Garth Mowat[1], Aurora Wildlife Research, RR 1, Site 14, Comp 8, Crescent Valley, British Columbia, V0G 1H0 CANADA

and

Kim G. Poole, Aurora Wildlife Research, 2305 Annable Rd., Nelson, British Columbia, V1L 6K4 CANADA

Habitat Associations of Short-tailed Weasels in Winter

Abstract

We sampled short-tailed weasel (*Mustela erminea*) presence in three study areas in the Selkirk and Purcell mountains of southeast British Columbia using hair removal traps and snow tracking.We extracted measures of forest cover and ecosystem type from digital resource databases to investigate habitat associations of weasels.We summarized use at the sample location (site scale) and in 500 m radius windows (home range scale) to investigate the effect of scale on our findings.Short-tailed weasels were detected in all forests surveyed.These covered the range from open dry Douglas-fir (*Pseudotsuga menziesii*) forests to dense wet western redcedar (*Thuja plicata*)—western hemlock (*Tsuga heterophylla*) forests, and varied in structure from very recent clear-cuts to mature stands >300 yr in age.At the site scale, weasels were detected more often in younger stands with incomplete crown closure. At the larger scale, weasels used home ranges that had less mean crown closure, but no trend was observed across stand age.We conclude that weasels in montane forests prefer open habitats and that stand age is not functionally related to habitat preference. The greater use of younger stands at the site scale can be explained by the correlation between crown closure and age.Weasels occurred in all the ecosystems sampled, including sub-alpine parkland, but appeared to be more abundant in wetter ecosystems, perhaps due to the greater primary productivity of these ecosystems.

Introduction

Short-tailed weasels inhabit forested ecosystems throughout the circumpolar region (King 1983) and are found throughout British Columbia (BC), except for some of the smaller coastal islands (Cowan and Guiguet 1965).Short-tailed weasels (hereafter, weasels) use early successional habitat or forest edges, including meadows, marshes, and riparian woodlands (Simms 1979; King 1983; Fagerstone 1987).Weasels are rare on the islands of coastal BC.In these wet environments they are found in early seral or edge habitats but not in continuous forest (Mowat et al. 2000; Reid et al. 2000).

No data are available on weasel habitat use in montane areas in western Canada.We examined weasel habitat associations in three study areas in southeastern BC to describe weasel use of forested environments during winter.We examined habitat use across stand age and crown closure because these variables index succession and structure which may have general relationships with habitat quality for weasels.

[1]Author to whom correspondence should be addressed.
E-mail: gmowat@telus.net

Study Areas

Our Selkirk study area covered 797 km^2 of the central Selkirk Mountains(Fig. 1).Three biogeoclimatic zones occurred in this area: interior cedar-hemlock (ICH), Engelmann spruce (*Picea engelmannii*)-subalpine fir (*Abies lasiocarpa*)(ESSF) and alpine tundra (AT) (Meidinger and Pojar 1991; Braumandl and Curran 1992).In this area, ICH forests are found below about 1400 m above sea level, where western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*) and spruce hybrids (*Picea* spp.) are the dominant overstory species. ESSF forests are found between roughly 1400 and 2300 m, where these two species dominate the canopy, although many early seral stands are dominated by lodgepole pine (*Pinus contorta*). Extensive areas of AT are found above about 2300 m.We did not sample in alpine tundra but we did sample in subalpine parkland forests.

The Purcell study area was a 1512 km^2 region in the central Purcell Mountains (Fig. 1).The diversity of ecosystems was greater in the Purcell study area than the Selkirk study area.Along with the three zones described above, two dryer zones occurred in this area: interior Douglas-fir (IDF) and montane spruce (MS).The IDF zone

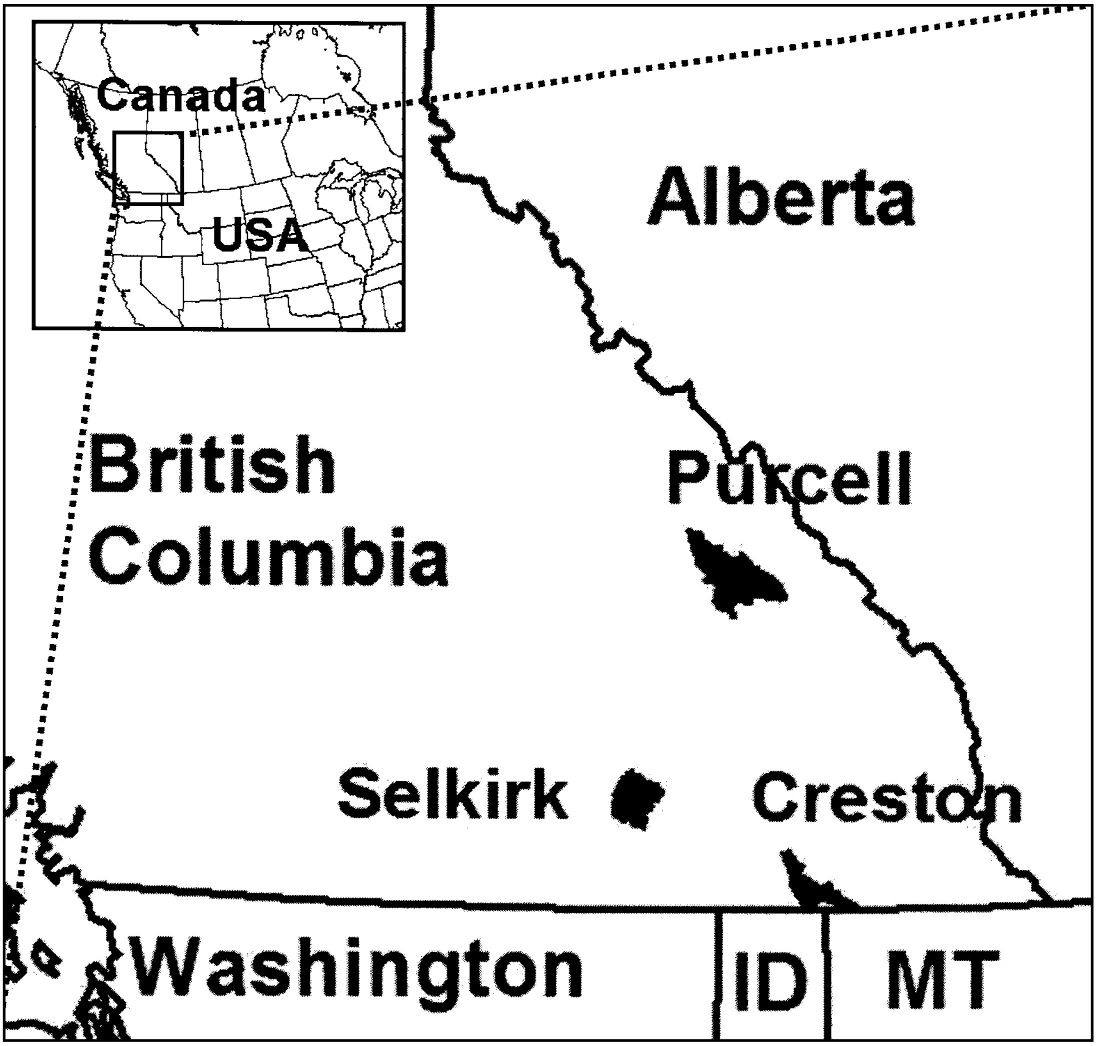

Figure 1. The location of the Selkirk, Purcell and Creston study areas in southeast British Columbia.

was dominated by Douglas-fir, lodgepole pine, and western larch (*Larix occidentalis*) stands. Engelmann spruce and lodgepole pine were the dominant canopy species in the MS ecosystem.

The Creston study area (650 km^2) was located in the southern Purcell Mountains and, like the central Purcell area, was transitional between moist and dry climatic regions (Fig. 1).All of the Creston area we sampled was located within ICH dry and ICH moist subzones.ESSF and, in some areas, AT zones occurred above the ICH zone, but were not sampled.Due to extensive fires early in the 1900s, mixed seral stands of lodgepole pine, Douglas-fir, ponderosa pine (*Pinus ponderosa*), western larch, western white pine (*P. monticola*), and paper birch (*Betula papyrifera*) were more common than cedar-hemlock stands in the Creston area.

Extensive logging has occurred throughout all three areas, most within the past 30 years.Fur trappers were active in all three study areas during the winters we sampled but did not target weasels. Based on fur returns, six weasels were killed by trappers on the Purcell area during the winter we worked, compared to 115 American martens (*Martes americana*).We suspect a similarly low number of weasels were killed in the Selkirk and

Creston areas. We assume the number of weasels killed by fur trappers did not affect the outcome of our analyses.

Methods

Field Methods

Weasel detection data were collected ancillary to other research objectives. The primary objective for sampling the Selkirk area was to estimate marten density (Mowat and Paetkau 2002). The primary objective in the Purcell area was to measure habitat associations of martens (Mowat, In Press), and in the Creston area our primary objective was to examine ungulate habitat selection (Poole and Mowat, In Press).

In the Selkirk and Purcell study areas we collected detection data for weasels at hair sites using baited glue traps to remove hair from animals. Hair traps were fashioned after the design presented by Foran et al. (1997). Snow tracking was also used to assess the presence of a target species within a 10 m radius of a hair trap, both during the setting and removal of traps. Sampling was distributed systematically across both study areas. The Selkirk study area was divided into 86 9-km^2 square cells and each cell was sampled on four separate occasions for 14.6 days on average (SD = 3.14) between 15 January and 14 March 1997 to collect data for mark-recapture analysis. The trap was usually moved after each trapping occasion. Traps were installed in places we felt would be most likely to catch martens within the cell, thus habitat was not sampled randomly or in proportion to availability. Sites were mostly set in patches of trees to maximize marten detection but a broad variety of sites from single trees in recently logged areas to forest >300 yr old were sampled.

We divided the Purcell study area into 5-km^2 cells and randomly located one sample site in each cell. If there was a road within 500 m of a cell then we restricted the trap location to within 500 m of the road. If no roads existed within 500 m of the cell, then the location was randomly located. In practice many sites were too difficult or dangerous to access and these sites were moved closer to accessible roads. Cells with no road within 500 m were accessed using a helicopter. In that case we set the site in the closest landing location to the sample point below treeline. We set one hair trap in 194 cells between 31 January and 26 March 2001; one cell was sampled twice in different locations. Each site was active for an average of 15.0 days (SD = 2.63) and was not visited again until it was removed. Martens usually remove the bait from the trap during their first visit, and another individual or species, such as a weasel, was rarely detected after a marten had visited a site (Mowat and Paetkau 2002; Mowat, In Press). In the Selkirk and Purcell areas sites were located >1 km apart to minimize multiple detections of the same individual (Zielinski and Kucera 1995).

While sampling for marten, Mowat and Paetkau (2002) found that detection success for hair traps in the Selkirk Mountains was poorer for weasels than for martens, and we tried to improve detection success for weasels in the subsequent Purcell study. We attached a 4 x 4 x 15 cm block of wood to the trap tree parallel to the bait to enable easier access to the bait and glue patches for weasels.

We identified species detected in hair traps based on hair morphology and tracks at a site (Mowat and Paetkau 2002). Weasels have short white hair, while both red squirrels (*Taimiasciurus hudsonicus*) and northern flying squirrels (*Glaucomys sabrinus*) have short red-brown to gray hair with little difference between the length of the guard and underfur. Fisher (*Martes pennanti*) did not occur in the Selkirk or Purcell study areas (Cowan and Guiguet 1965; Gibilisco 1994), and during winter mink (*Mustela vison*) were rare in the upland areas we sampled (Mowat and Paetkau 2002). Visual identification was not certain for 57 samples from the Selkirk study area and 27 samples from the Purcell study; these were sent to a commercial genetics lab (Wildlife Genetics International, Nelson, Canada) for species testing. All 22 samples that were confirmed as weasel by genetic testing were short-tailed weasel; no long-tailed weasel (*M. frenata*) were detected.

We counted tracks in snow along transects to measure weasel distribution in the Creston area between 12 February and 29 March 2002. We ran transects directly upslope from the valley bottom. We spaced 62 transects at 3-km intervals along 189 km of valley bottom. The upper elevation limit for transects (generally 1000 to 1200 m) was set *a priori* to reach above the highest elevations that we expected deer (*Odocoileus* spp.) and elk (*Cervus elaphus*) to use in late winter (K. Poole and G. Mowat, unpublished data). We measured distance along each transect using a hip-chain and obtained global positioning system (GPS) locations at 100-m intervals along each transect. For each 100-m segment, we recorded the number of weasel tracks, but analyzed the data based on the presence or absence of weasel tracks in each segment.Weasels were occasionally detected in sequential segments.Transects were surveyed 1 to 8 d after snowfall ($\bar{x}$ = 4.1, SD = 2.0).

Statistical Analysis

We derived overstory crown closure and stand age from BC Forest Cover data which maps forest structure and floristics based on overstory species at a scale of 1:20,000.This mapping is based on interpretation of 1:15,000 scale black and white air photos and ground truthing plots. Biogeoclimatic subzones were digitally mapped at 1:50,000 scale (Meidinger and Pojar 1991; Braumandl and Curran 1992).

To analyze habitat associations we combined stand age and overstory closure into categories that were comparable among study areas.The smallest sample size in any category for the Purcell and Selkirk data was 5, all other categories had n > 10. The mean sample size within categories at sites was 28.5 (SD = 13.7) and 32.1 (SD = 15.3) in 500 m windows.For Creston the lowest sample in a category was 56 while the mean was 300 (SD = 236).We divided the percent use by the percent available to generate a relative measure of detection success that is analogous to the forage ratio *W* (Krebs 1989).This simple analysis approach was used because sampling was unlikely to be random or independent, and grouping the samples into categories would reduce the influence of random error and outliers.We deleted all hair sites that detected only martens because the potential for trap interference was great given the much greater abundance of martens.Martens were detected at over half the sites sampled hence removing these sites greatly reduced sample size and may have biased the sample against forested sites.Weasels were detected at some sites where marten were also detected because hair traps detected both species (rare) or weasels were detected by tracks in snow (more common).No sites were deleted from the Creston track data.In the Selkirk and Purcell areas we analyzed stand age and crown closure at two scales: points to measure use at the site or foraging scale, and within a 500 m radius (78 ha) circular window to measure use at the home range scale.The 500 m window size was based on home range size estimates for male weasels from the nearest study area (Lisgo 1999).We did not calculate mean measures in 500 m windows for Creston because tracks were sampled along transects and segments within 500 m were auto-correlated.Spearman rank correlation was used to measure the relationship between crown closure and stand age.

Results

After sites that detected martens were removed, weasels were detected at 34 of 133 sites (26%) in the Selkirks, 19 of 97 sites (20%) in the Purcells, and 62 of 1,201 (5%) track segments near Creston.Marten were also detected at 11 sites where weasels were detected in both the Selkirk and Purcell study areas.Hair traps were not efficient at detecting weasels.In the Selkirks 14 of 34 weasel detections were based on tracks near the site while 10 of 19 detections were based on tracks in the Purcell study area.The proportion of approaches within 10 m of a site that failed to generate a weasel hair sample was similar between the Selkirk and Purcell areas (41% versus 40%, respectively; Mowat and Paetkau 2002).This suggests the step-up block added to the traps in the Purcells did not improve detection of weasels.Most detection failures resulted because the weasel did not climb the tree to the trap.

We detected weasels in all forest types from open dry Douglas-fir stands to moist closed cedar-hemlock stands and from valley bottoms to sub-alpine parkland.Weasels were detected more often at sites with low crown closure (Fig. 2), and this observation was maintained at the broader scale of analysis (Fig. 3).Stands with <10% crown closure were used more than more closed stands in all study areas.There was greater use of younger stands at the site scale (Fig. 4) but not at the broader scale (Fig. 5).Stand age and crown closure at sites was correlated on all three study area ($r > 0.62$, $P < 0.001$ for all study areas) but less so in 500 m radius windows (r = 0.29, P = 0.004 for Purcells and not significant for Selkirk).Detection rates were similar in ICH and ESSF zones in the Selkirks (Fig. 6), greater in the ESSF over the IDF and MS in the Purcells, and greater in the ICH moist than the ICH dry at Creston (Fig. 6).The ICH and ESSF had similar rainfall in the Selkirks while the ESSF was wetter than the IDF and MS in the Purcells (Braumundl

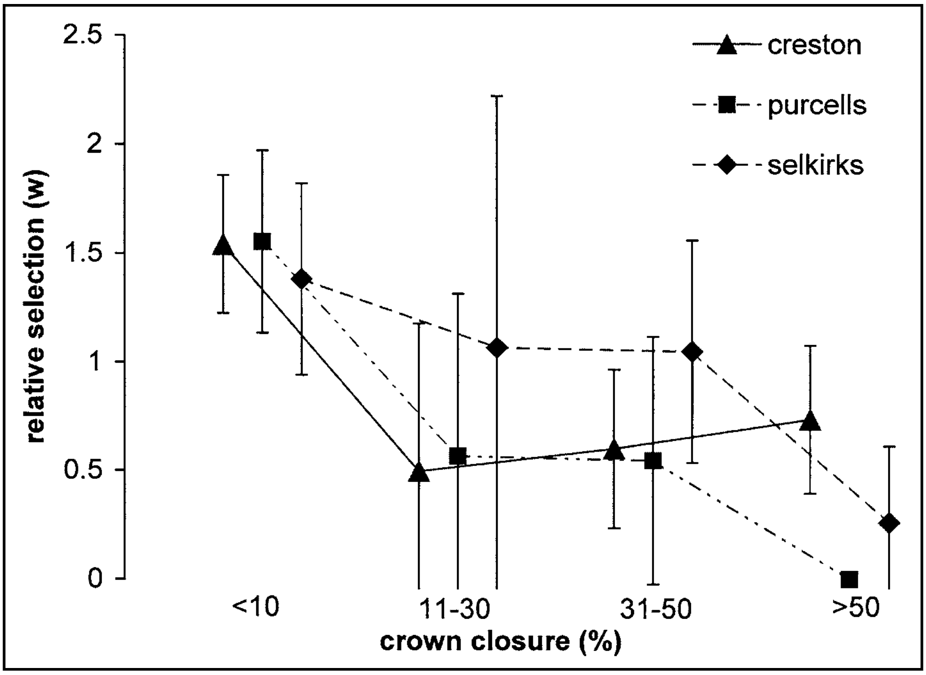

Figure 2. Habitat use of weasels at the site scale across increasing crown closure for the Selkirk, Purcell and Creston study areas.Use is indexed by percent use divided by percent available (*W*) and error bars are 95% confidence intervals.

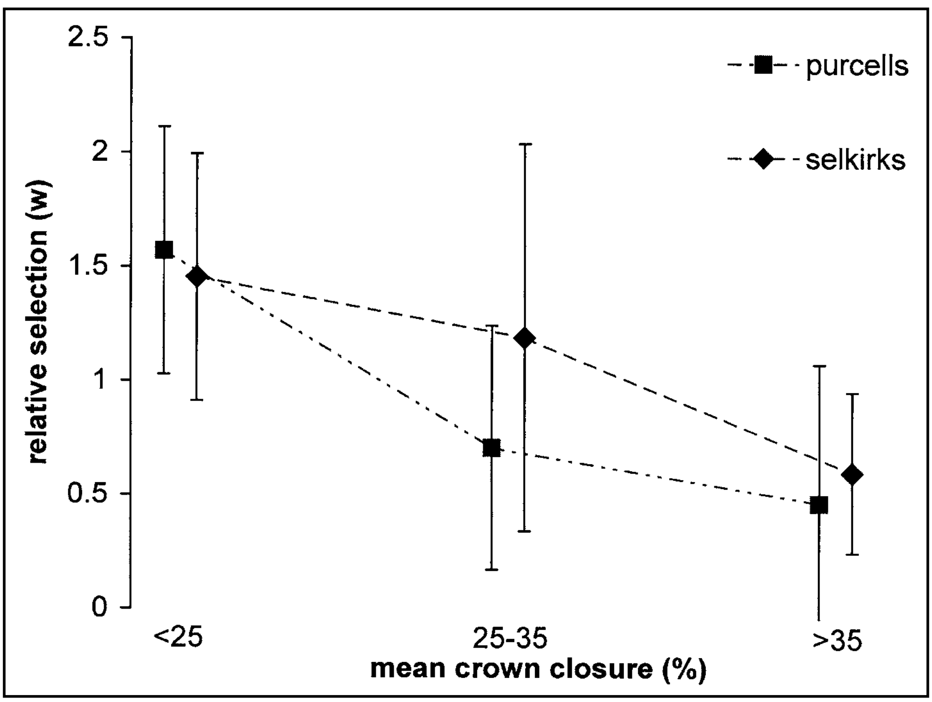

Figure 3. Habitat use of weasels when crown closure is averaged in a 500 m radius of the sample site (home range scale) for the Selkirk and Purcell study areas.Use is indexed by percent use divided by percent available (*W*) and error bars are 95% confidence intervals.

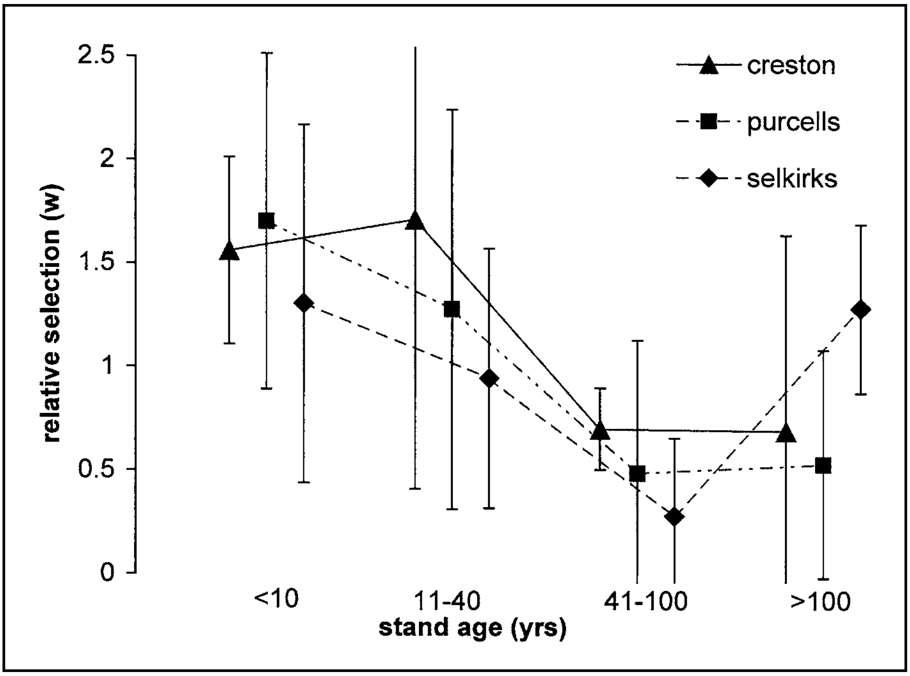

Figure 4. Habitat use of weasels at the site scale across increasing stand age for the Selkirk, Purcell and Creston study areas.Use is indexed by percent use divided by percent available (*W*) and error bars are 95% confidence intervals.

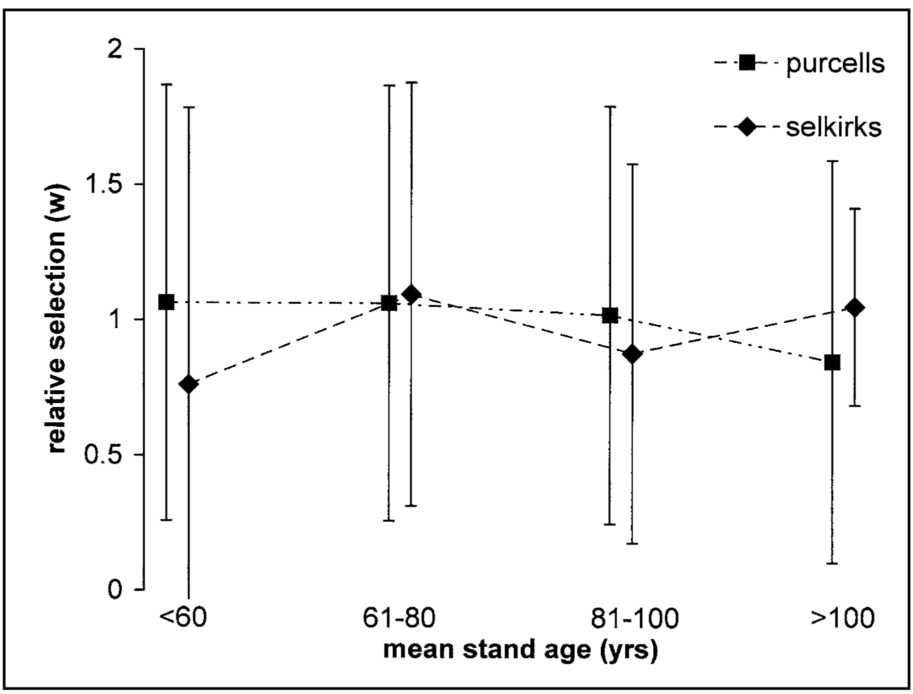

Figure 5. Habitat use of weasels when stand age is averaged in a 500 m radius of the sample site (home range scale) for the Selkirk and Purcell study areas.Use is indexed by percent use divided by percent available (*W*) and error bars are 95% confidence intervals.

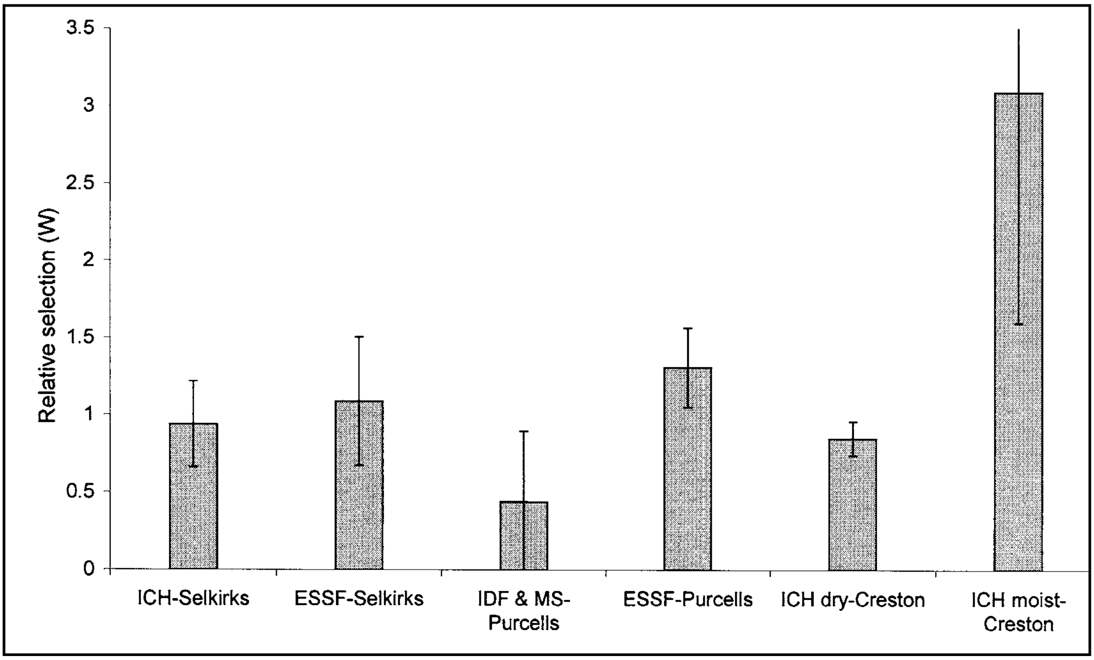

Figure 6. Habitat use of weasels among ecosystems for the Selkirk, Purcell and Creston study areas.Use is indexed by percent use divided by percent available (*W*) and error bars are 95% confidence intervals.

and Curran 1992).Weasels were detected more often in wet ecosystems.

Discussion

We detected short-tailed weasels in all forests surveyed, which varied in structure from very recent clear-cuts to mature stands >300 yr in age. Short-tailed weasels living in forested environments appear to prefer open areas across much of their range (King 1983; Fagerstone 1987).Our results provide broad support for this general association because we sampled much larger areas that included greater physical and ecological variation than other workers.Based on our analysis within 500 m of hair sites, weasels also appeared to choose home ranges with lower mean overstory than the surrounding landscape.Simms (1979) noted that short-tailed weasels choose home ranges with substantial amounts of early successional habitat.Short-tailed weasels were detected more often in thinned mid-seral stands than un-thinned stands in western Washington, possibly due to the greater understory in the thinned stands (Wilson and Carey 1996).Lisgo (1999) and O'Donoghue et al. (2001) found weasels in all but the driest forest types in the boreal forests they sampled, and here too selection was most often for more open habitats.In dense coastal forests weasels are usually detected in small openings along roadways, watercourses, or in grassy cut-blocks (Mowat et al. 2000; Reid et al. 2000).All areas we surveyed contained at least small openings from roads, watercourses, or avalanche chutes, and perhaps weasels made use of these small, unmapped openings when they resided in densely forested landscapes.Use of riparian communities at fine scales may be due to the presence of open habitats, which are interspersed among a generally closed canopy matrix (Mowat et al. 2000; Reid et al. 2000).

At the site scale, weasels were also detected more often in younger stands in all three areas, although use of the oldest stands was similar to younger stands in the Selkirk study area.There was no association across stand age within 500 m windows suggesting that the finer scale trend was based on the correlation between stand age and crown closure, and not some more fundamental relationship with stand age.We suggest that the fundamental habitat association is the preference for open stands and landscapes, not the preference for younger trees in the overstory.

What is the functional relationship between short-tailed weasels and open stands?Short-tailed weasels in the circumpolar north are small and prey mainly on voles and mice (King 1989).Voles, other than *Clethrionomys*, are most abundant in open grassy sites (Johnson and Johnson 1982), therefore, weasel use of open sites may be explained by the abundance of their principal prey.In northern Alberta, Lisgo (1999) found male weasels ate more squirrels than did females, and males used more closed canopy forest than females, who hunted mainly voles.This partitioning of resources may explain why weasels are often found in both open and closed environments in the same landscape, notwithstanding greater use of open environs.A second explanation for the preference for open sites is based on competition.Martens are likely the main competitor of weasels in most of the forested ecosystems they occupy and martens appeared to be more abundant in all three study areas.Detection success for marten was 69% in the Selkirks, 63% in the Purcells, and 8% for the Creston area which was 1.6 to 3.2 times higher than for weasels.Red-backed voles (*Clethrionomys* spp.) and red squirrels are generally more important foods than other voles for martens and both prey species occur in forested sites (Buskirk and Ruggiero 1994).Martens avoided young, open canopy stands in all three study areas (Mowat, In Press; Poole and Mowat, unpubl. data) and competition between martens and weasels may exclude the smaller short-tailed weasel from closed canopy habitat.

Weasels occurred in all the ecosystems sampled, but like martens (Mowat, In Press), they appeared to be more abundant in the wetter ecosystems in a study area.Several authors have noted that weasels prefer moist or riparian sites within their home ranges, even in very wet environments (Doyle 1990; Lisgo 1999; Mowat et al. 2000; Reid et al. 2000), but this does not explain our observations.Our ecosystems were hundreds of km^2 in size and we suggest the greater abundance of weasels in wetter ecosystems was due to greater ecosystem productivity, not behavioral preferences for structure, floristics, or the need to drink (Fagerstone 1987).

Our hair-traps provided weak measures of occurrence for weasels because detection success was poor; this short-coming was partially overcome by track detection near hair traps.Variation in detection success among sites was likely random, which may have reduced the power of our comparisons but was unlikely to cause directional bias. Similarly, autocorrelation was unlikely to cause a major bias in the Creston data because the 1,201 track segments (sample units) were located on 62 systematic transects and weasels were detected on 62 segments on 29 different transects.

We did not sample availability representatively in any study area, but our samples covered the range of possible variation for both crown closure and stand age in all three study areas.Further, the large size of our study areas and the systematic nature of our samples conferred considerable independence among samples. We sampled habitat use among very different ecosystems, across large scales, using different methods, and our results among study areas concur.The non-random nature of our site locations negates our ability to make specific inferences about habitat selection within study areas, such as building a predictive map of habitat quality.We suggest that the non-random nature of our sample locations did not bias detection across the range of our analysis variables, nor negate general comparisons across the range of variation sampled.

Acknowledgements

Funding for this work was provided by Forest Renewal British Columbia, Slocan Forest Products, Tembec Inc., and the Arrow IFPA.We thank K. Stuart-Smith, P. Frasca, G. Richardson, R. Serrouya, P. Cutts, M. Panian, C. Strobeck, C. Davis and D. Underwood for logistical and administrative support.D. Stanley, D. Fear, M.-A. Beaucher, S. Petrovic, M. Petrovic, P. Cutts and C. Shurgot helped with fieldwork.D. Paetkau, M. Paradon, M. Watt, K. Stalker, C. Kyle, and J. Weldon assisted with DNA analysis.M. Buchanan and D. Pritchard did GIS mapping and data extraction. S. Minta and K. Heinemeyer kindly shared their knowledge about hair removal of martens.Thanks to V. Nams, I. Adams and R. Weir for their reviews of the manuscript.

Literature Cited

Braumandl, T. F., and M. P. Curran, editors. 1992. A field guide for site identification for the Nelson Forest Region. Land Management Handbook No. 20, B.C. Ministry of Forests, Victoria, British Columbia, Canada.

Buskirk, S. W., and L. F. Ruggiero. 1994. Marten. Pages 7-37 *In* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski (editors). The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. USDA Forest Service GTR-RM-254. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Cowan, I. M., and C. J. Guiguet. 1965. The mammals of British Columbia, 3rd edition. Handbook No. 11, British Columbia Provincial Museum, Victoria, British Columbia, Canada.

Doyle, A. T. 1990. Use of riparian and upland habitats by small mammals. Journal of Mammalogy 71:14-23.

Fagerstone, K. A. 1987. Black-footed ferret, long-tailed weasel, short-tailed weasel, and least weasel. Pages 548-574 *In* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch (editors). Wild furbearer conservation and management in North America. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

Foran, D. S., K. C. Crooks, and S. C. Minta. 1997. DNA-based analysis of hair to identify species and individuals for population research and monitoring. Wildlife Society Bulletin 25:840-847.

Gibilisco, C. J. 1994. Distributional dynamics of modern *Martes.* Pages 283-296 *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.

Johnson, M. L., and S. Johnson. 1982. Voles. Pages 326-354 *In* J. A. Chapman, and G. A. Feldhamer (editors). Wild mammals of North America: biology, management, and economics. John Hopkins University Press, Baltimore, New Jersey.

King, C. M. 1983. *Mustela erminea*. Mammalian Species No. 195.

King, C. M. 1989. The natural history of weasels. Cornell University Press, Ithaca, New York.

Krebs, C. J. 1989. Ecological Methodology. Harper and Row, New York, USA.

Lisgo, K. A. 1999. Ecology of the short-tailed weasel in mixed-wood boreal forest of Alberta. M.Sc. thesis, University of British Columbia, Vancouver, Canada.

Meidinger, D., and J. Pojar. 1991. Ecosystems of British Columbia. Special Report Series 6, B.C. Ministry of Forests, Research Branch, Victoria, B.C., Canada.

Mowat, G., C. Shurgot, and K. G. Poole. 2000. Using track plates and remote cameras to detect marten and short-tailed weasels in coastal cedar hemlock forests. Northwestern Naturalist 81:113-121.

Mowat, G., and D. Paetkau. 2002. Estimating marten population size using hair capture and genetic tagging in southeast British Columbia. Wildlife Biology 8:201-209.

Mowat, G. *In press*. Winter habitat associations of American martens Martes americana in interior wet-belt forests. Wildlife Biology.

O'Donoghue, M., S. Boutin, E. J. Hofer, and R. Boonstra. 2001. Other mammalian predators. Pages 324-338 *In* C. J. Krebs, S. Boutin, and R. Boonstra (editors). Ecosystem dynamics of the boreal forest: the Kluane project. University of Oxford Press, New York.

Poole, K. G. and G. Mowat.*In press*.Winter habitat relationships of deer and elk in the temperate interior mountains of British Columbia. Wildlife Society Bulletin.

Reid, D. G., F. L. Waterhouse, P. E. F. Buck, A. E. Derocher, R. Bettner, and C. D. French. 2000. Inventory of Queen Charlotte Islands ermine. Pages 393-406 *In* L. Darling (editor). At risk: proceedings of a conference on the biology and management of species and habitats at risk. B.C. Ministry of Environment, Lands and Parks, Victoria, Vol. 1.

Simms, D. A. 1979. Studies of an ermine population in southern Ontario. Canadian Journal of Zoology 57:824-832.

Wilson, T. D., and A. R. Carey. 1996. Observations of weasels in second-growth Douglas-fir forests in the Puget Trough, Washington. Northwestern Naturalist 77:35-39.

Zielinski, W. J., and T. E. Kucera, editors. 1995. American marten, fisher, lynx and wolverine: survey methods for their detection. USDA Forest Service, PSW-GTR-157, Pacific Southwest Research Station, Albany, California, USA.

Received 29 July 2004
Accepted for publication 6 March 2005