Terrestrial Mammal Conservation

Global evidence for the effects of interventions for terrestrial mammals excluding bats and primates

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Cover image: Cape mountain zebra (*Equus zebra zebra*), De Hoop Nature Reserve, South Africa. Photograph by Rebecca K. Smith, CC-BY.

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2. Threat: Residential and commercial development

Background

Threats from residential and commercial development include the destruction of habitat, pollution and impacts from transportation and service corridors. Interventions in response to these threats are described in the following chapters: *Habitat protection*, *Habitat restoration and creation*, *Threat: Pollution* and *Threat: Transportation and service corridors*. The interventions that are more specific to development, including development of recreational facilities, are discussed in this section.

This section also includes interventions aimed at reducing human-wildlife conflict where continuation of this conflict can prompt calls for management actions including lethal control of the species involved.

Residential development can result in an increase in populations of domestic cats *Felis catus* and dogs *Canis lupus familiaris*, which can prey on wild mammals. Interventions that involve reducing predation by cats and dogs in residential areas are included here but see also interventions within *Invasive alien and other problematic species*.

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2.1. Protect mammals close to development areas (e.g. by fencing)

https://www.conservationevidence.com/actions/2324

- We found no studies that evaluated the effects of protecting mammals close to development areas (e.g. by fencing).

'We found no studies' means that we have not yet found any studies that have directly evaluated this intervention during our systematic journal and report searches. Therefore, we have no evidence to indicate whether or not the intervention has any desirable or harmful effects.

Background

Mammals living at the edge of developed areas may face particular threats from predation by domestic animals, persecution, road traffic and disturbance. Fencing could be erected in some situations, to reduce exposure of wild mammals to such threats.

2.2. Keep cats indoors or in outside runs to reduce predation of wild mammals

https://www.conservationevidence.com/actions/2326

- **One study** evaluated the effects on potential prey mammals of keeping cats indoors or in outside runs. This study was in the UK[1].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

- **Survival (1 study):** One replicated study in the UK[1] found that keeping domestic cats indoors at night reduced the number of dead or injured mammals that were brought home.

BEHAVIOUR (0 STUDIES)

Background

Domestic cats *Felis catus* can be major predators on wild mammals. For example, one study estimated that domestic cats in the UK brought home 52–63 million mammals over a five-month period (Wood *et al.* 2003). Keeping them indoors, or in enclosed outdoor runs, may substantially reduce their impact on wild mammals.

See also: *Use collar-mounted devices to reduce predation by domestic animals.*

Woods M., Mcdonald R. & Harris S. (2003) Predation of wildlife by domestic cats *Felis catus* in Great Britain. *Mammal Review*, 33, 174–188, https://doi.org/10.1046/j.1365-2907.2003.00017.x

A replicated study in 1997 in urban and rural areas in the UK (1) found that domestic cats *Felis catus* that were kept indoors at night brought home fewer dead or injured mammals than cats that were allowed outside. The average number of mammals brought home by cats that were kept indoors at night (6.0) was less than the number delivered by those that were allowed outside (8.9). Between April and August, cat owners recorded the number of prey brought home by 90 cats which were kept inside at night and 192 cats which were allowed outside. Only cats living in households with no other cats were included in the study.

(1) Woods M., McDonald R.A. & Harris S. (2003) Predation of wildlife by domestic cats *Felis catus* in Great Britain. *Mammal Review*, 33, 174–188, https://doi.org/10.1046/j.1365-2907.2003.00017.x

2.3. Use collar-mounted devices to reduce predation by domestic animals

https://www.conservationevidence.com/actions/2332

- **Five studies** evaluated the effects on mammals of using collar-mounted devices to reduce predation by domestic animals. Three studies were in the UK[1,2,3], one was in Australia[4] and one was in the USA[5].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (5 STUDIES)

- **Survival (5 studies):** Five replicated studies (including four randomized, controlled studies), in the UK[1,2,3], Australia[4] and the USA[5], found that bells[1,2,3], a sonic device[3], and a neoprene flap (which inhibits pouncing)[4] mounted on collars, and a brightly coloured and patterned collar[5] all reduced the rate at which cats predated and returned home with mammals. In one of these studies, an effect was only found in autumn, and not in spring[5].

BEHAVIOUR (0 STUDIES)

Background

Domestic animals can predate a range of wild mammals, with cats *Felis catus* a potentially significant predator. For example, one study estimated that domestic cats in the UK brought home 52–63 million mammals over a five-month period (Woods *et al.* 2003). Various measures have been suggested, or are enacted, to try to reduce this predation, including a range of deterrents or warnings attached to collars that are worn by cats.

Woods M., Mcdonald R. & Harris S. (2003) Predation of wildlife by domestic cats *Felis catus* in Great Britain. *Mammal Review*, 33, 174–188, https://doi.org/10.1046/j.1365-2907.2003.00017.x

A replicated, randomized, controlled study in 1999 in urban and rural areas of Lancashire, UK (1) found that domestic cats *Felis catus* wearing a bell brought home fewer dead/injured mammals than did cats without a bell. Over an eight-week period, the total number of mammals brought home by cats when wearing bells (82) was less than half than that delivered during periods without a bell (167). The rate of delivery of items did not change over time, suggesting cats did not adapt to hunting with bells. Between July and October, a total of 41 cats were randomly allocated to either: four weeks without a bell followed by four weeks with a bell, four weeks with a bell followed by four weeks without, or alternate weeks with and without a bell, beginning with one

week with a bell. Bells were fitted to a collar. Only cats that previously brought prey home and wore a collar were investigated. The number of prey delivered was recorded by cat owners.

A replicated study in 1997 in urban and rural areas in the UK (2) found that domestic cats *Felis catus* wearing a bell brought home fewer dead/injured mammals than cats without a bell. The average number of mammals brought home by cats with bells fitted to a collar (5.6) was smaller than the number delivered by cats not wearing a bell (9.9). Between April and August, cat owners recorded the number of prey brought home by 92 cats which wore bells and 190 cats which did not wear bells. Only cats living in households with no other cats were included in the study.

A replicated, randomized, controlled study in 2002–2003 in the UK (3) found that fewer mammals were brought home by domestic cats *Felis catus* fitted with a bell or a sonic device on their collar than by cats wearing a plain collar, but the type of device did not matter. In 2002, fewer mammals were returned by cats equipped with a bell (120) or a CatAlert™ sonic device (111) than by cats wearing a plain collar (181). In 2003, the average number of mammals returned was similar for cats equipped with one bell (0.07 mammals/cat/day), two bells (0.07 mammals/cat/day) or a CatAlert™ sonic device (0.05 mammals/cat/day). Between April and August 2002, 68 cats were fitted with each of the three types of collar (a bell, a sonic device or a plain collar) for one month at a time, in a random order. Owners recorded live prey items and collected dead items for identification. Between May and September 2003, 67 cats were fitted with a collar with either one bell, two bells or a sonic device. Owners recorded all prey items, and identified them to species wherever possible. Sonic devices were set to 'permanently on'.

A replicated, randomized, controlled study in 2005 in a residential area in Perth, Australia (4) found that domestic cats *Felis catus* wearing a collar with a CatBib™ 'pounce protector' (a neoprene flap that hangs from the collar) brought home fewer mammals than did cats without a CatBib™. When equipped with a CatBib™, cats brought home fewer mammals (total of 59) than when not wearing a collar (total of 105). Adding a bell to the CatBib™ did not further reduce the number of mammals returned (with bell: 26, without bell: 33). Wearing a CatBib™ stopped 45% of cats from catching mammals altogether. In

November–December 2005, in a random order, 56 cats underwent a period of three weeks wearing a CatBib™ and three weeks without a CatBib™. For the three weeks with a CatBib™, cats were randomly assigned either a CatBib™ only or a CatBib™ and bell. Only cats that frequently brought home intact prey were included in the study. Owners collected dead prey items and recorded live prey before release.

A replicated, randomized, controlled study in 2013–2014 in a residential area of New York state, USA (5) found that domestic cats *Felis catus* wearing collars with bright colours and patterns brought home fewer mammals than did cats with no collars in autumn, but not in spring. From September–November 2013, 54 cats brought home fewer mammals (0.6/cat) in six weeks spent wearing a Birdsbesafe® collar with bright colours and patterns than the same cats did during six weeks without a collar (1.2/cat). However, in a repeat experiment from April–June 2014, there was no difference (with collar: 1.1/cat; without collar: 1.1/cat). Cats were randomly allocated to one of two groups, beginning with or without a Birdsbesafe® collar, and the treatment on each cat was changed every two weeks throughout a 12-week period. Only cats that regularly brought home intact prey were included in the study. Owners collected dead prey items and recorded live prey before release.

(1) Ruxton G.D., Thomas S. & Wright J.W. (2002) Bells reduce predation of wildlife by domestic cats (*Felis catus*). *Journal of Zoology*, 256, 81–83, https://doi.org/10.1017/s0952836902000109

(2) Woods M., McDonald R.A. & Harris S. (2003) Predation of wildlife by domestic cats *Felis catus* in Great Britain. *Mammal Review*, 33, 174–188, https://doi.org/10.1046/j.1365-2907.2003.00017.x

(3) Nelson S.H., Evans A.D. & Bradbury R.B. (2005) The efficacy of collar-mounted devices in reducing the rate of predation of wildlife by domestic cats. *Applied Animal Behaviour Science*, 94, 273–285, https://doi.org/10.1016/j.applanim.2005.04.003

(4) Calver M., Thomas S., Bradley S. & McCutcheon H. (2007) Reducing the rate of predation on wildlife by pet cats: The efficacy and practicability of collar-mounted pounce protectors. *Biological Conservation*, 137, 341–348, https://doi.org/10.1016/j.biocon.2007.02.015

(5) Willson S.K., Okunlola I.A. & Novak J.A. (2015) Birds be safe: can a novel cat collar reduce avian mortality by domestic cats (*Felis catus*)? *Global Ecology and Conservation*, 3, 359–366, https://doi.org/10.1016/j.gecco.2015.01.004

2.4. Keep dogs indoors or in outside enclosures to reduce threats to wild mammals

https://www.conservationevidence.com/actions/2334

- We found no studies that evaluated the effects on mammals of keeping dogs indoors or in outside enclosures to reduce threats to wild mammals.

'We found no studies' means that we have not yet found any studies that have directly evaluated this intervention during our systematic journal and report searches. Therefore, we have no evidence to indicate whether or not the intervention has any desirable or harmful effects.

Background

Domestic dogs *Canis lupus familiaris* may have multiple negative impacts on wild mammals including through predation, disease transmission and disturbance (Hughes & Macdonald 2013). In some places, domestic dogs roam freely and are major predators of wild mammals. For example, Wierzbowska *et al.* (2016) estimated that over 33,000 wild animals (primarily mammals, especially brown hare *Lepus europaeus* and roe deer *Capreolus capreolus*) were killed by free-ranging dogs annually in Poland. Keeping dogs indoors or in outside enclosures may reduce their impacts, including predation, on wild mammals.

Hughes J. & Macdonald D.W. (2013) A review of the interactions between free-roaming domestic dogs and wildlife. *Biological Conservation*, 157, 341–351, https://doi.org/10.1016/j.biocon.2012.07.005

Wierzbowska I.A., Hędrzak M., Popczyk P., Okarma H. & Crooks K.R. (2016) Predation of wildlife by free-ranging domestic dogs in Polish hunting grounds and potential competition with the grey wolf. *Biological Conservation*, 201, 1–9, https://doi.org/10.1016/j.biocon.2016.06.016

2.5. Keep domestic cats and dogs well-fed to reduce predation of wild mammals

https://www.conservationevidence.com/actions/2335

- We found no studies that evaluated the effects on mammals of keeping domestic cats and dogs well-fed to reduce predation of wild mammals.

'We found no studies' means that we have not yet found any studies that have directly evaluated this intervention during our systematic journal and report searches. Therefore, we have no evidence to indicate whether or not the intervention has any desirable or harmful effects.

Background

Domestic pets can be major predators on wild mammals. For example, an estimated 57 million mammals are killed by domestic cats *Felis catus* in the UK each year (Wood *et al.* 2003) while negative impacts of domestic dogs *Canis lupus familiaris* on wild mammals include predation, disease transmission and disturbance (Hughes & Macdonald 2013). Keeping animals well fed might reduce their hunting activities and other interactions with wild mammals.

Woods M., Mcdonald R. & Harris S. (2003) Predation of wildlife by domestic cats *Felis catus* in Great Britain. *Mammal Review*, 33, 174–188, https://doi.org/10.1046/j.1365-2907.2003.00017.x

Hughes J. & Macdonald D.W. (2013) A review of the interactions between free-roaming domestic dogs and wildlife. *Biological Conservation*, 157, 341–351, https://doi.org/10.1016/j.biocon.2012.07.005

2.6. Translocate problem mammals away from residential areas (e.g. habituated bears) to reduce human-wildlife conflict

https://www.conservationevidence.com/actions/2336

- **Eleven studies** evaluated the effects of translocating problem mammals (such as bears) away from residential areas to

reduce human-wildlife conflict. Six studies were in the USA[1–5,11], two were in Canada[7,8], one was Russia[6], one was in India[9] and one was in Romania[10].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (6 STUDIES)

- **Survival (6 studies):** A controlled study in the USA[3] found that grizzly bears translocated away from conflict situations had lower survival rates than did non-translocated bears. A replicated study in the USA[11] found that fewer than half of black bears translocated from conflict situations survived after one year. Two of three studies (two controlled), in the USA[2,4,5], found that after translocation away from urban sites, white-tailed deer survival was lower than that of non-translocated deer. The third study found that short-term survival was lower but long-term survival was higher than that of non-translocated deer. A study in Russia[6] found that most Amur tigers translocated after attacking dogs or people did not survive for a year after release.

BEHAVIOUR (0 STUDIES)

OTHER (6 STUDIES)

- **Human-wildlife conflict (6 studies):** Five studies (including one controlled and two replicated studies), in the USA[1,3,11] and Canada[7,8], of brown/grizzly[1,3] or black[7,8,11] bears translocated away from residential areas or human-related facilities, found that at least some returned to their original capture location[1,7,8,11] and/or continued to cause nuisance[3,8]. In two of the studies[1,8], most returned to their capture area and one black bear returned six times following translocation[7]. A before-and-after study in India[9] found that leopards translocated away from human-dominated areas, attacked more humans and livestock than before-translocation. A controlled study in Romania[10] found that translocated brown bears occurred less frequently inside high potential conflict areas than outside, the opposite to bears that had not been translocated.

Background

There is a variety of ways in which mammals in urban, residential or other human-occupied locations can come into conflict with people. Some species may raid garbage and create a mess while doing so, some may cause damage to gardens or parks, some may act aggressively towards humans and some mammals present substantial road traffic hazards. In many communities, there is a pressure to address these issues by focussing solutions on preventing or deterring mammals from accessing such areas. One such method is translocation, typically to an area away from habitation. This intervention can fail if translocated animals continue to cause problems at residential areas (including by returning to their capture site) or if survival of translocated animals is low. If the intervention is successful, it can reduce incentives for carrying out lethal control of such animals.

See also: *Species management — Translocate mammals*.

A study in 1979–1981 of a large boreal and subarctic forest area in Alaska, USA (1) found that translocated Alaskan brown bears *Ursus arctos* did not settle at their release site and most returned to their capture area. Twelve of 20 translocated adult bears returned to their capture area in 13–133 days. Returning bears had been released, on average, closer to their capture site (145–255 km) than had non-returning bears (168–286 km). No translocated female bears were known to have produced young in the following year. Forty-seven bears were caught between 22 May and 22 June 1979, marked and transported by vehicle or aircraft. Adults were radio-collared and relocation data were adequate for monitoring movements and survival of 20 of these. Bears were monitored by radio-tracking from an airplane in May–October 1979 and from other radio-tracking data and hunter kills in 1979–1981.

A controlled study in 1984–1988 at four woodland and grassland sites in Illinois, USA (2) found that following translocation away from urban sites to reduce human-wildlife conflict, white-tailed deer *Odocoileus virginianus*, had a lower survival rate that did deer that were not translocated. Annual survival of translocated adult female deer

(34%) was lower than that of resident adult female deer at one of the original capture sites (73%). Fifty deer (25 females, 25 males) were caught, mostly with rocket nets, between 18 December and 31 March in 1984–1988, at three largely urban sites. They were released at a rural site, ≤80 km from capture sites. Females were radio-collared and monitored every one to two weeks initially, then less frequently. Survival was compared with that of 12 additional females that were caught, radio-collared, and released at the capture site.

A controlled study in 1975–1993 in a forested national park in Wyoming, USA (3) found that grizzly bears *Ursus arctos* translocated away from bear-human conflict situations had lower survival rates than did non-translocated bears and over one third required multiple translocations. Translocated bears had a lower annual survival rate (83%) than that of non-translocated bears (89%). Of 81 translocated bears, 50 were moved once, 15 were moved twice, nine were moved three times, four were moved four times and three were moved five times. In a 20,000-km^2 study area, 81 bears were translocated 3–128 km away from human conflict situations, such as having entered residential areas. With recaptures, there were 138 bear translocations in total between 1975 and 1993. Survival was compared with that of 160 bears captured and released without translocation during the same period. Bears were monitored by radio-tracking from an aircraft.

A controlled study in 1995–1996 in a residential and forest area in South Carolina, USA (4) found that white-tailed deer *Odocoileus virginianus* translocated from a residential area to a nearby forest had lower short-term survival but higher long-term survival than did non-translocated deer. After three months, a lower proportion of translocated deer (52%) was alive, than of non-translocated deer (76%). After 12 months, a higher proportion of translocated deer was alive (39%) than of non-translocated deer (33%). Fifty percent of translocated deer dispersed from the release site whereas no non-translocated deer dispersed. Nineteen deer were caught with rocket nets in a residential area, in December 1995. Ten were moved 3 km and released in a forest preserve. Nine were released at the capture site. Deer were radio-collared and were monitored for up to 12 months.

A study in 1997–2000 of a residential area and a forest in Missouri, USA (5) found that after translocation away from a residential area,

white-tailed deer *Odocoileus virginianus* had a lower survival rate than did deer that were not translocated. Annual survival after one year for translocated deer (30%) was lower than for non-translocated deer (69%). Among translocated deer, the largest causes of death were hunting (33%) and muscle weakness following capture ('capture myopathy'; 29%). Among non-translocated deer, roadkill (68%) and hunting (12%) were the largest causes of death. Eighty deer (51 male, 29 female) were caught in a residential area in January–February 1999, radio-collared, and released in a conservation area 160 km away. At the same capture site, additional deer (quantity not stated) were caught, radio-collared, and released at point of capture from December 1997 to March 1998.

A study in 2001–2004 in a mountainous protected area in eastern Russia (6) found that following translocation of Amur tigers *Panthera tigris altaica* that had attacked dogs *Canis lupus familiaris* or people around villages, most did not survive for a year after release. One of the four translocated tigers survived for at least 10 months. The other three were killed by people, between 20 days and one year after release. Two of the animals killed were suspected to have been poached, while one was killed after killing domestic dogs. In 2001–2003, four tigers that had been involved in attacks on domestic dogs (three tigers) or a human (one tiger) were translocated 150–350 km to a protected area. Before release, two tigers that were emaciated when caught were held in a 1-ha enclosure for 162–388 days. All tigers were fitted with radio-collars and released into areas known to be used by wild tigers. Animals were radio-tracked approximately weekly, over an unspecified period, by researchers on foot, in vehicles, or in a plane.

A study in 1994–1997 of extensive forest and a residential area in Ontario, Canada (7) found that repeated translocation of an adult female black bear *Ursus americanus* that habitually fed from garbage containers did not prevent it from returning and resuming nuisance behaviour at the capture site. The bear was translocated six times, over distances of 40–389 km (average 152 km), and returned each time to the initial capture area. On two of the returns to the capture area, the bear was accompanied by cubs. The maximum distance between any two capture sites was 10 km. The bear habitually foraged at unsecured garbage containers in residential areas. It was caught and translocated six times between June 1994 (when estimated to be nine years old) and

1997. It was ear-tagged at first capture and radio-collared at the time of the second capture and translocation.

A replicated study in 1982–1997 in three mainly forested areas in Ontario, Canada (8) found that translocating black bears *Ursus americanus* that caused nuisance around habitation or other human-related installations reduced their nuisance behaviour, though some animals continued to cause problems. Among translocated bears, ≥30% were involved in at least one further nuisance event. This occurred mostly in adult females (48%), followed by adult males (39%), juvenile females (26%) and juvenile males (18%). Seventy-three percent of translocated adult bears returned to their area of capture, compared to 29% of juveniles. Bears released further from their capture point were less likely to return (data presented as statistical model coefficients). In each of three regions, bear relocation and tag recovery data were obtained. In total, 123 bears were relocated after displaying nuisance behaviour, and were moved on average 70–80 km. Study periods in the three areas spanned three, four and 14 years.

A before-and-after study in 1993–2003 in a largely arable area in Maharashtra, India (9) found that after leopards *Panthera pardus fusca* were translocated away from human-dominated areas, the frequency and fatality of leopard attacks on humans increased and attacks on livestock increased. There were more leopard attacks on humans after translocations began (8–24/year) than before (1–7/year) and these resulted in more human fatalities (after: 3–11/year; before: 0–2/year). There were more leopard attacks on livestock after translocations began (average 166 attacks/year) than in the 12 months before translocations began (106 attacks). Authors reported that the attacks were by the translocated leopards. In a 4,275-km^2 study area, with a human population density of 185 people/km^2, 103 leopard translocations occurred between February 2001 and December 2003. Eighty-six leopards were caught in human-dominated areas, with 29 translocated <60 km to either of two natural forest sites and 56 moved >200 km to release sites elsewhere. Eleven leopards from outside the study area were also released at the natural forest sites. Location data were not available for six translocations. Human attack data during the translocation period were compared with those collated for 1993–2000.

A controlled study in 2008–2011 in a mixed landscape in the Eastern Romanian Carpathians, Romania (10) found that brown bears *Ursus arctos* translocated to reduce conflict with humans, some of which had been rehabilitated as orphans, occurred less frequently inside high potential conflict areas than outside. Bears were present less frequently inside high potential conflict areas than outside if they had been translocated (occurrences inside: 501; outside: 1,517) or rehabilitated (inside: 462; outside: 1,180) and particularly if they had been rehabilitated and translocated (inside: 245; outside: 963). Bears that had not been translocated or rehabilitated occurred inside the high potential conflict areas more than outside (inside: 2,166; outside: 1,067). Rehabilitated and translocated bears spent less time (9 hrs) in the conflict areas than those that had not been rehabilitated and translocated (14 hrs). Similar time was spent in those areas by bears that had just been translocated (4 hrs) or rehabilitated (6 hrs). Eight bears were radio-tracked for 3–17 months (541–1,869 locations/bear) in 2008–2011 across the 15,822 km^2 study site. There were two bears of each of four types: translocated but not rehabilitated, translocated and rehabilitated, not translocated but rehabilitated and not translocated or rehabilitated. The four bears (two male) were translocated >60–100 km from their capture site due to conflict with humans (damage and/or frequently visited settlements, e.g. waste disposal sites). Four bears (two male) were orphan bear cubs that were released after rehabilitation in relatively natural conditions for a maximum of two years. High potential conflict areas were those with human settlements, partially agricultural fields and woodlands.

A replicated study in 1995–1997 in an unspecified number of mountain sites in Colorado, USA (11) found that after translocation of black bears *Ursus americanus* that were involved in conflict with humans, fewer than half survived after one year and some returned to capture sites. One year after translocation, 50% of adult black bears and 28% of sub-adult bears had survived. Of 66 captured bears, 14 returned to capture sites and 16 repeated some form of problem behaviour. In May and October of 1995–1997, sixty-six bears that were considered a nuisance or threat to human safety were captured. All were individually marked with ear tags and lip tattoos and were fitted with radio-collars. Within two days of capture, bears were translocated to release sites. Bears were radio-tracked opportunistically, from the ground and from a plane, once a week, in May–October of 1995–1997.

(1) Miller S. & Ballard W. (1982) Homing of transplanted Alaskan brown bears. *The Journal of Wildlife Management*, 46, 869–876, http://doi.org/10.2307/3808219

(2) Jones J.M & Witham J.H. (1990) Post-translocation survival and movements of metropolitan white-tailed deer. *Wildlife Society Bulletin*, 18, 434–441.

(3) Blanchard B.M. & Knight R.R. (1995) Biological consequences of relocating grizzly bears in the Yellowstone Ecosystem. *The Journal of Wildlife Management*, 59, 560–565, http://doi.org/10.2307/3802463

(4) Cromwell J.A., Warren R.J. & Henderson D.W. (1999) Live-capture and small-scale relocation of urban deer on Hilton Head Island, South Carolina. *Wildlife Society Bulletin*, 27, 1025–1031.

(5) Beringer J., Hansen L.P., Demand J.A., Sartwell J., Wallendorf M. & Mange R. (2002) Efficacy of translocation to control urban deer in Missouri: costs, efficiency, and outcome. *Wildlife Society Bulletin*, 30, 767–774.

(6) Goodrich J.M. & Miquelle D.G. (2005) Translocation of problem Amur tigers *Panthera tigris altaica* to alleviate tiger-human conflicts. *Oryx*, 39, 454–457, https://doi.org/10.1017/s0030605305001146

(7) Landriault L., Hall M., Hamr J. & Mallory, F. (2006) Long-range homing by an adult female black bear, *Ursus americanus*. *The Canadian Field-Naturalist*, 120, 57–60, https://doi.org/10.22621/cfn.v120i1.246

(8) Landriault L.J., Brown G.S., Hamr J. & Mallory F.F. (2009) Age, sex and relocation distance as predictors of return for relocated nuisance black bears *Ursus americanus* in Ontario, Canada. *Wildlife Biology*, 15, 155–164, https://doi.org/10.2981/07-084

(9) Athreya V., Odden M., Linnel J. & Karanth U. (2011) Translocation as a tool for mitigating conflict with leopards in human dominated landscapes of India. *Conservation Biology*, 25, 133–141, https://doi.org/10.1111/j.1523-1739.2010.01599.x

(10) Pop, I.M., Sallay, A., Bereczky, L. & Chiriac, S. (2012) Land use and behavioral patterns of brown bears in the South-Eastern Romanian Carpathian Mountains: A case study of relocated and rehabilitated individuals. *Procedia Environmental Sciences*, 14, 111–122, https://doi.org/10.1016/j.proenv.2012.03.011

(11) Alldredge M.W., Walsh D.P., Sweanor L.L., Davies R.B. & Trujillo A. (2015) Evaluation of translocation of black bears involved in human–bear conflicts in South-central Colorado. *Wildlife Society Bulletin*, 39, 334–340, https://doi.org/10.1002/wsb.526

2.7. Issue enforcement notices to deter use of non-bear-proof garbage dumpsters to reduce human-wildlife conflict

https://www.conservationevidence.com/actions/2345

- **One study** evaluated the effects of issuing enforcement notices to deter use of non-bear-proof garbage dumpsters to reduce human-wildlife conflict. This study was in the USA[1].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (0 STUDIES)

OTHER (1 STUDY)

- **Human-wildlife conflict (1 study):** A replicated, controlled, before-and-after study in the USA[1] found that issuing enforcement notices requiring appropriate dumpster use did not reduce garbage accessibility to black bears.

Background

Bears can be opportunistic feeders that sometimes raid sources of food left by humans. If food in garbage containers is not secured, this too can be targeted. As well as potentially causing mess, bears attracted to garbage containers may come to associate humans with sources of food and their behaviour may become problematic, through displays of aggression or boldness. Such animals may be translocated or lethally controlled. The issue could be reduced if food in garbage containers is made inaccessible to bears. Issuing enforcement notices is one way of attempting to increase compliance with legislation requiring proper use of bear-proof dumpsters.

See also: *Translocate problem mammals away from residential areas (e.g. habituated bears) to reduce human-wildlife conflict*.

A replicated, controlled, before-and-after study in 2008 of four alleyways in business and residential areas in Colorado, USA (1) found

that issuing enforcement notices requiring appropriate dumpster use did not reduce garbage accessibility to black bears *Ursus americanus*. Changes in the proportion of dumpsters violating legislation in alleyways where enhanced enforcement occurred (after enforcement: 20% of dumpsters; before: 42%) did not significantly differ from those in alleyways without enhanced enforcements (after: 24% of dumpsters; before: 49%). Similarly, there was no significant difference in changes in legislation compliance between individual dumpsters issued with enforcement notices (after issuing: 36% of dumpsters; before: 72%) and those not (after: 17% of dumpsters; before 36%). In treatment alleys (with 37 dumpsters) there were daily patrols. Twenty-two written notices were issued on 18 dumpsters and two verbal warnings were given. Two additional alleys (30 dumpsters) had continuing lower level of enforcement action. Pre- and post-treatment surveys took place between 1 July and 25 August 2008. Dumpsters were regarded as violating legislation if they were not bear-resistant or if food waste was otherwise accessible.

(1) Baruch-Mordo S., Breck S.W., Wilson K.R. & Broderick J. (2011) The carrot or the stick? Evaluation of education and enforcement as management tools for human-wildlife conflicts. *PLoS ONE*, 6, e15681, https://doi.org/10.1371/journal.pone.0015681

2.8. Prevent mammals accessing potential wildlife food sources or denning sites to reduce nuisance behaviour and human-wildlife conflict

https://www.conservationevidence.com/actions/2346

- **Two studies** evaluated the effects of preventing mammals accessing potential wildlife food sources or denning sites to reduce nuisance behaviour and human-wildlife conflict. One study was in the USA[1] and one was in Switzerland[2].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (0 STUDIES)

OTHER (2 STUDIES)

- **Human-wildlife conflict (2 studies):** A replicated, controlled study in the USA[1] found that electric shock devices prevented American black bears from accessing or damaging bird feeders. A before-and-after study in Switzerland[2] found that electric fencing excluded stone martens from a building.

Background

Some mammals will utilize food, denning sites or other resources in human modified environments in such ways that risks them being regarded as exhibiting nuisance behaviour. Such behaviour might include damaging property, creating mess, causing noise disturbance or posing a perceived thrseat to humans. If mammals can be excluded from such situations, such as through electric fencing, this may reduce human-wildlife conflict and might, thus, reduce motivations for carrying out lethal control of such animals.

A replicated, controlled study in 2004 of 10 forest sites in Minnesota, USA (1) found that installing electric shock devices prevented American black bears *Ursus americanus* from accessing or damaging bird feeders. Bird feeders protected by electric shock devices suffered less bear damage (none of 10 was accessed or damaged) than did unprotected feeders (four of 10 accessed or destroyed). Two imitation bird feeders were installed at each of 10 sites, ≥30 km apart. One feeder was protected by an electric shock device, the 'Nuisance Bear Controller'. This device had two 6-volt batteries wired to an automobile vibrator coil/condenser, emitting 10,000–13,000 volts through a disk when contact was made by an animal. The other feeder was unprotected. Ground around each feeder was cleared to enable identification of bear signs. Feeders were in place from 1 July to 15 November 2004. They were monitored, and bait replenished, at least weekly.

A before-and-after study in 2006 on a building in Switzerland (2) found that electric fencing excluded stone martens *Martes foina* from the property. The rate of martens passing through gaps into the building's attic after electric fence installation was lower (0.1 martens/day) than before the fence was installed (1.9 martens/day). It was lower still (0 martens/day) after the fence was modified. The property, built in the 1950s, was used frequently by martens, resulting in serious damage.

Two electric fence types were deployed: wire mesh net for larger gaps and electric wire strands for small openings. Marten movements were monitored by video camera from 12 June to 27 July 2006. This covered nine nights before and seven nights after fence installation and 10 further nights after a crevice was modified by adding an extra electric wire strand. Checks were made for marten re-entry over a further 103 nights, by monitoring for bait removal and for faeces.

(1) Breck S., Lance N. & Callahan, P. (2006) A shocking device for protection of concentrated food sources from black bears. *Wildlife Society Bulletin*, 34, 23–26, https://doi.org/10.2193/0091-7648(2006)34[23:asdfpo]2.0.co;2

(2) Kistler C., Hegglin D., von Wattenwyl K. & Bontadina F. (2013) Is electric fencing an efficient and animal-friendly tool to prevent stone martens from entering buildings? *European Journal of Wildlife Research*, 59, 905–909, https://doi.org/10.1007/s10344-013-0752-5

2.9. Provide diversionary feeding for mammals to reduce nuisance behaviour and human-wildlife conflict

https://www.conservationevidence.com/actions/2323

- **Three studies** evaluated the effects of providing diversionary feeding for mammals to reduce nuisance behaviour and human-wildlife conflict. Two studies were in the USA[1,3] and one was in Slovenia[2].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (1 STUDY)

- **Uptake (1 study):** A site comparison study in Slovenia[2] found that 22–63% of the estimated annual energy content of the diet of brown bears comprised provided diversionary food.

OTHER (2 STUDIES)

- **Human-wildlife conflict (2 studies):** Two before-and-after studies (one also a site comparison) in the USA[1,3] found that

diversionary feeding reduced nuisance behaviour by black bears.

Background

Some mammals are attracted to residential or business areas by availability of food or other resources. Whilst many such mammals go unnoticed some, such as bears that raid garbage bins, can be perceived as a threat to humans or can cause damage to property or create a mess. Such animals are sometimes managed by being translocated to sites away from built-up areas whilst lethal control may be carried out in some situations. If diversionary feeding can reduce the extent to which animals exhibit nuisance behaviour, this may reduce motivations for carrying out lethal control or other intensive management.

See also: *Agriculture and aquaculture — Provide diversionary feeding to reduce crop damage by mammals to reduce human-wildlife conflict* and *Provide diversionary feeding to reduce predation of livestock by mammals to reduce human-wildlife conflict*.

A before-and-after study in 1981–1991 in an area of forest, residences and recreation facilities in Minnesota, USA (1) found that diversionary feeding reduced nuisance behaviour by black bears *Ursus americanus*. During eight years in which diversionary feeding was used, fewer bears (two bears) were removed for nuisance behaviour than in the three years before diversionary feeding started (six bears). Bears that visited the feeding site did not exhibit nuisance behaviour. A diversionary feeding site was operated during 1984–1991. This site was 0.25–3.4 km from a range of problem areas, including homes, a campground and a picnic site with unsecured bins and other food sources. The feeding location was stocked with beef fat and, sometimes, grapes. Bears were monitored using radio-tracking and direct observation and by ear tag returns from hunters.

A site comparison study in 1993–1998 in three regions comprising mainly forest and agricultural fields in Slovenia (2) found that providing diversionary feeding to reduce human-brown bear *Ursus arctos* conflict

resulted in 22–63% of the estimated annual energy content of the diet of bears comprising supplementary food. Across the three regions, supplemental food was highest in the diet and was the most important food items in spring (maize: 27%; carrion: 26%), but not in summer (total 26%) and autumn (27%). The annual proportion of maize in the diet increased with the density of feeding sites (low density: 10–20%; high density: 52%). The proportion of all supplementary food in the diet followed a similar pattern (low density feeding sites: 22–33%; high density: 63%). In the three regions there was at least one carrion feeding site/60 km^2 of bear habitat (annual estimate: 33–146 kg/km^2) and maize feeding sites at average densities of one site/5.6 km^2 of bear habitat (annual estimate: 70–280 kg/km^2). Approximately two-thirds of feeding sites were supplied with food throughout the year. One region had a higher intensity of supplemental feeding (34 feeding sites/km^2) than the other two (16 feeding sites/km^2). A total of 714 brown bear scats were collected opportunistically (153–313/season, 220–260/region) from March to November 1993–1998 across the three regions and analysed.

A before-and-after and site comparison study in 2007 of 20 local communities in Lake Tahoe Basin, USA (3) found that diversionary feeding of black bears *Ursus americanus* during a drought reduced human-bear conflicts, particularly in communities closest to feeding sites. Overall, the total number of human-bear conflicts/month was lower three months after diversionary feeding commenced (834) compared to one month before (1,819), although the difference was not tested for statistical significance (data reported in Stringham & Bryant 2016). Average daily declines in conflicts during the three months of feeding were greater at seven communities located 1 km from feeding sites (1.2%) than at three communities located ≥8 km from feeding sites (0.6%). Diversionary feeding was carried out in September–November 2007 after human-bear conflicts increased during a drought. Fruit and nuts were scattered over a 100 m^2 area at 10 forest sites located 1–20 km from 20 communities. Human-bear conflicts (bears in yards, homes etc.) were reported to a telephone hotline in May–November 2007.

Stringham S. & Bryant, A. (2016) Commentary: Distance-dependent effectiveness of diversionary bear bait sites. *Human–Wildlife Interactions*, 10, 128–131, https://doi.org/10.26077/d5bv-c877

(1) Rogers L.L. (2011) Does diversionary feeding create nuisance bears and jeopardize public safety? *Human–Wildlife Interactions*, 5, 287–295.

(2) Kavčič, I., Adamič, M., Kaczensky, P., Krofel, M., Kobal, M. & Jerina, K. (2015) Fast food bears: brown bear diet in a human-dominated landscape with intensive supplemental feeding. *Wildlife Biology*, 21, 1–8, https://doi.org/10.2981/wlb.00013

(3) Stringham S.F. & Bryant, A. (2015) Distance-dependent effectiveness of diversionary bear bait sites. *Human–Wildlife Interactions*, 9, 229–235, https://doi.org/10.26077/5a9d-rk41

2.10. Scare or otherwise deter mammals from human-occupied areas to reduce human-wildlife conflict

https://www.conservationevidence.com/actions/2347

- **Ten studies** evaluated the effects of scaring or otherwise deterring mammals from residential areas to reduce human-wildlife conflict. Six studies were in the USA[3,4,5,7,8,9], three were in Canada[1,2,6] and one was in Tanzania[10].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (0 STUDIES)

OTHER (10 STUDIES)

- **Human-wildlife conflict (10 studies):** Two of four studies (including one randomized and controlled study) in the USA[3,4,5,8], found that a range of noise and pain deterrents did not prevent black bears from returning to urban areas or other human-occupied sites[3,4]. The other two studies[5,8] found that such actions did deter them from seeking food at human-occupied sites. Two of three studies, in the USA[7,9] and Canada[6], found that chasing nuisance black bears with dogs[7] and chasing elk with people or dogs[6] caused them to stay away longer or remain further from human occupied areas. The other study found that attempts to scare coyotes did not cause them to avoid human occupied areas[9]. A before-and-after study in Canada[1] found that an electric fence prevented

polar bear entry to a compound. A study in Canada[2] found that chemical and acoustic repellents did not deter polar bears from baits in most cases. A replicated study in Tanzania[10] found that drones caused African savanna elephants to quickly leave residential areas.

Background

There is a variety of ways in which mammals in urban, residential or other human-occupied locations can come into conflict with people. Some species may raid garbage and create a mess while doing so, some may cause damage to gardens or parks, some may act aggressively towards humans and some mammals present substantial road traffic hazards. In many communities, there is a pressure to address these issues by focussing solutions on preventing or deterring mammals from accessing such areas. If non-lethal means can be successfully deployed, this could reduce incentives for achieving this through carrying out lethal control of such species.

A before-and-after study in 1983–1985 at a research compound in Manitoba, Canada (1) found that after the area was enclosed with an electric fence, no polar bears *Ursus maritimus* entered it. Over a total of approximately five months over two summers with the fence installed, no polar bears entered the compound. However, before the fence was installed in those years and in the previous year before it was first installed, nine different bears visited the compound, some on multiple occasions. The study was conducted in a research compound where 10–15 biologists resided between May and September each year. In July–September 1984 and June–September 1985, a temporary two-strand electric fence was erected around the 300-m compound perimeter. The two strands of wire were 30 and 60 cm above the water or ground. The fence emitted 40 pulses/min of direct current (peak output of 8,000 volts). When the fence activated, two 110-decibel horns also sounded.

A study in 1978 at a shrubland and grassland site in Manitoba, Canada (2) found that acoustic deterrents and baits treated with chemical deterrents did not, in most cases, repel polar bears *Ursus maritimus*. Out

of 55 visits, acoustic deterrents repelled bears on 17 visits and did not repel them on 38 visits. From 294 visits, chemical deterrent repelled bears five times but did not repel them during 289 visits. However, bears remained for shorter periods at chemical repellent-treated bait stations (average 98–317 s) than at baits without repellents (average 420 s). In October–November 1978, polar bears were attracted to 13 bait stations with sardines. Stations were all 100–500 m from a 6-m-high tower, from which bear responses were observed. At one bait station, a loudspeaker was placed 5m from the bait. Sounds played through the loudspeaker included bear sounds, human shouting, killer whale sounds, radio noise and human hissing and barking like a bear. Ten bait stations were sprayed with dog-repellents or household chemicals. Two bait stations had no repellents.

A study in 1990–1998 of a largely forested national park in North Carolina and Tennessee, USA (3) found that following capture and release back at capture sites, most black bears *Ursus americanus* did not subsequently repeat nuisance behaviour, such as entering picnic sites or campgrounds. For 50 out of 85 captures, bears were not subsequently sighted at capture locations during the remainder of that year. In four further cases, no management action was required that year, even if the bear was re-sighted at its capture location. In a 2,080-km^2 national park, 63 bears exhibiting nuisance behaviour (such as raiding bins) were captured by live-trapping or darting. Bears were immobilised, individually marked and had a tooth extracted (for aging) before release, after recovery from anaesthesia, <150 m from their capture site.

A randomized, controlled study in 1997–2002 in residential areas and adjacent forest across at least four mountain ranges in Nevada, USA (4) found that subjecting nuisance black bears *Ursus americanus* to deterrents intended to scare them, did not prevent their return to urban areas. The average time for bears to return to urban areas after treatments did not differ significantly between those chased by dogs *Canis lupus familiaris* in addition to noise and projectile deterrents (154 days), those subject to the same deterrents excluding chasing by dogs (88 days) or those not subject to deterrents (65 days). Fifty-seven of the 62 bears in the study returned to urban areas. Forty-four of these returned within 40 days. Nuisance bears (which raided garbage) were captured and radio-collared between July 1997 and April 2002. They were randomly

assigned to deterrent treatments including chasing by dogs (20 bears), deterrent treatments excluding chasing by dogs (21 bears) or no deterrent (20 bears). Additional to chasing by dogs, deterrents entailed pepper spraying, firing 12-gauge rubber buckshot or rubber slugs, loud cracker shells and shouting. Deterrents were administered at release sites, 1–75 km from capture locations.

A replicated, controlled study in 2004 of ten forest sites in Minnesota, USA (5) found that installing electric shock devices prevented American black bears *Ursus americanus* from accessing or damaging bird feeders. Bird feeders protected by electric shock devices suffered less bear damage (none of ten accessed or damaged) than did unprotected feeders (four of ten accessed or destroyed). Two imitation bird feeders were installed at each of ten sites, ≥30 km apart. One feeder was protected by an electric shock device, the Nuisance Bear Controller. This device had two 6-volt batteries wired to an automobile vibrator coil/condenser, emitting 10,000–13,000 volts through a disk when contact is made by an animal. The other feeder was unprotected. Ground around each feeder was cleared to enable identification of bear signs. Feeders were in place from 1 July to 15 November 2004. They were monitored, and bait replenished, at least weekly.

A controlled study in 2001–2002 at a town and surrounding forest in Alberta, Canada (6) found that after being chased by humans, the average distance of elk *Cervus canadensis* from the town increased more than it did for elk chased by dogs *Canis lupus familiaris* or for elk that were not chased. The average distance of elk from the town boundary increased for all treatment groups but the increase was larger for elk chased by humans (after: 1,130 m; before: 184 m) than for elk chased by dogs (after: 1,041 m; before: 535 m) or for elk that were not chased (after: 881 m; before: 629 m). Twenty-four elk were radio-collared. Each was assigned to being chased by humans, chased by dogs or not chased, 10 times, from November 2001 to March 2002. Chases lasted 15 minutes and covered averages of 1,148 m when humans (shooting starter pistols) chased elk and 1,219 m when two border collie dogs chased elk. Non-chased elk moved an average of 49 m during 15 minutes. Capture and collar-fitting may have produced some aversive response though animal handling was uniform across groups. Displacement from the town

boundary was calculated from daily sightings or radio-signals, from September 2001 to March 2002.

A study in 2005–2006 at a site comprising marsh, forest, farmland, and residential areas in Louisiana, USA (7) found that chasing nuisance black bears *Ursus americanus* with dogs *Canis lupus familiaris*, in addition to making noise and shooting with rubber buckshot, increased the amount of time until they next exhibited nuisance behaviour compared to solely making noise and shooting rubber buckshot. Black bears subjected to chasing by dogs, loud noise and shooting with rubber buckshot took longer to return to nuisance behaviour (58 days) than did bears that were subjected to loud noise and shooting with rubber buckshot but not chasing by dogs (48 days). Between April 2005 and July 2006, eleven bears reported to be exhibiting nuisance behaviour were live-trapped. All were immobilized and fitted with radio-collars. Upon release, six bears were subjected to loud noise, shooting with rubber buckshot and chasing with dogs and five were subjected to loud noise and shooting with rubber buckshot alone. Bears were monitored for recurring nuisance behaviour for up to 5 months after release.

A study in 2002–2005 in a national park in California, USA (8) found that aversive conditioning reduced the number of black bears *Ursus americanus* that were accustomed to seeking food at human-frequented locations revisting. Of 29 bears accustomed to taking human-food, 17 ceased to do so, six required continued aversion conditioning and six 'persistent offenders' were removed or killed for safety reasons. Over 150 bears were subject to 1,050 aversive conditioning events. Of these, 729 events involved 36 individual food-conditioned or habituated bears (seven became habituated in the final year of the study, so their subsequent behaviour was not assessed). Five personnel drove bears from campsites and other human-occupied areas by throwing rocks and using sling shots, pepper spray, rubber slug projectiles and chasing. All actions were accompanied by shouting. Aversive conditioning actions were carried out each summer, from June 2002 to September 2005.

A replicated, controlled study in 2014 of four urban areas in Colorado, USA (9) found that attempts to scare away coyotes *Canis latrans* did not decrease their use of areas also frequently used by people. On trails frequently travelled by people, the overlap between coyote

and human activity was similar where community-level programmes were run to scare coyotes and where programmes were not run (data presented as coefficients of overlap, incorporating frequency and timing of use). On trails with less human traffic, overlap between coyote and human activity was greater where programmes were run than where they were not run. These differences were not tested for statistical significance. Four urban park and open space areas were studied. In two, community-level programmes were run. These primarily involved shouting, throwing objects, and/or aggressively approaching coyotes. Activities were promoted by signs, social media, emailing to multiple recipients, education stations and an online video. Programmes were not run in the two control areas. Coyote and human use of trails were monitored using five camera traps in each area for a 3–4-week period, generating >50,000 independent records of people and coyotes.

A replicated study in 2016 in two savanna reserves in Tanzania (10) found that using drones to deter African savanna elephants *Loxodonta africana* from towns led to elephants leaving the sites quickly. On all 13 occasions, when drones were deployed, elephants began to flee within one minute. Elephants were typically herded to an area > 1 km from villages. Before using drones, rangers were trained during three 4-day workshops. In February–March and May–August 2015 and in March–April 2016, rangers deployed drones in 13 situations when elephants were found close to villages. Each drone was fitted with a flashlight, to locate elephants at night, and, during the day, a live video feed from a camera on the drone was used. Elephant responses were recorded over 60-second intervals for the first 10 minutes of the drone flight.

(1) Davies J.C. & Rockwell R.F. (1986) An electric fence to deter polar bears. *Wildlife Society Bulletin*, 14, 406–409.

(2) Miller G.D. (1987) Field tests of potential polar bear repellents. *Bears: Their Biology and Management*, 7, 383–390, https://doi.org/10.2307/3872649

(3) Clark J.E., van Manen F.T. & Pelton M.R. (2002) Correlates of success for on-site releases of nuisance black bears in Great Smoky Mountains National Park. *Wildlife Society Bulletin*, 30, 104–111.

(4) Beckmann J., Lackey C. & Berger J. (2004) Evaluation of deterrent techniques and dogs to alter behavior of 'nuisance' black bears. *Wildlife Society Bulletin*, 32, 1141–1146, https://doi.org/10.2193/0091-7648(2004)032[1141:eodtad]2.0.co;2

(5) Breck S., Lance N. & Callahan P. (2006) A shocking device for protection of concentrated food sources from black bears. *Wildlife Society Bulletin*, 34, 23–26, https://doi.org/10.2193/0091-7648(2006)34[23:asdfpo]2.0.co;2

(6) Kloppers E.L., St. Clair C. & Hurd T.E. (2005) Predator-resembling aversive conditioning for managing habituated wildlife. *Ecology and Society*, 10, 31, https://doi.org/10.5751/es-01293-100131

(7) Leigh J. & Chamberlain M.J. (2008) Effects of aversive conditioning on behavior of nuisance Louisiana black bears. *Human-Wildlife Conflicts*, 2, 175–182, https://doi.org/10.26077/frgt-yq55

(8) Mazur R.L. (2010) Does aversive conditioning reduce human–black bear conflict? *The Journal of Wildlife Management*, 74, 48–54, https://doi.org/10.2193/2008-163

(9) Breck S.W., Poessel S.A. & Bonnell M.A. (2017) Evaluating lethal and nonlethal management options for urban coyotes. *Human–Wildlife Interactions*, 11, 133–145, https://doi.org/10.5070/v427110686

(10) Hahn N., Mwakatobe A., Konuche J., de Souza N., Keyyu J., Goss M., Chang'a A., Palminteri S., Dinerstein E. & Olson D. (2017) Unmanned aerial vehicles mitigate human–elephant conflict on the borders of Tanzanian Parks: a case study. *Oryx*, 51, 513–516, https://doi.org/10.1017/s0030605316000946

2.11. Retain wildlife corridors in residential areas

https://www.conservationevidence.com/actions/2354

- **One study** evaluated the effects on mammals of retaining wildlife corridors in residential areas. This study was in Botswana[1].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (1 STUDY)

- **Use (1 study):** A replicated study in Botswana[1] found that retained wildlife corridors in residential areas were used by 19 mammal species, including African elephants.

Background

Residential and commercial developments can fragment home ranges of mammal species, making access to some resources difficult or dangerous. Retention of wildlife corridors, such as undeveloped land, riversides, woodland strips or other habitat through which mammals can pass, may help to reduce or mitigate some of these impacts of development.

A replicated study in 2012–2014 in seven semi-arid residential and agricultural sites in northern Botswana (1) found that retained wildlife corridors in residential areas were used by African elephants *Locondonta africana* and 18 other mammal species. There were 2,619 camera-trap images of elephants captured, over 516 days. Elephant activity peaked in August, when 13 elephants/day were detected. Nineteen mammal species in total were recorded, including civet *Civettictis civetta* and buffalo *Syncerus caffer* (other species not named). Seven corridors that crossed urban and agricultural areas between a forest reserve and a major river were monitored using camera traps. The seven corridors were either fenced or otherwise ran between developed areas. They were 750–1,700 m long and 3–250 m wide. Camera traps were attached to trees or posts at 1.5–1.8 m high and operated for 24 hours/day from 1 November 2012 to 30 April 2014.

(1) Adams T.S., Chase M.J., Rogers T.L. & Leggett K.E. (2017) Taking the elephant out of the room and into the corridor: can urban corridors work? *Oryx*, 51, 347–353, https://doi.org/10.1017/s0030605315001246

2.12. Install underpasses beneath ski runs

https://www.conservationevidence.com/actions/2355

- **One study** evaluated the effects on mammals of installing underpasses beneath ski runs. This study was in Australia[1].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (1 STUDY)

- **Use (1 study):** A replicated study in Australia[1] found that boulder-filled crossings beneath ski slopes were used by seven small mammal species.

Background

Infrastructure and land management associated with the ski industry has, on balance, a negative effect on mammals (Sato *et al.* 2013). One source of impact is habitat fragmentation, through construction of ski runs across previously forested slopes. Underpasses could facilitate mammal movements between habitat patches, especially if they mimic previous ground conditions across rocky slopes.

Sato C.F., Wood J.T. & Lindenmayer D.B. (2013) The effects of winter recreation on alpine and subalpine fauna: a systematic review and meta-analysis. PLoS ONE, 8, e64282, https://doi.org/10.1371/journal.pone.0064282

A replicated study in 2009–2013 in a woodland, heath, and grassland site in New South Wales, Australia (1) found that boulder-filled crossings beneath ski slopes were used by small mammals. Seven mammal species were detected using crossings. From 131 detections where mammals were identified to species, the most frequent were bush rat *Rattus fuscipes* (62 detections), broad-toothed rat *Mastacomys fuscus* (35 detection), dusky antechinus *Antechinus swainsonii* (21 detections) and black rat *Rattus rattus* (10 detections). Eight boulder-filled crossings were constructed under ski runs on grass slopes of a ski area that operated in June–September. Crossings linked remnant heath or woodland. Crossings comprised trenches, 0.4–2.4 m deep, 1–9 m wide, 12–79 m long and filled with rocks of 0.2–2 m diameter. Mammal passage was monitored using hair tubes every 3–6 m (4–13 tubes/crossing). Most crossings were surveyed biannually (7 days in each March–April and November–December) from March 2009 to April 2013.

(1) Schroder M. & Sato C.F. (2017) An evaluation of small-mammal use of constructed wildlife crossings in ski resorts. *Wildlife Research*, 44, 259–268, https://doi.org/10.1071/wr16102

2.13. Provide woody debris in ski run area

https://www.conservationevidence.com/actions/2356

- **One study** evaluated the effects on mammals of providing woody debris in ski run areas. This study was in the USA[1].

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

- **Abundance (1 study):** A controlled study in the USA[1] found that placing woody debris on ski slopes did not affect overall small mammal abundance and had mixed effects on individual species abundances.

BEHAVIOUR (0 STUDIES)

Background

Ski-runs are traditionally created by removing trees and undergrowth along with removal of tree stumps and reshaping of topsoil by bulldozing (Ries 1996). As a result, they can present barriers to animal movement (Mansergh & Scotts 1989) and reduce animal abundance (Morrison *et al*. 1995). The provision of woody debris on ski runs may increase use by small mammals.

Mansergh I.M. & Scotts D.J. (1989) Habitat continuity and social organization of the mountain pygmy-possum restored by tunnel. *The Journal of Wildlife Management*, 53, 701–707, https://doi.org/10.2307/3809200

Morrison J.R., De Vergie W.J., Alldredge A.W. & Andree W.W. (1995) The effects of ski area expansion on elk. *Wildlife Society Bulletin*, 23, 481–489.

Ries J.B. (1996) Landscape damage by skiing at the Schauinsland in the Black Forest, Germany. *Mountain Research and Development*, 16, 27–40, https://doi.org/10.2307/3673893

A controlled study in 1999–2001 of coniferous forest and adjacent meadow in Colorado, USA (1) found that placing woody debris on ski slopes did not affect overall small mammal abundance and had mixed results on individual species. Differences in abundance between treatments were not tested for statistical significance. In the two years following ski run establishment, a similar number of small mammals

was caught each year on a ski run with woody debris (76–77 individuals) and a run without (75–83 individuals). Red-backed voles *Clethrionomys gapperi* were more abundant where woody debris was added (23–43 individuals) than where no woody debris was added (1–23). Similar numbers of heather voles *Phenacomys intermedius* were caught in both areas (with debris: 10–16; without debris: 10–19) and there were fewer least chipmunk *Tamias minimus* in areas with woody debris (15–31 individual) than without (42–46 individuals). Ski runs were established in 1999. One run had one or more tree limbs placed end to end in rows across the run, with rows 3–9 m apart. The other did not contain woody debris. Small mammals were live-trapped over four consecutive days on three occasions in July–September 1999–2001.

(1) Hadley G.L. & Wilson K.R. (2004) Patterns of small mammal density and survival following ski-run development. *Journal of Mammalogy*, 85, 97–104, https://doi.org/10.1644/1545-1542(2004)085%3C0097:posmda%3E2.0.co;2