in social structure and modify housing environments accordingly.

Separation of Taxa and Minimizing Stress

The AWA and animal regulations (Office of Laboratory Animal Welfare 2002a, 2002b; USDA 2005) state that animals housed in the same primary enclosure must be compatible. That is, prey species should not be maintained near carnivores in the same animal room, and diverse taxa of carnivores generally should not be housed together. Closely related species of some rodents frequently co-occur in nature and often can be housed in the same room without difficulty.

The general principles for identifying captive mammals in pain or distress are abnormal appearance or behavior. Normal appearances and behavior are determined by species-specific characteristics and personal experience of the handlers. Because behavioral changes are the means to identify pain or distress, all personnel involved with animals should understand the normal behavioral patterns of the species they are housing. Thus, all animals should be monitored regularly by trained staff.

A source of pain generally is easy to identify if it is a physical abnormality, but stress or distress might not be due to pain and is not immediately recognizable. IACUCs generally consider that procedures that cause pain or distress in humans likely also will cause pain or distress in other animals. Characteristics of an animal in pain include, but are not limited to diarrhea or vomiting, poor coat, inflammation or bleeding, hair loss, abnormal posture, incessant scratching, self-aggression, lameness, whining, weight loss (20–25% of baseline), decreased food or water consumption (dehydration), decreased activity, or changes in body temperature, pulse, or respiratory rate (NRC 1992). Behaviors that might signal pain or distress include listlessness or lethargy, lying on the side for extended periods, inability to reach food or water, or unusual or prolonged vocalizations (NRC 1992).

Release of Captive Mammals

Release of wild-caught mammals held in captivity might be justified in the case of endangered or threatened species or species of special concern because of population levels or population dynamics, or for individuals held for only short periods. Research designs that require release of captive animals as part of a manipulation must be planned to minimize potential impact on the local population and stress to the released individuals.

Concerns regarding release of individuals held in captivity for more than short periods include the following:

- Introduction of individuals into an area without available dens and resources (especially problematic with highly territorial species)
- Alteration of population genetics
- Introduction of individuals not acclimated to the local environment
- Introduction to wild populations of pathogens acquired in a captive environment
- Stress on local populations and released individuals
- Excessive exposure to predation of released individuals due to inappropriate foraging cycles (entrained by captive light cycles or environments), extensive foraging due to not having caches built up for winter months, or lack of familiarity with local resources
- Disruption of social systems
- Animals losing or not learning foraging skills
- Legality of reintroduction of captive animals (varies with state and country)

Decisions on release and permissible duration of captivity before release are often species-specific and must be made on a case-by-case basis. Holding individuals of a given species for one or a few days to recover from surgical implantation of a transmitter or data logger is usually appropriate. In contrast, release of highly territorial species held for even short periods into the same environment from which they were captured can be problematic because vacant territories can be usurped, and reintroduction of the resident virtually guarantees a conflict that would not have occurred had the resident not been removed. For additional information regarding the potential release of marine mammals, investigators are referred to the best practices for these taxa developed by the National Marine Fisheries Service (http://www.nmfs.noaa.gov/pr/pdfs/health/release_guidelines.pdf). Final disposition of captive individuals is of concern, but the integrity of natural populations must be the highest priority in project design and IACUC deliberations.

EUTHANASIA

The *Guide* defines euthanasia as ''the act of killing animals by methods that induce rapid unconsciousness and death without pain or distress'' (NRC 1996:65). Euthanasia is a 2-step process that involves use of an agent to depress or eliminate the function of the central nervous system and a 2nd step to stop the heart. The 1st action causes the animal to become unconscious and insensitive to pain. Although both of these goals can be accomplished with a single agent, the primary concern is alleviating pain immediately.

Inhalation of carbon dioxide (hypoxia) commonly is used as a method of euthanasia in the United States. Although euthanasia by carbon dioxide has been the accepted method of choice in laboratory settings for the past 2 decades, it recently has been shown that some species display a high degree of avoidance of concentrations of carbon dioxide because of irritation of mucosal linings (Leach et al. 2002). Alternatively, argon gas has been used in the European Union for laboratory mice (*M. musculus*). Euthanasia techniques are reviewed and approved by the IACUC during review of the animal care and use protocol. Investigators should be aware that animal welfare regulations urge following the most current *AVMA Guidelines on Euthanasia* (AVMA 2007) and that deviations from these guidelines must be justified. Justification for deviations can include citation of published literature or results from pilot studies.

Mammals must be euthanized humanely when live-caught individuals are retained as voucher specimens or when individuals are injured or distressed and cannot be released. Field methods for euthanasia should be quick and as painless as possible, compatible with study design and size, behavior, and species of animal. When nothing can be done to relieve pain or distress or when recovery is not expected, euthanasia is indicated. Except when specifically excluded by permit or law (e.g., with endangered species), protocols involving fieldwork should explicitly indicate the circumstances for and method of euthanasia for voucher and distressed or injured animals, even when animal mortality is not an anticipated outcome, to accommodate unplanned injuries.

Euthanasia must be conducted by personnel properly trained in the procedure being used. Proper euthanasia technique includes a follow-up examination to confirm the absence of a heartbeat. Standard tests for successful euthanasia include a toe pinch, dilated pupil (lack of response to touch on eye), and absence of heartbeat; cessation of breathing is not a sufficient criterion. Decapitation, cervical dislocation, or thoracotomy (open biopsy of lung, pleura, hilum, and mediastinum) should be administered after euthanizing drugs to insure that animals do not revive (AVMA 2007). Although decapitation and cervical dislocation might be humane when administered by properly trained personnel, protocols proposing these techniques in the laboratory must justify these methods if sedation or anesthesia are not administered (AVMA 2007). Investigators also should be aware that adding steps of sedation and anesthesia before euthanasia might add distress and even impose additional pain to the animal. For many species of small body size, euthanasia (e.g., cervical dislocation) can be done efficiently in the field without sedation by experienced personnel.

Although euthanasia of small mammals in field settings can be accomplished using any of the techniques approved by the AVMA, field settings pose challenges because use of injectable controlled substances or inhalants can present additional risks to investigators and stress to the animals. Thoracic compression offers an acceptable alternative under these circumstances. Thoracic compression is an approved method of euthanasia for small birds (AVMA 2007) and has been used effectively for decades by practicing mammalogists. The AVMA lists advantages of thoracic compression as speed of euthanasia, apparent painlessness, and maximizing use of the carcass. Cervical dislocation and other mechanical techniques are of limited utility in many of these same instances because of logistical considerations and because they distort important body measurements, destroy needed tissues and skeletal elements, and alter hormonal profiles through contamination by blood. The ASM considers thoracic compression an acceptable form of euthanasia when the investigator is skilled in the procedure and when the individual mammals to be handled are sufficiently small that the thoracic cavity can be collapsed to prevent inspiration.

Acceptable methods of euthanasia—their advantages, disadvantages, and effectiveness—are reviewed in the *AVMA Guidelines on Euthanasia* (AVMA 2007). The report also provides information on inhalant agents, noninhalant pharmaceutical agents, and physical methods used in euthanasia. Unacceptable methods generally include air embolism, blow to the head, burning, chloral hydrate, cyanide, decompression, drowning, exsanguination (unless blood is collected from the unconscious animal as part of the approved protocol), formalin, various household products, hypothermia, neuromuscular blocking agents, rapid freezing, strychnine, and stunning (Appendix 4—AVMA 2007). Recently, the American College of Laboratory Animal Medicine evaluated rodent euthanasia. They had 3 issues of concern: euthanasia of fetal and neonatal rodents, use of carbon dioxide for euthanasia, and impact of euthanasia techniques on data collection. Publications by the American College of Laboratory Animal Medicine (www.aclam.org/pdf/newsletter2005-12.pdf) provide appropriate directives on these topics. For collecting methods using kill traps it is important to recall the AVMA position that, although kill traps do not always render a rapid or stress-free death consistent with their criteria for euthanasia, situations exist when use of live traps and subsequent euthanasia are not possible or when it might be more stressful to the animals or dangerous to humans to use live traps as opposed to kill traps (AVMA 2007).

Finally, euthanasia must be performed with a conscious respect for its effect on other animals (including human observers). Fear in other animals can be triggered by distress vocalizations, fearful behavior, and release of odors and pheromones by a frightened animal (AVMA 2007). Thus, euthanasia should be done outside the perceptive range of other captive individuals.

Vouchering of Specimens and Ancillary Materials

Investigators always must plan what to do with animals from wild populations when their study is completed or when animals are procured unexpectedly during the study. The latter might result from incidental deaths when animals are found dead in traps or on roadways. All specimens and ancillary material generated from field studies should be deposited with relevant data into an accredited research collection. The ASM Systematic Collection Committee has compiled a list of accredited collections in the Western Hemisphere (Hafner et al. 1997). The information is available online at http://www.mammalsociety.org/committees/index.asp. Deposition of specimens and ancillary materials in permanent collections maximizes benefits from each specimen collected, ensures access to valuable data by future investigators, and serves as a voucher for individuals or species used in published research. Further, in some instances archived specimens might be used in lieu of sacrificing individuals in future studies.

Human Safety

Working with wild mammals, particularly in field situations, involves inherent risks, both biotic (e.g., bites, pathogens, parasites, and venomous plants and animals) and abiotic (e.g., lightning and exposure). Fortunately, most of these risks can be minimized with basic training, planning, mentoring, and experience. Investigators have the responsibility to ensure that personnel handling, transporting, or maintaining wild-caught mammals are qualified and familiar with the associated hazards (e.g., bites and exposure to body fluids) and requirements of the target species (e.g., bats—Constantine 1988). With appropriate preparation and training, investigators can adequately protect themselves and collaborators while conducting fieldwork with mammals (Kunz et al. 1996).

Many universities and other institutions offer field courses, workshops, and online programs for investigators and students to achieve the proper training in fieldwork and in working with wild-caught mammals. Occupational health medical staffs also provide strategies for avoiding biological, chemical, and other hazards. Sources such as the Centers for Disease Control and Prevention (1998, 1999; http://www.cdc.gov/) or state health departments can provide current information and precautions for personnel conducting epidemiological studies or working with populations suspected of posing specific health risks. Additionally, the ASM provides updated guidelines relative to hantavirus pulmonary syndrome for mammalogists and wildlife researchers conducting work on rodents that should be broadly applicable for field studies (Kelt et al. 2010). These guidelines also make the important clarification that earlier published guidelines by the Centers for Disease Control and Prevention (1998, 1999) never were intended to apply to field investigators conducting nonviral-based research on rodents. Special precautions (e.g., vaccinations) to ensure human safety might be necessary when transporting individuals known or suspected of carrying potentially lethal pathogens such as hantavirus or the rabies virus. In areas where zoonotics are known to occur bagging traps with a gloved hand and bringing them to a central processing area that follows institutional biosafety recommendations might be sufficient. Additional precautions might be required at the time of final processing of the captured animal, depending on data required. Although chloroform is considered highly hazardous to personnel, with attendant health risks of cancer and liver toxicity (http://www.osha.gov/sltc/healthguidelines/chloroform/recognition.html), under open-air field conditions its use might be appropriate because it kills ectoparasites that might pose greater risks to the researcher through transmission of disease.

Many IACUCs will require the investigator to document their protocols for human health and safety while working with wild-caught mammals. However, investigators and IACUC members should remain cognizant that risks from zoonoses vary depending on mammalian species, local environmental conditions, and the potential pathogens. Safety precautions should match perceived risks.

Summary

These updated guidelines on the use of mammals, including wild species, emphasize that investigators are responsible for compliance with federal and state guidelines regulating care and use of animals in research, display, and instruction. Investigators should work with IACUCs to develop research protocols that allow the scientific research objectives to be completed successfully while complying with animal welfare regulations. A rational, well-justified protocol, written succinctly and completely, will facilitate a positive and productive dialog with the IACUC. The task of the IACUC is to provide assurance to federal regulatory agencies and the public that animal research at an institution is being accomplished in accordance with the regulations and intent of the AWA and work with researchers and educators to develop appropriate protocols. IACUCs must be strong advocates for animal welfare and also animal use in research and education, especially when investigators provide clear justification for animal use and expertise upon which the IACUC can rely. These interactions foster strong, positive, and professional relationships between the IACUC and the investigator.

From initial design to completion of a study, investigators should exercise good judgment and prudence when using animals in research. IACUCs appreciate working with investigators who provide details of their research designs and goals. The ''3 Rs'' of Reducing the number of individuals without compromising statistical validity or biological significance, Replacing ''higher'' animals with ''lower'' ones, and Refinements of techniques and care to minimize pain or distress to animals (NRC 1996) are important goals for field mammalogy. Even in faunal surveys a cap on the number of animals collected usually is imposed by the permitting agency and likewise is expected by the IACUC. Underestimates of the number of animals needed for a study might invalidate results. Therefore, a sufficient number of animals (i.e., the number needed to meet research goals) must be clearly requested and justified. ''Replacement'' in mammals might be achieved by using cell lines, voucher materials from previous studies, or computer simulations where possible. Further, larger mammals usually are not collected in surveys or for genetic work. Rather, they can be subsampled by ear punch or hair combs, or tissues might be requested from mammalian research collections where much of this material might already be archived as specimens. Other alternatives include using carcasses of species of interest (especially larger carnivores or ungulates) that have been trapped or hunted for other purposes. However, investigators are reminded that such sources may introduce undesirable biases associated with age, sex, or size. Finally, an example of ''Refinement'' might include using behavioral responses as indicators of social dominance rather than outcomes of physical combat.

Most field investigators already embrace the ethical treatment of animals because of their respect for nature and their dedication to study wild species. These guidelines were developed to assist investigators in maintaining compliance and understanding the evolving suite of regulations. How we view use of mammals in research does not differ much from that of Joseph Grinnell when he walked Yosemite Valley nearly 100 years ago. Knowledge of most aspects of mammalian biology has advanced, but we still struggle with a basic understanding of our place in nature. Mammalogists continue to explore the farthest reaches of the earth. In contrast, the public and even some scientists in other fields have become removed sufficiently from what is wild that we still must be prepared to answer the question ''what good is it?'' That is, we must be able to communicate to a broad audience the applied and theoretical values of research on wild mammals. Proactive consideration of humane treatment of study animals will help to prevent retroactive criticism of our ethics and the research itself. With this in mind, the ultimate design of research objectives, and the methods and techniques to address those objectives, are the responsibility of the investigator. Guidelines can provide current information on ethical and regulatory standards, but they cannot replace individual judgment. Moreover, it is the investigator who has the drive, ingenuity, and freedom to seek novel and insightful advances in science.

RESUMEN

Las pautas generales para el uso de especies de mamíferos silvestres son actualizadas a partir de la previa versión de la Sociedad Americana de Mastozoología (ASM) (Gannon et al. 2007). Esta versión actualizada las técnicas profesionales mas actuales y reglamentaciones relacionadas al uso de ammiferos en investigación y enseñanza. Se incluyen recursos adicionales, resúmenes de procedimientos y requisitos de informes que no eran parte de versiones previas. Asimismo, incluimos detalles sobre el marcado, alberges, captura y colecta de mamíferos. Se recomienda que todo comité institucional para el cuidado y uso de animales, agencias regulatorias e investigadores usen estas guias al desarrollar protocolos de trabajo con animales salvajes. Estas guias fueron preparadas y aprobadas por la ASM cuya experiencia colectiva provee un entendimiento amplio y comprensivo de la biología de los mamíferos no domesticados en su ambiente natural. la versión mas recioente de estas pautas y todas las modificaciones subsequentes están disponibles en la pagina de la web del comité para el cuidado y uso de animales - ASM Animal Care and Use Committee page of the ASM website (http://mammalsociety.org/committees/index.asp).

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LITERATURE CITED

AD HOC COMMITTEE FOR ANIMAL CARE GUIDELINES. 1985. Guidelines for the use of animals in research. Journal of Mammalogy 66:834.

AD HOC COMMITTEE ON ACCEPTABLE FIELD METHODS IN MAMMALOGY. 1987. Acceptable field methods in mammalogy: preliminary guidelines approved by the American Society of Mammalogists. Journal of Mammalogy 68, supplement:1–18.

American Veterinary Medical Association. 2007. AVMA guidelines on euthanasia. http://www.avma.org/issues/animal_welfare/euthanasia.pdf. Accessed 27 October 2010.

Animal Care Program, Animal and Plant Health Inspection Service, United States Department of Agriculture. 1997. Animal care resource guide: animal care policy manual. Animal Care Program, Animal and Plant Health Inspection Service, United States Department of Agriculture, Washington, D.C. http://www.aphis.usda.gov/animalwelfare/policy.shtml. Accessed 25 May 2010.

Animal Care Program, Animal and Plant Health Inspection Service, United States Department of Agriculture. 2001. Animal care resource guide: research facility inspection guide. Animal Care Program, Animal and Plant Health Inspection Service, United States Department of Agriculture, Washington, D.C. http:/www.aphis.usda.gov/animal_welfare/rig.shtml. Accessed 25 May 2010.

Asper, E. D. 1975. Techniques of live capture of smaller Cetacea. Journal of the Fisheries Research Board of Canada 32:1191–1196.

Baker, R. J., and S. L. Williams. 1972. A live trap for pocket gophers. Journal of Wildlife Management 36:1320–1322.

Barclay, R. M. R., and G. P. Bell. 1988. Marking and observational techniques. Pp. 59–76 in Ecological and behavioral methods for the study of bats (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, D.C.

Beacham, T. D., and C. J. Krebs. 1980. Pitfall versus live-trap enumeration of fluctuating populations of *Microtus townsendii.* Journal of Mammalogy 61:486–499.

Boice, R. 1972. Water addiction in captive desert rodents. Journal of Mammalogy 53:395–398.

Braun, C. E. 2005. Techniques for wildlife investigations and management. Wildlife Society, Bethesda, Maryland.

Bush, M. 1995. Methods of capture, handling, and anesthesia. Pp. 25–40 in Wild mammals in captivity: principles and techniques (D. G. Kleiman, M. E. Allen, K. V. Thompson, and S. Lumpkin, eds.). University of Chicago Press, Chicago, Illinois.

Centers for Disease Control and Prevention. 1998. Hantavirus pulmonary syndrome—Colorado and New Mexico. Morbidity and Mortality Weekly Report 47:449–452.

Centers for Disease Control and Prevention. 1999. Update: hantavirus pulmonary syndrome—United States. Morbidity and Mortality Weekly Report 48:521–525.

Constantine, D. G. 1988. Health precautions for bat researchers. Pp. 491–526 in Ecological and behavioral methods for the study of bats (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, D.C.

Davidson, A. D., R. R. Parmenter, and J. R. Gosz. 1999. Responses of small mammals and vegetation to a reintroduction of Gunnison's prairie dogs. Journal of Mammalogy 80:1311–1324.

Dierauf, L. A., and F. M. D. Gulland (eds.). 2001. CRC handbook of marine mammal medicine. 2nd ed. CRC Press, Boca Raton, Florida.

Fowler, M. E. 1995. Restraint and handling of wild and domestic animals. 2nd ed. Iowa State University Press, Ames.

Gannon, W. L., R. S. Sikes, and the Animal Care and Use Committee of the American Society of Mammalogists. 2007. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 88:809–823.

Garsd, A., and W. E. Howard. 1981. A 19-year study of microtine population fluctuations using time-series analysis. Ecology 62:930–937.

Getz, L. L., and G. O. Batzli. 1974. A device for preventing disturbance of small mammal live-traps. Journal of Mammalogy 55:447–448.

Greer, L. L., J. Whaley, and T. K. Rowles. 2001. Euthanasia. Pp. 729–740 in CRC handbook of marine mammal medicine (L. A. Dierauf and F. M. D. Gulland, eds.). 2nd ed. CRC Press, Boca Raton, Florida.

Grinnell, J. 1928. Recommendations concerning the treatment of large mammals in Yosemite National Park. Journal of Mammalogy 9:76.

Hafner, M. S., W. L. Gannon, J. Salazar-Bravo, and S. T. Alvarez-Castañeda. 1997. Mammal collections in the Western Hemisphere: a survey and directory of existing collections. American Society of Mammalogists, Allen Press, Lawrence, Kansas.

Hart, E. B. 1973. A simple and effective live trap for pocket gophers. American Midland Naturalist 89:200–202.

Hawes, M. L. 1977. Home range, territoriality, and ecological separation in sympatric shrews, *Sorex vagrans* and *Sorex obscurus*. Journal of Mammalogy 58:354–367.

Howard, W. E. and E. M. Brock. 1961. A drift fence pit-trap that preserves captured rodents. Journal of Mammalogy 42:386–391.

Kaufman, D. W., and G. A. Kaufman. 1989. Burrow distribution of the thirteen-lined ground squirrel in grazed mixed-grass prairie: effect of artificial habitat structure. Prairie Naturalist 21:81–83.

Kelt, D. A., M. S. Hafner, and the American Society of Mammalogists' ad hoc Committee for Guidelines on Handling Rodents in the Field. 2010. Updated guidelines for protection of mammalogists and wildlife researchers from hantavirus pulmonary syndrome (HPS). Journal of Mammalogy 91:1524–1527.

Kreeger, T. J. 1996. Handbook of chemical immobilization. International Wildlife Veterinary Services, Inc., Laramie, Wyoming.

Kuehn, D. W., T. K. Fuller, L. D. Mech, W. J. Paul, S. H. Fritts, and W. E. Berg. 1986. Trap-related injuries to gray wolves in Minnesota. Journal of Wildlife Management 50:90–91.

Kunz, T. H., and S. Parsons (eds.). 2009. Ecological and behavioral methods for the study of bats. 2nd ed. Johns Hopkins University Press, Baltimore, Maryland.

Kunz, T. H., R. Rudran, and G. Gurri-Glass. 1996. Human health concerns. Appendix 2. Pp. 255–264 in Measuring and monitoring biological diversity: standard methods for mammals (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, D.C.

Layne, J. N. 1987. An enclosure for protecting small mammal traps from disturbance. Journal of Mammalogy 68:666–668.

Leach, M., V. Bowell, T. Allan, and D. B. Morton. 2002. The aversion to various concentrations of different inhalational general anesthetics in rats and mice. Veterinary Record 150:808–815.

Macrina, F. L. (ed.). 2005. Scientific integrity: text and cases in responsible conduct of research. 3rd ed. American Society of Microbiology Press, Washington, D.C.

Martin, R. E., A. F. Deblase, and R. H. Pine. 2000. A manual of mammalogy: with keys to families of the world. McGraw-Hill, New York.

Munro, R. H. M., S. E. Nielsen, M. H. Price, G. B. Stenhouse, and M. S. Boyce. 2006. Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. Journal of Mammalogy 87:1112–1121.

National Institutes of Health, Office of Animal Care and Use. 2009. Guidelines for preparing USDA annual reports and assigning USDA pain and distress categories. http://oacu.od.nih.gov/arac/documents/usda_reports.pdf. Accessed 26 May 2010.

National Research, Council. 1992. Recognition and alleviation of pain and distress in laboratory animals. National Academy Press, Washington, D.C.

National Research Council. 1996. Guide for the care and use of laboratory animals. National Academy Press, Washington, D.C.

National Research Council. 2003. Guidelines for the care and use of mammals in neuroscience and behavioral research. National Academy of Sciences, Washington, D.C.

Office of Laboratory Animal Welfare. 2002a. Public Health Service policy on humane care and use of laboratory animals. National Institutes of Health, Department of Health and Human Services, Bethesda, Maryland.

Office of Laboratory Animal Welfare. 2002b. Institutional animal care and use committee guidebook. 2nd ed. National Institutes of Health, Department of Health and Human Services, Bethesda, Maryland.

Olfert, E. D., B. M. Cross, and A. A. Mcwilliams (eds.). 1993. Guide to the care and use of experimental animals. 2nd ed. Canadian Council on Animal Care, Ottawa, Ontario, Canada. Vol. 1.

O'Shea, T. J., and M. A. Bogan (eds.). 2003. Monitoring trends in bat populations in the United States and territories: problems and prospectus. United States Geological Survey Information and Technology Report ITR 2003-0003:1–274.

Ostfeld, R. S., M. C. Miller, and K. R. Hazler. 1996. Causes and consequences of tick (*Ixodes scapularis*) burdens on white-footed mice (*Peromyscus leucopus*). Journal of Mammalogy 77:266–273.

Powell, R. A., and G. Proulx. 2003. Trapping and marking terrestrial mammals for research: integrating ethics, performance criteria, techniques, and common sense. Institute for Laboratory Animal Research Journal 44:259–276.

Rothmeyer, S. W., M. C. McKinstry, and S. H. Anderson. 2002. Tail attachment of modified ear-tag radio transmitters on beavers. Wildlife Society Bulletin 30:425–429.

Rusak, B., and I. Zucker. 1975. Biological rhythms and animal behavior. Annual Review of Psychology 26:137–171.

Schmintz, S. D. 2005. Capturing and handling wild animals. Pp. 239–285 in Techniques for wildlife investigations and management (C. E. Braun, ed.). Wildlife Society, Bethesda, Maryland.

Sherwin, R. E., S. Haymond, D. Stricklan, and R. Olson. 2002. Freeze branding for permanently marking temperate bat species. Wildlife Society Bulletin 30:97–100.

Society for the Study of Animal Behaviour. 2006. Guidelines for the treatment of animals in behavioural research and teaching. Animal Behaviour 71:245–253.

Strathearn, S. M., J. S. Lotimer, G. B. Kolenosky, and W. M. Lintack. 1984. An expanding break-away radio collar for black bear. Journal of Wildlife Management 48:939–942.

Thomas, D. W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy 76:940–946.

United States Department of Agriculture. 2005. Animal Welfare Act and animal welfare regulations. Animal Welfare Act as of November 1, 2005 as found in the United States Code, Title 7—Agriculture, Chapter 54—Transportation, sale, and handling of certain animals, Sections 2131–2159. United States Government Printing Office, Washington, D.C.

Walker, W. A. 1975. Review of the live-capture fishery for smaller cetaceans taken in southern California waters for public display. Journal of the Fisheries Research Board of Canada 32:1197–1211.

West, P. M., and C. Packer. 2002. Sexual selection, temperature, and the lion's mane. Science 297:1339–1343.

Wilkinson, G. S., and J. W. Bradbury. 1988. Radio telemetry: techniques and analysis. Pp. 105–124 in Ecological and behavioral methods for the study of bats (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, D.C.

Wilson, D. E., F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster (eds.). 1996. Measuring and monitoring biological diversity: standard methods for mammals. Smithsonian Institution Press, Washington, D.C.

Wilson, D. E., and D. M. Reeder (eds.). 2005. Mammal species of the world: a taxonomic and geographic reference. 3rd ed. Johns Hopkins University Press, Baltimore, Maryland. Vols. 1 and 2.

Wood, M. D., and N. A. Slade. 1990. Comparison of ear-tagging and toe-clipping in prairie voles, *Microtus ochrogaster*. Journal of Mammalogy 71:252–255.

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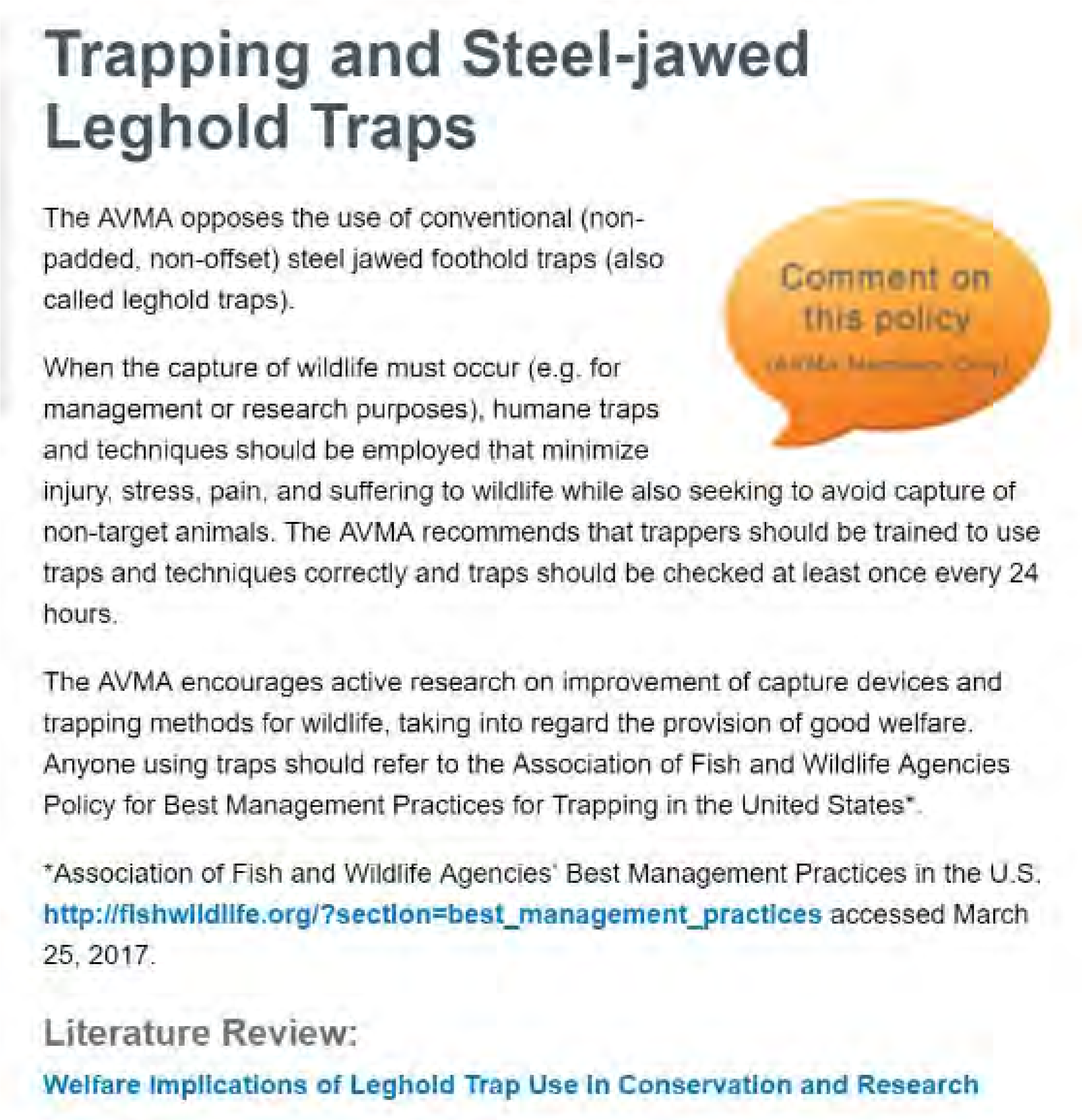

Trapping and Steel-jawed Leghold Traps

The AVMA opposes the use of conventional (non-padded, non-offset) steel jawed foothold traps (also called leghold traps).

When the capture of wildlife must occur (e.g. for management or research purposes), humane traps and techniques should be employed that minimize injury, stress, pain, and suffering to wildlife while also seeking to avoid capture of non-target animals. The AVMA recommends that trappers should be trained to use traps and techniques correctly and traps should be checked at least once every 24 hours.

The AVMA encourages active research on improvement of capture devices and trapping methods for wildlife, taking into regard the provision of good welfare. Anyone using traps should refer to the Association of Fish and Wildlife Agencies Policy for Best Management Practices for Trapping in the United States*.

*Association of Fish and Wildlife Agencies' Best Management Practices in the U.S. http://fishwildlife.org/?section=best_management_practices accessed March 25, 2017.

Literature Review:

Welfare Implications of Leghold Trap Use in Conservation and Research

Summary of Public Comments

FWP received and reviewed a total of 282 comments and letters.

Close to half the comments had some focus on wolves specifically.

160 comments (57%) identified as being against all trapping, most often describing the activity as “inhumane.” 78% of these were from outside of Montana. About 20% were one of several form letters. Several of these comments included language such as “torture,” “sinful,” “barbaric,” “sadistic,” “ignorant,” and “criminal.” One comment was threatening.

Of these 160 comments where it was clear that the person was against all trapping in general, 80% did not express an opinion on the specific issues in the proposal. Therefore, nearly half the public comment seemed to be an expression of the desire to simply eliminate trapping.

Of those who oppose trapping in general that did express an opinion on proposal specifics, 100% were in favor of a 24-hr check, and 100% were in favor of the proposed Modifications. When an opinion was expressed on the subject, this group was against Mandatory Education by a 4:1 margin. The most frequent reasoning given for opposing Education was that a class that included involvement by the Montana Trapper’s Association would be “unfair to non-consumptive users.” Most of the comments that opposed Mandatory Education appear to have initiated from a form letter by Wolves of the Rockies.

43 comments (15%) were from trappers, all but two from Montana. Of those who identified as trappers, 86% were for Mandatory Education, 83% were against Modifications, and all were against a 24-hr check. Many expressed that Mandatory Education and recommendations by FWP (rather than regulation) was the best way to achieve more the humane treatment of animals that Modifications and a Check-time are targeted toward.

Of those who did not specifically identify as a trapper or as being against all trapping in general, about half were for and half against Mandatory Education, about half were for and half against Modifications. 83% of this group expressed support for a 24-hr trap check.

99.9% of Montanans did not comment on this proposal.

Recommendations:

Mandatory Education

Mandatory trapper education should move forward as outlined. Developing and implementing a world-class program will be a serious and demanding undertaking and should be given high priority during the coming year. When done well, this program will improve many aspects of trapping in Montana for decades, including minimizing capture of non-targets and use of best practices (equipment and checks) that result in humane treatment of captured animals.

Public Comment Summary for June 2017 Trapping Proposal

Suggest striking the requirement to take the class again if a person has not purchased a license during the last 5 years. Several questions about exactly who does and does not have to take the class indicates the need to clarify in a succinct manner and via FWP media.

Modifications:

Retain the requirement for swivels as is. This modification is inexpensive and beneficial, and it did not receive any significant opposition. Strike the requirement for offsets and thicknesses. The details of these elements have not been thoroughly discussed and considered. They are expensive and time-consuming to implement, and thus any regulations that may arise regarding these elements should be based on a fully informed and exhaustive discussion prior to requiring specific changes.

It is important to note that the Association of Fish and Wildlife Agencies makes clear that their Best Management Practices were developed to be utilized as recommendations and not as the basis for regulations. If Montana moves to require elements identified as positive in the trapping BMP's, Montana will be moving toward a system that is used in Canadian Provinces where there is a list of approved traps.

Check Time

FWP should have a maximum time allowed legally between trap checks as a means of dealing with the occasional instance of negligence. Such a regulation would allow enforcement to pursue clear cases of negligence and would likely encourage reduced trap check intervals for some who currently check at "too long of an interval."

Of course, "too long of an interval" is subjective and dependent on an individual's judgement of what is ethical. Clearly there are wide and divergent opinions among the public regarding what is ethical or "too long of an interval." For some, any instance of trapping at all is unacceptable and unethical treatment of animals. For others, some of whom are trapping for purposes of reducing impacts of predators on livestock and livelihoods, the intent and need is to kill the animal by whatever means possible. Most who are trapping classified furbearers do not fall into either of the aforementioned categories. Perhaps for most Montanans, a group that did not comment on this proposal, the ethics of how long is too long to have an animal in a trap is a personal and individual decision that varies. An individual's judgement on how long is too long may also depend on situational specifics such as the likelihood of a capture, weather, or personal risk. FWP biologists and the Fish and Wildlife Commission have for many decades seemed to hold this flexible view that depends on personal ethics, having instituted a recommendation for a 48 hour check.

It should also be noted that a check time regulation will be very difficult to enforce. It is simply not feasible for FWP enforcement to "have a stopwatch ticking" on all trap-lines or even many trap-lines. Thus the effectiveness of a check-time toward achieving its desired outcome must be weighed against the pros and cons of other approaches.