Journal of Wildlife Management 74(3):405–410; 2010; DOI: 10.2193/2008-579

Management and Conservation Note

Factors Affecting Landscape Occupancy by Fishers in North-Central British Columbia

RICHARD D. WEIR,[1] *Artemis Wildlife Consultants, 4515 Hullcar Road, Armstrong, BC V0E 1B4, Canada*

FRASER B. CORBOULD, *Peace/Williston Fish and Wildlife Compensation Program, Suite 325, 1011 Fourth Avenue, Prince George, BC V2L 3H9, Canada*

ABSTRACT To better understand distribution and density of fishers (*Martes pennanti*) in industrial forests of north-central British Columbia, Canada, we examined factors affecting the probability of a potential home range being occupied by 10 radiotagged resident fishers in the Sub-Boreal Spruce biogeoclimatic zone between 1996 and 2000. Percentage of a home range in wetlands and recently logged (within past 12 yr) best predicted likelihood of occupancy by each fisher. Probability of a home range area being occupied by a resident fisher decreased with increasing amounts of wetlands and recent logging present in the area. We estimated that a 5% increase in wetlands or recent logging decreased the relative probability of occupancy of a potential home range by 50%. The accelerated rate of timber harvest in forests affected by mountain pine beetle (*Dendroctonus ponderosae*) infestations may have substantial implications for the ability of the landscape of central British Columbia to support sustainable populations of fishers.

KEY WORDS British Columbia, fishers, habitat, home range occupancy, landscape, *Martes pennanti*, selection.

Fishers (*Martes pennanti*) are medium-sized carnivores that occur in temperate and boreal forests of North America. Fishers are associated with forested ecosystems, from hardwood forests in the east to montane coniferous forests in the west (Powell 1993). Fishers are uncommon, but important, predators in the forests they occupy. Fishers use forested environments extensively and Proulx et al. (2004) identified loss of forested habitat from human development as the primary long-term threat to fisher populations.

Fishers make many resource selection decisions throughout their life, the first of which is to decide where in the landscape to establish a home range. Home range selection is a critical decision; it is within this home range that fishers must find sufficient resources to survive and reproduce, and all future resource selection decisions are dependent on the suite of habitats within this selected area. In areas where the landscape has high suitability, fishers occur throughout the landscape (e.g., ME, Arthur et al. 1989*a*; MA, Fuller et al. 2001; PQ, Garant and Crête 1997) and individuals may exhibit little selectivity in where they establish home ranges. However, in landscapes with less than optimal suitability, fishers may have to be highly selective and include habitats of sufficient quality within their home range to be able to survive and reproduce. Despite the importance of this selection decision, little is known about factors that influence home range establishment by fishers and, concomitantly, where home ranges occur within the landscape. Fishers successfully establish home ranges only where there is a sufficient concentration of suitable habitat; overhead cover appears to be a basic habitat requirement for the species (Powell 1993, 1994). In California, other factors that may affect where fishers occur include tree canopy closure, tree size class, percentage of conifers, and annual precipitation (Carroll et al. 1999). In Ontario, Canada, landscapes with low snow depths and high proportions of coniferous forest had the highest habitat suitabilities for fishers (Carr et al. 2007).

We explored broad-scale habitat selection by radiotagged fishers between 1996 and 2000 in the Williston region of north-central British Columbia, Canada, by examining where fishers occupied home ranges within the landscape. Our objective was to identify habitat features that fishers selected when choosing a home range and to develop a parsimonious model that predicted probability of occupancy for the species.

STUDY AREA

Our study area covered approximately 1,830 km^2, centered 70 km northwest of Mackenzie, British Columbia, Canada (55°19′N, 123°6′W), and was entirely within the Williston Reservoir watershed. Topography was characterized by a gently rolling plateau rising from the Rocky Mountain Trench (Williston Reservoir, full pool 672 m above sea level) in the east to the slopes of the Wolverine and Swannell Range mountains in the west. The plateau was drained by a series of small creeks with poorly developed or nonexistent floodplains.

The boundary of the study area was defined by the extent of the Sub-Boreal Spruce biogeoclimatic zone (SBS; Meidinger et al. 1991). Annual precipitation averaged 690 mm in the moist-cool SBS subzone and 905 mm in the wet-cool SBS subzone, and snowfall averaged 335 cm/year and 1,075 cm/year, respectively (MacKinnon et al. 1990). Snow cover generally lasted from mid-November until mid-April. Peak snow depths averaged 91 cm (SD = 30 cm) and typically occurred in mid-March. Mean annual temperature during the study was 2° C, with temperatures ranging between −47° C and 36° C.

Forests were dominated by hybrid spruce (*Picea glauca* × *engelmannii*), lodgepole pine (*Pinus contorta*), black spruce

[1] *E-mail: rweir@artemiswildlife.com*

Table 1. Set of candidate models used to examine probability of occupancy of home ranges within the landscape by radiotagged fishers in the Williston region of north-central British Columbia, Canada, 1996–2000. Categories summarize hypothesized relationships between probability of use and generalized habitat features in the model. For example, L-1 predicts inclusion of complex structural stages within the home range affected probability of occupancy.

Model	Model category	Probability of occupancy related to…	Reference
L-1	Inclusion	Complex structural stages	Jones and Garton 1994
L-2	Inclusion	Forested ecosystem associations	Unique hypothesis
L-3	Inclusion	Habitat suitability index	Allen 1983, Tully 2006
L-4	Inclusion	Mature and old structural stage productive ecosystems	Unique hypothesis
L-5	Inclusion	Mature and old structural stage riparian	Unique hypothesis
L-6	Inclusion	Stands $\geq$30% cover	Arthur et al. 1989*b*
L-7	Nonspecific	Granularity	Weir and Harestad 1997
L-8	Avoidance	Non-forested ecosystem associations	Unique hypothesis
L-9	Avoidance	Open areas	Powell 1993
L-10	Avoidance	Recent logging	Buck et al. 1994
L-null	Null	[No selection]	

(*Picea mariana*), and subalpine fir (*Abies lasiocarpa*), with deciduous components of trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*). Black cottonwoods (*Populus balsamifera* spp. *trichocarpa*) occurred as a minor element in riparian-type ecosystems and occasionally in other areas with sub-hygric or wetter ecological moisture regimes. Common understory shrubs were prickly rose (*Rosa acicularis*), black huckleberry (*Vaccinium membranaceum*), black twinberry (*Lonicera involucrata*), kinnikinnick (*Arctostaphylos uva-ursi*), and black gooseberry (*Ribes lacustre*).

Human-caused habitat disturbances in or immediately adjacent to the study area were fairly recent and extensive. With the flooding of the Rocky Mountain Trench by the Williston Reservoir that began in 1968, all lands below 672 m elevation were submerged; much of this area was riparian forest along the lower Omineca, Manson, and Parsnip rivers. Forest harvesting had occurred extensively throughout the study area over the past 30 years; 532 km^2 had been logged since 1970, representing 29% of the total study area. Forest harvesting and natural disturbances resulted in a mosaic of seral stages throughout the study area.

METHODS

We captured, radiotagged, and collected radiolocations on fishers throughout our study area between October 1996 and August 2000 (Weir and Corbould 2006, 2007). All capture and handling protocols met or exceeded capture and handling guidelines outlined in the protocols for Wildlife Capture and Handling (Resources Information Standards Committee 1998; Wildlife Act permit C076979). We estimated size and location of the home range for resident fishers with $\geq$30 radiolocations that we collected over $\geq$10 months using the 95% isopleth of the utilization distribution generated from the fixed kernel method with the smoothing parameter selected by least-squares cross-validation (Worton 1989, Seaman et al. 1999). We used the animal movement extension to ArcView (Hooge and Eichenlaub 1999) for home range calculations.

Using map-based ecosystem and terrain data, we compared the composition of home ranges occupied by radiotagged fishers to potential home ranges, which allowed us to compare used home ranges to available home ranges in the landscape for each individual and generate a resource selection function (RSF; Manly et al. 2002). We defined our landscape as the extent of the SBS that was effectively live-trapped (Weir and Corbould 2006). We measured distribution and abundance (i.e., availability) of stands within the landscape (Wilson et al. 1998) by generating 162 pseudo–home ranges for each fisher, which were size- and shape-specific replicates of the individual's home range positioned at a random geocoordinate within the landscape and then rotated to a randomly selected angle. We set 2 criteria for placement of pseudo–home ranges within the landscape: no part of the pseudo–home range could extend >100 m into the Williston Reservoir, and $\geq$50% had to lie within the SBS. We allowed overlap to occur between pseudo–home ranges and observed home range. To allow equivalent comparisons for measurements between used and pseudo–home ranges, we scaled all measurements to total area within the home range that occurred within the SBS. We considered home range occupancy as a binary response variable and used 1-M conditional logistic regression (Hosmer and Lemeshow 2000) to parameterize each candidate model. Using this approach, we compared one used home range to 162 pseudo–home ranges for each resident fisher to generate a RSF to explain occupancy of home ranges within the landscape.

We evaluated factors that affected occupancy by examining several hypothetical models that predicted the relationship between these variables and probability of use. Past research has identified several key habitat relationships that may affect where fishers will establish home ranges (Tables 1, 2). We based many of our models on previous research, but several were unique hypotheses. We compared support among models and assessed probability of each model in the candidate set. We considered 3 categories of models: those that predicted selection of home ranges on the basis of avoidance of stands, inclusion of stands, and general features. To achieve an event-to-parameter ratio of 10:1 (Peduzzi et al. 1996) in our candidate models, we were limited to single-variable models because of the number of home ranges that we identified.

We used 2 sources of spatial data for our analysis. Within each used and pseudo–home range, we measured the length of creeks and rivers by overlaying the home range with

Table 2. Variables used in candidate models to predict selection of home ranges within the landscape by radiotagged fishers in the Williston region of north-central British Columbia, Canada, 1996–2000.

Variable	Description
Recent logging	% home range logged between 1988 and 2000
Stands $\geq$30% cover	% home range in stands with $\geq$30% tree cover
Habitat suitability index	Area-weighted average of Allen's (1983) habitat suitability index
Granularity	No. of stands/km^2 in home range
Complex structural stages	% home range in young forest, mature forest, and old forest structural stages
Forested ecosystem associations	% home range in Pine-Cladina, Spruce-Dry, Black Spruce, Spruce-Zonal, Spruce-Moist, or Spruce-Wet ecosystem associations
Non-forested ecosystem associations	% home range in non-vegetated, wetland, or open water ecosystem associations
Mature and old structural stage riparian	Length of creeks and rivers in mature and old forest structural stages in each home range (km/km^2)
Mature and old structural stage productive ecosystems	% home range in mature and old forest structural stages of the Spruce-Zonal, Spruce-Moist, or Spruce-Wet ecosystem associations
Open areas	% home range logged since 1988 or in wetland ecosystem association

Terrain Resource Inventory Modelling data (TRIM; British Columbia Ministry of Sustainable Resource Management 2000). We determined the proportion of each home range with $\geq$30% tree cover using Forest Inventory Planning data (FIP; British Columbia Ministry of Forests 2002). We also used the FIP data to assess the proportion of each home range that had undergone timber harvest since 1988. We calculated estimates of the area-averaged habitat suitability index developed for fishers by Allen (1983) for each home range based on canopy closure, mean tree diameter at breast height, overstory composition, and layer count information in the FIP data. We measured the percentage of each home range in each site series and structural stage using 1:20,000-scale predictive ecosystem maps (PEM; Atticus Resource Consulting 2002, Timberline Forest Inventory Consultants 2004) and used these polygons to calculate the number of stands that occurred in each home range. We also combined PEM and TRIM data to determine the length of creeks and rivers in mature and old forest structural stages in each home range. We scaled each of these measures to home range area for each stratum (i.e., each fisher).

We used an information-theoretic approach to identify the most parsimonious model (Burnham and Anderson 1998) in the candidate set. We calculated Akaike's Information Criterion score modified for small sample sizes (AIC$_c$; Burnham and Anderson 1998) for each model, ranked relative support for each by comparing scores among competing models, and identified the best model from this candidate set by selecting the model with the lowest AIC$_c$ score. We used the difference in AIC$_c$ scores between each model and the best-selected model (Δ_i), in addition to Akaike weights (w_i), to quantify strength of evidence among the candidate set of models (Burnham and Anderson 1998). We identified the 95% confidence set of best models using the fewest top models whereby $\sum w_i$ was $\geq$0.95. We used odds ratios to quantify the effect of each variable on probability of occupancy by radiotagged fishers. We assessed model fit by calculating the percentage of data correctly classified by the best model using a straightforward confusion matrix.

RESULTS

We collected sufficient data to estimate home ranges for 10 resident fishers (2 M, 8 F). All individuals were breeding-age adults $\geq$2 years old that had stable home ranges, and 5 females successfully produced $\geq$1 litter of young during their respective monitoring periods. We monitored fishers for 730 days on average (SD = 438 days) during which we collected an average of 68 radiolocations for each fisher (SD = 28 locations). Monitoring effort was more or less equal throughout the year. Home ranges averaged 47.7 km^2 for females (SD = 16.5 km^2) and 219.0 km^2 for males (SD = 9.1 km^2) and comprised primarily mesic, sub-hygric, or hygric forests ($\bar{x}$ = 59% of home range area, SD = 13%) in young-forest or older structural stages ($\bar{x}$ = 60% of home range area, SD = 8%). Overlap of used and pseudo–home ranges varied among individuals ($\bar{x}$ = 5% of used home range area, SD = 12%, n = 1,620 replicates) but was as high as 24% for one male fisher that had a large, elongated home range.

The best approximating model to predict probability of occupancy by fishers included the percentage of home range in open areas (i.e., areas classified as wetland ecosystems or recently logged; Table 3). This model ranked 6.4 AIC$_c$ units better, and was 24 times more likely, than the next-best model. The 95% confidence set of best models included 8 models in total. The best model ranked 7.3 AIC$_c$ units better, and was 38 times more likely, than the null model, which predicted no selection. Probability of a home range area being occupied by a resident fisher decreased with increasing amounts of open area (odds ratio = 0.803, 95% CI = 0.663–0.973). Our findings suggest that a 5% increase in open areas within a potential home range decreased the relative probability of occupancy by 50% (Fig. 1), which is equivalent to logging 239 ha (e.g., 5% of a typical F home range in the Williston region) in a 12-year period. Forest-harvest units (i.e., cutblocks) in our study area averaged 16.7 ha (SD = 25.4 ha, n = 937) and ranged up to 225 ha. As such, a 5% increase in open areas would be roughly equivalent to logging 14 or 15 cutblocks within a 47.7-km^2 area over 12 years. The best model was a good predictor of the probability of a home range area being occupied by a resident fisher, with a rate of correct classification of 86.7%.

DISCUSSION

Fishers showed strong selection for where they established home ranges within the landscape, avoiding establishing

Table 3. Ninety-five percent confidence set of models that explained selection of home ranges across the landscape by 10 radiotagged fishers in the Williston region of north-central British Columbia, Canada, 1996–2000.

Model	Model category	Probability of occupancy related to...	K[a]	Log L[b]	AIC$_c$[c]	Δ_i[d]	w_i[e]
L-9	Avoidance	Open areas	1	−46.293	94.6	0	0.78
L-8	Avoidance	Non-forested ecosystem associations	1	−49.484	101.0	6.4	0.03
L-2	Inclusion	Forested ecosystem associations	1	−49.508	101.0	6.4	0.03
L-10	Avoidance	Recent logging	1	−49.613	101.2	6.6	0.03
L-null	Null	[No selection]	0	−50.938	101.9	7.3	0.02
L-6	Inclusion	Stands $\geq$30% cover	1	−49.923	101.8	7.3	0.02
L-5	Inclusion	Mature and old structural stage riparian	1	−49.941	101.9	7.3	0.02
L-3	Inclusion	Habitat suitability index	1	−49.981	102.0	7.4	0.02

[a] No. of estimated parameters in associated model.
[b] Log likelihood.
[c] Akaike's Information Criterion for small samples (Burnham and Anderson 1998).
[d] Difference in AIC$_c$ scores between model and best-selected model.
[e] Relative likelihood of model; Akaike wt (Burnham and Anderson 1998).

home ranges in areas with high densities of open areas. Being that fishers establish home ranges only where there is a sufficient concentration of suitable habitat (Powell 1994), our observation that fishers excluded wetland ecosystems and recently logged stands from their home range may be linked to the low densities of resources found in these areas. Wetlands and recently logged areas typically have little overhead cover, which likely exposes fishers to greater risk from aerial predators (Powell and Zielinski 1994). Furthermore, escape cover, such as trees for climbing, is farther apart in these environments, making fishers further susceptible to terrestrial predators. The relationship between open areas and where fishers occur has been observed elsewhere; in Ontario, fisher populations increased due to an increase in the amount of forested land (Lancaster et al. 2008), and fisher captures in Nova Scotia were negatively related to presence of wetlands (Potter 2002). Also, wetlands in north-central British Columbia have lower prey densities (e.g., snowshoe hares, squirrels, and voles) than forested areas (based on track surveys; R. D. Weir, Artemis Wildlife Consultants, unpublished data).

We assumed that fishers were capable of selecting any area in the landscape in which to establish a home range and that

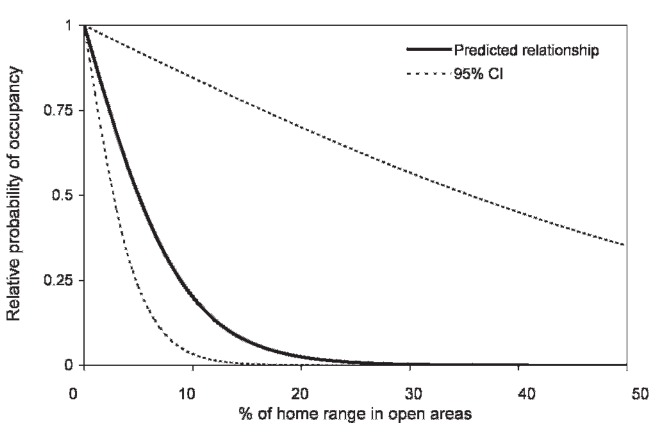

Figure 1. Effect of open areas (recent logging or wetlands) on relative probability of a home range being occupied by radiotagged fishers in the Williston region of north-central British Columbia, Canada, 1996–2000. A 25% increase in open areas within a potential home range reduced the relative probability of occupancy to almost nil.

the entire landscape was available. However, fishers exhibit intrasexually exclusive territories (Powell 1994), so the presence of other fishers likely influenced areas available for establishment of a home range. If fishers avoided areas already occupied by members of the same sex, we would expect that the effect of open areas on occupancy would be underestimated because individuals would not have the opportunity to select the best home ranges (i.e., those with few open areas). If fishers were attracted to areas with residents of the opposite sex, we would expect that home ranges would be more likely to include less-open areas. Given that our results were based on 8 females and 2 males and overlap was minimal within sexes, we suspect that it is most likely that the effect of open areas on home range occupancy was underestimated.

Avoidance of open areas is probably not the only habitat factor that affects where fishers establish home ranges within the landscape. We expect that other factors, such as availability of prey and reproductive denning, resting, and movement habitats also play a role in home range selection. Given our limited sample size, we could only evaluate simplistic models and, with a sample of 10 individuals, it is not clear if these results were representative of the regional population. Additional research involving larger sample sizes would allow for comparison of more complex models that may better predict the probability of occupancy by fishers.

Management Implications

The relationship between the extent of open areas and probability of home range occupancy suggests that past and proposed forest harvesting can strongly affect the ability of the landscape to support fishers, especially in landscapes in which wetland ecosystems are common. Landscapes with previous widespread and intensive forest harvesting may lose their ability to support fishers until these harvested areas regenerate sufficiently. Depending on the residual density of fishers in the harvested landscape, fishers need to disperse from adjacent areas with less forest harvesting for these landscapes to support resident fishers again. Intensive forest harvesting in the future may exacerbate the already diminished ability of modified landscapes to support fishers, particularly in forests that are slated for salvage harvest of diseased or damaged trees.

Throughout British Columbia, forests that support fishers are experiencing a widespread epidemic of mountain pine beetles (*Dendroctonus ponderosae*), which attack and kill lodgepole pine trees. Although considerable mortality of overstory pine trees occurs in stands affected by beetles, sufficient secondary structure likely remains (Coates et al. 2006) to support the need for overhead cover by fishers. However, to maximize recovery of timber value in affected areas, forest harvest in beetle-affected areas has increased substantially in terms of both spatial and temporal intensity (British Columbia Ministry of Forests 2004, 2007). Because salvage harvest of beetle-killed trees typically involves clear-cut harvesting, whereby all tree species (including spruce and fir) and secondary structure within the harvest unit are felled or cleared, our results suggest that this expedited harvest will gravely affect the ability of these landscapes to be occupied by fishers.

Acknowledgments
This project was funded by the Peace/Williston Fish and Wildlife Compensation Program (a joint initiative of BC Hydro and the British Columbia Ministry of Environment) and Forest Renewal British Columbia. The British Columbia Ministry of Environment, Slocan Group (Mackenzie Operations), Abitibi Consolidated, and the British Columbia Trapper's Association provided additional logistical support. Field assistance was provided by A. Bowser, V. Hawkes, J. McCormick, J. Perreault, and D. Wellwood. Thanks to S. Barry for Geographic Information System support. We thank H. Davis, D. Heard, E. Lofroth, and 2 anonymous reviewers for their constructive comments on this manuscript.

LITERATURE CITED

Allen, A. W. 1983. Habitat suitability index models: fisher. U.S. Fish and Wildlife Service, U.S. Department of the Interior Report FWS/OBS-82/10.45, Washington D.C., USA.

Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989*a*. Home range characteristics of adult fishers. Journal of Wildlife Management 53:674–679.

Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989*b*. Habitat use and diet of fishers. Journal of Wildlife Management 53:680–688.

Atticus Resource Consulting. 2002. Predictive ecosystem mapping (PEM) for the Mesilinka, Chunamon, and Osilinka resource management zones. Abitibi Consolidated Company of Canada–Mackenzie Region, Mackenzie, British Columbia, Canada. <http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=1498>. Accessed 18 Nov 2008.

British Columbia Ministry of Forests. 2002. Forest inventory planning. Province of British Columbia, Victoria, Canada.

British Columbia Ministry of Forests. 2004. Prince George timber supply area: rationale for allowable annual aut (AAC) determination. Province of British Columbia, Victoria, Canada. <http://www.for.gov.bc.ca/hts/tsa/tsa24/tsr3/rationale.pdf>. Accessed 18 Nov 2008.

British Columbia Ministry of Forests and Range. 2007. Williams Lake timber supply area: rationale for allowable annual aut (AAC) determination. Province of British Columbia, Victoria, Canada. <http://www.for.gov.bc.ca/hts/tsa/tsa29/tsr3/29ts07ra.pdf>. Accessed 18 Nov 2008.

British Columbia Ministry of Sustainable Resource Management. 2000. Terrain resource inventory modelling. Province of British Columbia, Victoria, Canada.

Buck, S. G., C. Mullis, A. S. Mossman, I. Show, and C. Coolahan. 1994. Habitat use by fishers in adjoining heavily and lightly harvested forest. Pages 368–376 *in* S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press, Ithaca, New York, USA.

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

Carr, D., J. Bowman, and P. J. Wilson. 2007. Density-dependent dispersal suggests a genetic measure of habitat suitability. Oikos 116:629–635.

Carroll, C., W. J. Zielinski, and R. F. Noss. 1999. Using presence–absence data to build and test spatial habitat models for the fisher in the Klamath region, USA. Conservation Biology 13:1344–1359.

Coates, K. D., C. Delong, P. J. Burton, and D. L. Sachs. 2006. Abundance of secondary structure in lodgepole pine stands affected by the mountain pine beetle. Forest Practices Branch, Ministry of Forests and Range, Victoria, British Columbia, Canada. <http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/report.pdf.>. Accessed 18 Nov 2008.

Fuller, T. K., E. C. York, S. M. Powell, T. A. Decker, and R. M. DeGraaf. 2001. An evaluation of territory mapping to estimate fisher density. Canadian Journal of Zoology 79:1691–1696.

Garant, Y., and M. Crête. 1997. Fisher, *Martes pennanti*, home range characteristics in a high density untrapped population in southern Québec. Canadian Field-Naturalist 111:359–364.

Hooge, P. N., and B. Eichenlaub. 1999. Animal movement extension to ArcView, version 2.04. Alaska Biological Sciences Center, U.S. Geological Survey, Anchorage, USA.

Hosmer, D. W., and S. Lemeshow. 2000. Applied logistic regression. Second edition. John Wiley and Sons, New York, New York, USA.

Jones, J. L. and E. O. Garton. 1994. Selection of successional stages by fishers in north-central Idaho. Pages 377–388 *in* S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press, Ithaca, New York, USA.

Lancaster, P. A., J. Bowman, and B. A. Pond. 2008. Fisher, farms, and forests in eastern North America. Environmental Management 42:93–101.

MacKinnon, A., C. DeLong, and D. Meidinger. 1990. A field guide for identification and interpretation of ecosystems of the northwest portion of the Prince George Forest Region. British Columbia Ministry of Forests, Land Management Handbook number 21, Victoria, Canada.

Manly, B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald, and W. P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies. Second edition. Kluwer Academic, Norwell, Massachusetts, USA.

Meidinger, D. V., J. Pojar, and W. L. Harper. 1991. Chapter 14: sub-boreal spruce zone. Pages 209–221 *in* D. V. Meidinger and J. Pojar, editors. Ecosystems of British Columbia. Special report service number 6. British Columbia Ministry of Forests, Research Branch, Victoria, Canada.

Peduzzi, P., J. Concato, E. Kemper, T. R. Holford, and A. R. Feinstein. 1996. A simulation study of the number of events per variable in logistic regression analysis. Journal of Clinical Epidemiology 49:1373–1379.

Potter, D. N. 2002. Modelling fisher (*Martes pennanti*) habitat associations in Nova Scotia. Thesis, Acadia University, Wolfville, Nova Scotia, Canada.

Powell, R. A. 1993. The fisher: life history, ecology, and behavior. Second edition. University of Minnesota Press, Minneapolis, USA.

Powell, R. A. 1994. Structure and spacing of *Martes* populations. Pages 101–121 *in* S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press, Ithaca, New York, USA.

Powell, R. A., and W. J. Zielinski. 1994. Chapter 3: fisher. Pages 38–72 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, technical editors. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Proulx, G., K. B. Aubry, J. D. S. Birks, S. W. Buskirk, C. Fortin, H. C. Frost, W. B. Krohn, L. Mayo, V. Monakov, D. C. Payer, M. Santos-Reis, R. D. Weir, and W. J. Zielinski. 2004. World distribution and status of the genus *Martes* in 2000. Pages 21–76 *in* D. J. Harrison, A. K. Fuller, and G. Proulx, editors. Martens and fishers (*Martes*) in human-altered environments: an international perspective. Springer Science+Business Media, New York, New York, USA.

Resources Information Standards Committee. 1998. Live animal capture and handling guidelines for wild mammals, birds, amphibians, and reptiles. Standards for components for British Columbia's biodiversity number 3. Province of British Columbia, Victoria, Canada.
Seaman, D. E., J. J. Millspaugh, B. J. Kernohan, G. C. Brundige, K. J. Raedeke, and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. Journal of Wildlife Management 63:739–747.
Timberline Forest Inventory Consultants. 2004. Blackwater predictive ecosystem mapping retrofitting database. Slocan Forest Products, Mackenzie, British Columbia, Canada. <http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=1489>. Accessed 18 Nov 2008.
Tully, S. M. 2006. Habitat selection of fishers (*Martes pennanti*) in an untrapped refugium: Algonquin Provincial Park. Thesis, Trent University, Peterborough, Ontario, Canada.
Weir, R. D., and F. B. Corbould. 2006. Density of fishers in the Sub-Boreal Spruce biogeoclimatic zone of British Columbia. Northwestern Naturalist 87:118–127.
Weir, R. D., and F. B. Corbould. 2007. Factors affecting diurnal activity of fishers in north-central British Columbia. Journal of Mammalogy 88:1508–1514.
Weir, R. D., and A. S. Harestad. 1997. Landscape-level selectivity by fishers in south-central British Columbia. Pages 252–264 *in* G. Proulx, H. N. Bryant, and P. M. Woodward, editors. *Martes*: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Canada.
Wilson, S. F., D. M. Shackleton, and K. L. Campbell. 1998. Making habitat-availability estimates spatially explicit. Wildlife Society Bulletin 26:626–631.
Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164–168.

Associate Editor: Green.