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Fishers (*Martes pennanti*) are medium-sized carnivores of the family Mustelidae that are found in boreal and temperate coniferous and deciduous-coniferous forests across North America (Proulx and others 2004). Fishers are rare, but important members of the forest ecosystems that they occupy, and as mesocarnivores may play an essential role in regulating populations of many mid-sized mammals in these forests (Roemer and others 2009). In British Columbia, Fishers are harvested for their fur and can be legally trapped on registered traplines in the central and northern portions of the province between 1 November and 15 February. Harvest of Fishers has declined considerably in British Columbia over the past 30 y. Causes for harvest declines are unexplained, but may include both declining populations and declining trapper effort. Fishers currently have a provincial status of S2S3 in British Columbia, designating it as a species of ''special concern'' (BCCDC 2010).

To ensure that Fisher harvests are sustainable, wildlife managers and trappers need basic population information. Population density is a key piece of data upon which harvest levels should be based. Because Fishers are secretive and difficult to inventory (Powell and Zielinski 1994), until recently harvest management of Fishers in British Columbia has been largely based on studies from eastern North America, where density estimates range from 50 to 385 Fishers/1000 km^2 (Powell and Zielinski 1994; Fuller and others 2001). Recent work in north-central British Columbia, however, has demonstrated that the density of Fishers in coniferous-dominated western forests are substantially lower (for example, 8.8 Fishers/1000 km^2, Weir and Corbould 2006), and more conservative harvest management is required relative to eastern Fisher populations.

Habitat quality is not uniform throughout British Columbia and, as a result, Fisher density is believed to vary among regions (Weir 2003; Lofroth 2004). This is reflected in the variability of Fisher harvest across the province. The boreal mixed-wood forests of northeastern British Columbia have consistently high harvests of Fishers and are believed to be among the most productive areas for this species in the province (Lofroth 2004). To improve our knowledge of Fisher density in British Columbia, we estimated the density of Fishers in a representative boreal mixed-wood forest landscape in northeastern British Columbia. This information will provide wildlife managers and trappers with better data to evaluate sustainable harvest levels and help facilitate population persistence.

Our work builds upon Weir and Corbould's (2006) estimation of Fisher density in the sub-boreal spruce forests of north-central British Columbia by applying their methods to Fishers in boreal mixed-wood forests. Because our data was collected, analyzed, and interpreted following methods identical to that of Weir and Corbould (2006), readers are directed to this article for comprehensive details of the capture methodology, density estimation, its biases, and resultant implications for interpretation of the results.

Our study area covered 950 km^2 of boreal mixed-wood forests (that is, the moist-warm subzone of the Boreal White and Black Spruce biogeoclimatic zone; DeLong and others 1990) in the Kiskatinaw Plateau and Peace Lowlands ecosections (Demarchi 1995) to the south and west of Dawson Creek, BC (UTM: Zone 10, 674000 E, 6182000 N, NAD83). The climate of the study area is cold and dry, which is typical of continental boreal forests. Mean annual temperature in this biogeoclimatic subzone is 1.1°C, with 485 mm of precipitation/y, of which approximately 40% falls as snow (DeLong and others 1990).

Forests are typical of boreal mixed-wood landscapes. Dominant tree species include Trembling Aspen (*Populus tremuloides*), White Spruce (*Picea glauca*), Lodgepole Pine (*Pinus contorta*), and Black Spruce (*Picea mariana*), with minor components of Balsam Poplar (*Populus balsamifera* spp. *balsamifera*) and Paper Birch (*Betula papyrifera*). Young forest stages are comprised primarily of Trembling Aspen or Lodgepole Pine, whereas spruce or seral associations of Trembling Aspen dominate later-successional stands.

Human-caused alteration of the study area was extensive. Considerable areas on the northern, western, and eastern edges of the study area had been cleared for agriculture. Forest harvesting of both coniferous and deciduous stands had occurred throughout the study area, and extensive exploration and development of oil and gas reserves had occurred since 1990. Although we made arrangements with registered trapline owners so that they did not actively trap Fishers or American Martens (*Martes americana*) within the study area, some trapping occurred through permits on unallocated traplines and as illegal poaching.

We captured and radio-tagged Fishers and estimated density using the methods of Weir and Corbould (2006). Live traps were located in favorable habitats throughout the study area and set 1.0 km apart on average (range = 0.1–12.7 km, n = 274). We calculated the density of Fishers twice during the year, in the fall (31 October) and late-winter (31 March), by dividing the area that was effectively sampled during each annual capture session by the number of Fishers known to be alive (minimum number alive, MNA, Krebs 1966; see Weir and Corbould 2006 for additional tallying details). We identified live traps that were operational for sufficient time to capture a resident Fisher based on the latency to 1st detection (Zielinski and Stauffer 1996). We captured 75% of resident Fishers within 10 d of traps being operational within their home range. Furthermore, we captured 75% of adult Fishers within the 90% isopleth (90% UD) of their respective winter utilisation distribution (estimated from >30 temporally independent radio-locations collected over >10 mo using Animal Movement extension to ArcView [Hooge and Eichenlaub 1999]); 75% of these 90% UDs were ≥17.0 km^2 (RD Weir, Artemis Wildlife Consultants, unpubl. data). We used this lower quartile to estimate the minimum area that was effectively sampled by each live trap by placing a 4.65-km buffer around each trap site that was active for ≥10 d during each capture session. Lastly, to delineate the entire area that we effectively sampled, we also included portions of the home ranges for resident radio-tagged Fishers (that is, 95% isopleths of the annual UD) that fell outside of the effectively live trapped area as defined above (as per Weir and Corbould 2006).

We operated 274 different live traps for 4003 trap-nights (that is, 1 trap operational for 1 24-h period) over 4 annual capture sessions that occurred during winter months between March 2005 and March 2008 (Table 1). On average, sites were active for 14 trap-nights during 2005 (range: 2–20, n = 52), 16 trap-nights during 2006 (range: 1–23, n = 69), 14 trap-nights during 2007 (range: 2–38, n = 93), and 14 trap-nights during 2008 (range: 2–42, n = 65). Live trapping effort averaged 2.0 trap-nights/km^2 in 2005, 1.2 trap-nights/km^2 in 2006, 1.5 trap-nights/km^2 in 2007, and 1.2 trap-nights/km^2 in 2008.

We captured 26 Fishers (17 F, 9 M) during 4 annual capture sessions. At 1st capture, 17 Fishers were adults (≥1.5 y; 12F, 5M) and 9 were juveniles (<1-y old; 5F, 4M). We did not include data from the 2005 capture session in our density calculations because radio-telemetry monitoring during 2005 was not sufficient to estimate home ranges of captured Fishers; thus we estimated densities for the 2006, 2007, and 2008 capture sessions. Among the 3 y of sampling, the average density at 31 October was 18.4 Fishers/1000 km^2 (s = 6.2, n = 3 capture sessions; Table 1), and at 31 March was 16.3 Fishers/1000 km^2 (s = 4.7, n = 3 capture sessions; Table 1). The estimated density varied among years, ranging from 11.4 to 23.1 Fishers/1000 km^2.

Density of Fishers that we studied in the boreal mixed-wood forest was almost double that found using identical methods in the Williston region of the Sub-Boreal Spruce biogeoclimatic zone (8.8 Fishers/1000 km^2 in late-winter; Weir and Corbould 2006). Although

TABLE 1. Fall (31 October) and late-winter (31 March) density estimates derived from the minimum number alive (MNA) estimate for areas sampled during each annual capture session in the Kiskatinaw Plateau region near Dawson Creek, BC, 2006–2008. ad = adult; juv = juvenile.

Capture session[a]	Trap-nights[b]	# of sites	MNA: 31 October ad	MNA: 31 October juv	MNA: 31 October Σ	MNA: 31 March ad	MNA: 31 March juv	MNA: 31 March Σ	Area sampled[c] (km^2)	Density ($Fishers/1000\ km^2$) 31 Oct	Density ($Fishers/1000\ km^2$) 31 Mar
2006	1072	69	6	4	10	6	4	10	880	11.4	11.4
2007	1284	93	10	8	18	10	8	18	866	20.8	20.8
2008	934	65	15	3	18	11	2	13	780	23.1	16.7

[a] January to March, but including December 2006 in the 2007 session.
[b] 1 trap-night = 1 live trap set for one 24-h period.
[c] Estimated using a 4.65-km diameter buffer around each live trap that was operational for ≥10 trap-nights and the 95% isopleths of resident tagged animals that were alive during the capture session.

these 2 study areas were separated by only 250 km, they occurred on opposite sides of the continental divide and in different biogeoclimatic zones. As such, the areas were quite different ecologically and the variation in density of Fishers may be attributable to differences in abiotic and biotic characteristics between the 2 biogeoclimatic zones. Boreal mixed-wood forests may have more catchable prey than sub-boreal coniferous forests; all adult Fishers that we radio-tagged had copious fat deposits in their greater omentum, whereas Fishers in the Williston study rarely had fat deposits (RD Weir, Artemis Wildlife Consultants, unpubl. data). Additionally, the energetic costs of locomotion during winter may be higher in the Williston region because the mobility of Fishers is hampered by deep, soft snow (Raine 1983); considerably more snow falls in the Williston region (480 cm/y; Weir and Corbould 2008) than in the Kiskatinaw region of the Boreal White and Black Spruce zone (190 cm/y; DeLong and others 1990). Interestingly, the density estimate for our study area was consistent with that predicted for Fishers in this region (Lofroth 2004).

These differences, among other potential differences such as supply of reproductive dens and cold-weather rest sites, may have contributed to the higher suitability of the landscape to support Fishers in boreal mixed-wood than sub-boreal coniferous forests. Higher habitat suitability resulting from readily obtainable food resources and decreased costs of locomotion during winter may allow Fishers to occupy many areas in the landscape of the boreal forest, whereas areas with sufficient concentrations of quality habitat may be much rarer in sub-boreal coniferous forests. Indeed, resident Fishers in our study area occupied much of the landscape (RD Weir, Artemis Wildlife Consultants, unpubl. data), whereas extensive portions of the landscape in the Sub-Boreal Spruce zone did not have resident Fishers (Weir and Corbould 2010).

Despite the density of Fishers in our study area being higher than in the Sub-Boreal Spruce zone, it was still substantially lower than estimates reported from elsewhere within the species' range. The reasons for the considerable differences in density between British Columbia and other areas are unclear. The MNA technique that we used to estimate density was different than that used in California (mark-resight; Thompson 2008), Ontario and Massachusetts (territory mapping; Fuller and others 2001; Koen and others 2007), and Quebec (snow-tracking and territory mapping; Garant and Crete 1997), which may have resulted in some differences in density estimates. As identified in Weir and Corbould (2006), our MNA techniques may have underestimated the density of Fishers in our study area, but the intensive effort expended to capture Fishers in the study area, the relatively high frequency with which we caught adult females relative to other age-sex classes, the apparent good health of Fishers, and the anecdotal observation that Fisher tracks were not observed during the winter period in any area that did not have a captured animal suggests that the negative bias in our estimate was likely minimal.

Fisher densities in British Columbia were between 4 and 33% of those reported in eastern North America and California, which suggests that factors other than estimator-bias contributed to the differences in density. As mentioned previously, abiotic and biotic factors, such as snow conditions and prey availability, may affect overall landscape suitability. These factors, among others, vary widely between British Columbia and environments in eastern and southern portions of the Fisher's range, and may explain some of the differences in Fisher density encountered throughout the species' range.

Our density estimate will better inform the management of Fishers and their populations within boreal mixed-wood forests of northeastern British Columbia. The number of Fishers that can be sustainably harvested per unit area will be substantially lower in the landscapes of British Columbia than elsewhere in the species' range. Although a density estimate provides useful information on the current status of the population of Fishers in boreal mixed-wood forests, specific data on birth and death rates and population growth are still needed to accurately estimate sustainable harvest levels. Information is also needed on the relationships among densities, population dynamics, habitat, and prey to help guide the management and conservation of Fisher populations in the dynamic and industrialized forest landscapes of northeastern British Columbia.

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