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Verification of a Forest Rating System to Predict Fisher, *Martes pennanti*, Winter Distribution in Sub-boreal Forests of British Columbia, Canada

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This study verified the ability of a forest rating system to predict the winter distribution of Fisher (*Martes pennanti*) in the Sub-boreal Spruce Biogeoclimatic Zone of central interior British Columbia. Forest polygons (i.e., homogenous areas with similar forest stand characteristics) were classified according to their age and structural development, canopy closure, basal area in mature trees, average tree diameter at breast height, and percentage of shrub cover. Approximately 170 km of transects randomly distributed across polygons were inventoried (snowshoed) from December to February 2005-2008. A total of 278 Fisher tracks were recorded. The observed frequency of Fisher tracks per polygon type was significantly ($P < 0.05$) different from expected. The majority (245 or 88.1%) of tracks were recorded in excellent- and high-quality polygons corresponding mostly to mixed coniferous stands. On average, these stands were 138.2 years old, and had 54.4% canopy closure, 38.1 m^2/ha basal area, 27.8 cm dbh, and 11.4% shrub cover. This study showed that the forest rating system was adequate to predict Fisher winter distribution, and could be used to develop forest management plans that are compatible with the species habitat requirements.

Key Words: Fisher, *Martes pennanti*, habitat rating, sub-boreal forest, winter habitat, British Columbia.

In order to predict the distribution of Fisher (*Martes pennanti*) in the Sub-boreal Spruce (SBS) Biogeoclimatic Zone of British Columbia, Proulx (2006a) developed a forest rating system where forest polygons (i.e., homogenous areas with similar forest stand characteristics) were classified according to their age and structural development, canopy closure, basal area in mature trees, average tree diameter at breast height (dbh), and percentage of shrub cover. Proulx (2006a) tested his polygon rating system in Tree Farm License 30 (TFL 30), a relatively small area of the Sub-boreal Spruce (SBS) Biogeoclimatic Zone (Figure 1), and concluded that it was possible to predict Fisher winter distribution using forest inventory data. The SBS Biogeoclimatic Zone is, however, a large area with considerable geographic variation in regional climate and soils (Figure 1). Also, Proulx (2006) recommended that his rating system be tested in other regions of the SBS zone to ascertain his findings.

The objective of this study was to assess and predict the late-winter distribution of Fisher in various regions of the SBS Biogeoclimatic Zone of British Columbia.

Study Area

The study was conducted in central interior British Columbia, within the SBS Biogeoclimatic Zone (Figure 1) where Hybrid White Spruce (*Picea engelmanii* × *glauca*) and Subalpine Fir (*Abies lasiocarpa*) were the dominant climax tree species (Meidinger et al. 1991). Lodgepole Pine, *Pinus contorta,* occurred in mature forests in the drier parts of the zone, and both Lodgepole Pine and Trembling Aspen (*Populus tremuloides*) were pioneered species in many early-successional stands. Douglas-fir (*Pseudotsuga menziesii*) was at the northernmost border of its natural range and sporadically occurred on dry, warm and rich sites at lower elevations. Black Spruce (*Picea mariana*) was occasionally found in climax upland forests (Meidinger et al. 1991).

The SBS Biogeoclimatic Zone had various subzones on the basis of relative precipitation and temperature (Meidinger et al. 1991; Stevens 1995*). Warmer, drier subzones included Douglas-fir, Soopalie (*Sheperdia canadensis*), Pinegrass (*Calamagrostis rubescens*), and Rough-leaved Ricegrass (*Oryzopsis asperifolia*). Moister, cooler zones typically had Subalpine Fir, Five-leaved Bramble (*Rubus pedatus*), Palmate Coltsfoot (*Petsites frigidus* var. *palmatus*), Clasping-leaved Twistedstalk (*Streptopus amplexifolius*), and Oak Fern (*Gymnocarpium dryopteris*). In order to properly assess Fisher winter distribution across subzones, track surveys were conducted in Supply Blocks of Canadian Forest Products Ltd. and Pope & Talbot Ltd. In the Prince George Forest District (53°55'N, 122°44'W),

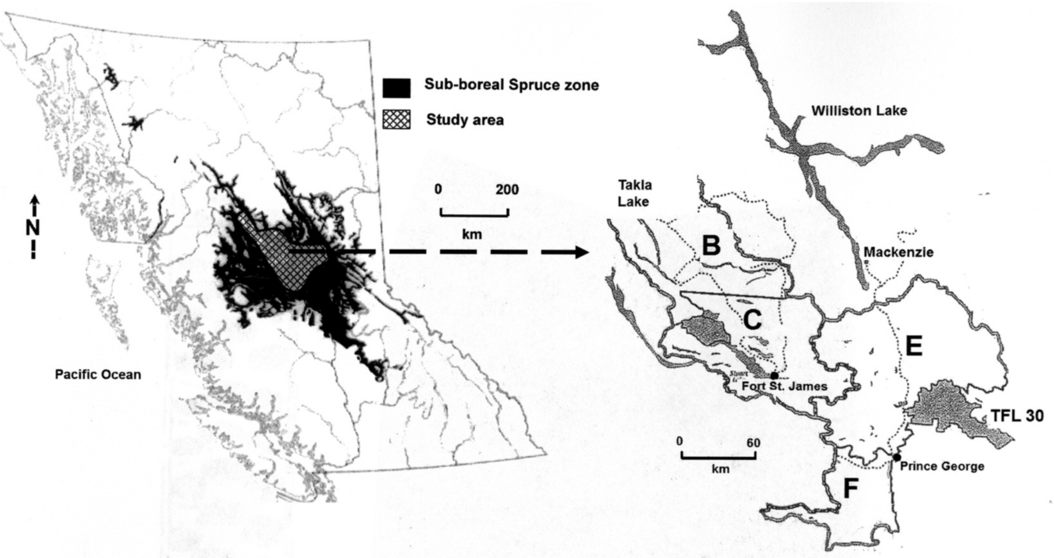

FIGURE 1. Location of study area in central interior British Columbia.

field investigations occurred in Supply Block F (700 000 ha of forested area; dry warm subzone) in the southwest portion of the district, and in Supply Block E (905 000 ha; wet cool and moist cool subzones) in the north (Figure 1). In Fort St. James District (54°27'N, 124°15'W), the study was conducted in an area (B-C) overlapping the northern portion of Supply Block C and the southern portion of Supply Block B (708 000 ha of forested area; dry warm, moist cool, and wet cool subzones) (Figure 1).

Methods

Predictive Fisher distribution maps

On the basis of Proulx's (2006a) work in TFL 30, I used the British Columbia Vegetation Resources Inventory (VRI; BC Ministry of Sustainable Resource Management 2003*) to rate and classify polygons according to a series of criteria, and produce predictive Fisher distribution maps. The polygon classification considered forest disturbance (presence: 0; absence: 4 points), age (≤ 60 years: 0; 61-80: 1; 81-100: 2; 101-120: 3; and >120: 5 points), presence of mature or old structural stages (2 points), basal area ≥ 20 m^2/ha in mature trees (1 point), ≥ 30% canopy closure (2 points), shrub cover (0%: 0; 5-20%: 1; 20-40%: 2; > 40: 3 points), and dbh ≥ 27.5 cm: 1 point) (Proulx 2006a). Polygons were classified as excellent- (14-18 points), high- (11-13 points), medium- (6-10 points), or low- (< 6 points) quality. Resulting predictive maps were mosaics of polygons with different potential for Fisher depending on stand characteristics.

Field assessment of polygons

Field assessments were conducted from December to February 2005-2008, in Supply Blocks F (43 transects), E (32 transects), and B-C (71 transects). Transects averaging ≥ 1-km long on a yearly basis and ≥ 1-km apart were randomly laid across landscapes and crossed all polygon types. Transect lengths varied according to accessibility, safety, and environmental conditions. Transects were plotted on predictive maps, and starting points were tied by compass bearings and distance to distinctive topographic features. They were inventoried (snowshoed) under various environmental conditions (snow depths: 45-180 cm; temperatures: -25°C to 2°C) using a compass, 1:50 000 scale maps, and a hip chain (device with filament) to record linear distances.

We recorded only well-defined tracks, those not melted or deformed, not filled with crusty snow, and judged to be fresh, i.e., ≤ 48 h old since last snow fall (subjective assessment based on the experience of the researcher). Due to the similarity between Fisher and American Marten (*Martes americana*) footprints (Halfpenny et al. 1995), when mustelid tracks were encountered, they were investigated on both sides of transects and within forest stands to find the best tracks available. The combination of footprint (pattern and size, presence/absence of toe pad prints) and trail (gait, distance between jumps, and dragging of the feet) characteristics was used to identify all tracks (Murie 1975; Rezendes 1992; Halfpenny et al. 1995). American Marten tracks are usually smaller, although the foot-

TABLE 1. Winter distribution of Fisher tracks according to polygon types, central interior British Columbia, 2005-2008.

	Supply blocks							
	F (2005-2007)		E (2006-2008)		B-C (2006-2008)		All (2005-2008)	
	Total transect length – m (%)	Number of Fisher tracks (%)	Total transect length – m (%)	Number of Fisher tracks (%)	Total transect length – m (%)	Number of Fisher tracks (%)	Total transect length – m (%)	Number of Fisher tracks (%)
Low	10716 (26.4)	2 (5.6)	11149 (26.2)	5 (7.8)	20567 (23.6)	2 (1.1)	42432 (24.9)	9 (3.2)
Medium	–	–	7118 (16.7)	16 (25)	13713 (15.8)	8 (4.5)	20831 (12.2)	24 (8.6)
High	4036 (10)	7 (19.4)	6453 (15.1)	5 (7.8)	13293 (15.3)	51 (28.7)	23782 (14)	63 (22.7)
Excellent	25808 (63.6)	27 (75)	17901 (42)	38 (59.4)	39510 (45.4)	117 (65.7)	83219 (48.9)	182 (65.5)
Total	40560 (100)	36 (100)*	42621 (100)	64 (100)*	87083 (100)	178 (100)*	170264 (100)	278 (100)*

*Observed Fisher track distribution significantly different from expected ($P < 0.05$).

prints of female Fishers and male American Martens may be of similar size. In winter, the undersurface of American Marten's feet is heavily covered with hair and toe pads do not show (Murie 1975; Rezendes 1992). The undersurface of Fishers' feet has relatively sparse hair, and pads show well in clear prints (Halfpenny et al. 1995). Fishers tend to create a trough when walking in soft snow, drag their feet, and leave tail drag-marks in the snow (de Vos 1951; Raine 1983).

Approximate track locations along transects were determined using hip chain distances and forestry maps. Forestry companies provided VRI stand characteristics for polygons where Fisher tracks were recorded; data for a few polygons were not available at time of analysis.

Data analyses

The proportion of inventory transects within each polygon type was used to determine the expected frequency of tracks per type for each supply block, and for all of them together (Proulx 2006a). Chi-square statistics with Yates correction (Zar 1999) were used to compare observed to expected frequencies of track intersects per polygon type (Proulx 2006a; Proulx and O'Doherty 2006). If the chi-square analysis suggested an overall significant difference between the distributions of observed and expected frequencies, a G test for correlated proportions (Sokal and Rohlf 1981) was used to compare observed to expected frequencies for each polygon type (Proulx 2006b). Probability values ≤ 0.05 were considered statistically significant.

Autocorrelation is often present in ecological data and may not be totally avoided (Proulx and O'Doherty 2006). It potentially occurs during analysis of track survey data because of the uncertainty in whether one or more animals have made the tracks being counted. It is difficult to confirm that a series of tracks along a transect belong to the same animal (de Vos 1951) because home ranges overlap (Badry et al. 1997; Weir 2003) and winter dispersal movements are known to occur (Arthur et al. 1993). Because of rugged environmental conditions, we did not follow tracks that crossed close together to learn whether the same animal made them. On the other hand, on the basis of track characteristics, we deduced that two different animals could be as close as 100 m apart along the same transect. To minimize spatial autocorrelation, only tracks ≥100 m apart, within the polygon type, were recorded (Proulx and O'Doherty 2006). However, tracks < 100 m apart but in two different polygons were also recorded.

Results

A total of 278 Fisher tracks (36 to 178/supply block) were recorded over 170 264 m of transects (Table 1). In each supply block, < 8% of Fisher tracks were found in low-quality polygons, but more than two-third of tracks were in excellent- and high- quality polygons (Table 1). In each supply block, the distribution of tracks per polygon type was significantly ($\chi^2 \geq 8.6$, df ≥ 2, $P < 0.02$) different from expected (Table 1). Overall, Fishers were selecting for excellent- and high-quality polygons, and avoided low-quality ones (G tests ≥ 6.7, $P < 0.01$) (Table 1).

VRI information was obtained for 269 tracks. There were 258 tracks in forests: 205 in coniferous (22 in stands dominated by one species, and 183 in mixed coniferous), 43 in coniferous-deciduous, and 10 in deciduous stands. Eleven tracks were recorded in cut blocks and immature stands. On average, forest stands with Fisher tracks were 138.2 ($n = 258$, $SD = 43.6$) years old, and had 54.4 (± 12.6; $n = 257$) % canopy closure, 38.1 (± 10.2; $n = 255$) m^2/ha basal area, 27.8 (± 5; $n = 258$) cm dbh, and 11.4 (± 12.9; $n = 258$) % shrub cover.

Discussion

Proulx's (2006a) habitat rating was adequate to predict Fisher winter distribution in the whole SBS Biogeoclimatic Zone. Fisher tracks were found mostly in late-successional mixed-coniferous stands in winter, as was found by Proulx (2006a) and Weir and Corbould (2008) elsewhere in the SBS Zone of British Columbia, and Coulter (1966), Arthur et al. (1989) and Raine (1983) in other regions of North America. Lodgepole Pine was present in association with Subalpine Fir, Spruce, and Douglas-fir in mixed coniferous stands that provided Fishers with a multi-layered overhead cover, usually with > 40% canopy closure. Field observations indicated that these forests were also rich in coarse woody debris and snags. Such forests are known to provide Fisher with protection against predators (Powell and Zielinski 1994; Proulx et al. 1994) and deep snow that may limit their movements and distribution (Krohn et al. 1995), and meet their needs for foraging and resting (Weir 2003; Proulx et al. 2004; Weir and Corbould 2008). Coniferous-deciduous stands also provide Fishers with protection and food, and with large deciduous trees that may be used as maternal dens (Weir 2003), particularly in riparian sites (Weir and Corbould 2008).

The biology of Fisher in western Canada is well known (Weir 2003; Proulx et al. 2004; Weir and Corbould 2008), and its winter distribution may be predicted with the forest rating system presented in this study. Therefore, it is possible to develop forest harvest plans that take into consideration Fisher winter habitat requirements. This is particularly important in British Columbia where the species was listed as vulnerable in 1992 (Weir 2003).

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