

## LANDSCAPE-LEVEL SELECTIVITY BY FISHERS IN SOUTH-CENTRAL BRITISH COLUMBIA

RICHARD D. WEIR<sup>1</sup>

*Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, CANADA V5A 1S6*

ALTON S. HARESTAD

*Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, CANADA V5A 1S6*

**Abstract:** We examined landscape-level selectivity by fishers (*Martes pennanti*) in south-central British Columbia from December 1990 to May 1993. Fifteen fishers were live-trapped, radio-collared, and translocated into the study area. Landscape-level selectivity was determined by comparing the availability of stands within the landscape to the following: (1) those used by 15 transient fishers (13 F, 2 M) prior to home-range establishment, and (2) the habitat composition of the seasonal home ranges of 9 resident fishers (7 F, 2 M). While they were transient, the translocated fishers used non-vegetated and early seral stage stands (<10 years) significantly less frequently than expected based on availability within the landscape. They used the young forests (41-80 years) and coniferous forests significantly more frequently than expected. Translocated fishers moved extensively before establishing home ranges. Large rivers and topography were not barriers to movement. Selectivity for the inclusion of some forest phases within home ranges was exhibited by some individuals, but there were no consistent trends. Our research has implications for the maintenance of fisher populations in south-central British Columbia because increases in the proportion of early seral stages in the region caused by habitat alteration, such as forest harvesting, may reduce the suitability of the landscape as dispersal habitat for fishers.

### Introduction

Like most other *Martes* species, fishers (*M. pennanti*) occur primarily in forested landscapes and often prefer late-successional forests over younger seral stages (e.g., Clem 1977, Jones and Garton 1994). Although in eastern portions of their range in North America fishers may not require late-successional stands (Arthur et al. 1989, Krohn et al. 1995), fishers in western coniferous forests may rely on the structures and ecological processes associated with late successional stands to fulfill many of their life requirements (Ruggiero et al. 1994).

<sup>1</sup> Present address: P.O. Box 4778, Smithers, British Columbia, Canada V0J 2N0

A landscape, by our definition, is a large unit of land that contains a series of watersheds and includes a variety of different vegetation types. In forested landscapes, these vegetation types are generally referred to as stands. Selection of habitat within the landscape can occur during 2 periods in the life of fishers: when fishers are transient, and when they are resident. While transient, fishers make landscape-level decisions when selecting stands to use within the landscape. Habitat selection at the landscape level can also be examined by comparing the stand composition of home ranges occupied by resident fishers with the stand composition of the landscape. The stand composition of the home ranges of resident fishers is the result of landscape-level selectivity made by fishers when they established or inherited their home ranges. During both transient and resident periods, habitat selection occurs at the landscape scale and is constrained by the composition of the landscape.

Several population processes occur at the landscape spatial scale and are important for the persistence of fisher populations. For an area to support a viable population of a species, individuals must successfully navigate the landscape and establish home ranges, and survive and reproduce in these new ranges (Ebenhard 1991). Through habitat alteration, modifications to the structure and composition of the forested landscape may have detrimental effects on the rates of population processes within and among fisher populations. Examination of landscape-level selection provides insight into the viability of fisher populations within a particular area.

To conserve fishers in the increasingly altered and fragmented landscapes of central British Columbia, several aspects of the habitat requirements of fishers at the landscape scale need to be described. Once these requirements have been identified, ecosystem managers may be able to modify habitat alterations so that they are more compatible with the needs of fishers.

We examined habitat selection in the landscape of the dry-warm subzone of the Sub-Boreal Spruce biogeoclimatic zone of south-central British Columbia by comparing the availability of stands in the landscape to the use of stands by transient fishers before home-range establishment and to the stand composition of fisher home ranges for both translocated and resident fishers. If landscape-level selection occurs, fishers should show selectivity in their use of stands while they are transient. Furthermore, if landscape-level selection occurs, stands that are included within the home ranges of fishers should be different from their availability in the landscape.

### Study Area

The study area covered 1500 km<sup>2</sup> and was centred 65 km northeast of Williams Lake, British Columbia. The boundary of the study area was defined by

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the extent of the dry-warm subzone of the Sub-Boreal Spruce (SBSdw) biogeoclimatic zone. The Sub-Boreal Spruce zone is heavily forested and dominates the central interior of British Columbia. It generally occurs from valley bottoms up to 1300 m in elevation (Meidinger et al. 1991). The climate of the Sub-Boreal Spruce zone is continental and is characterized by severe, snowy winters and relatively warm, moist, and short summers. Mean annual temperatures in the study area range from 3.4° to 3.7°C (B.C. Ministry of Forests 1987).

The study area consisted of gently rolling hills, with elevations ranging between 750 and 1250 m. Upper elevations on the western border of the study area were transitional to the moist-cool subzone of the Sub-Boreal Spruce zone, which occurs on hills above 1300 m (B.C. Ministry of Forests 1987). The study area was bounded on the south and southwest by the drier Sub-Boreal Pine-Spruce and Interior Douglas-fir zones, and on the east by the Interior Cedar-Hemlock zone.

Forests were dominated by Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), and hybrid white spruce (*Picea engelmannii* x *glauca*), with trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and black cottonwood (*Populus balsamifera trichocarpa*) occurring as minor components. The SBSdw has a natural disturbance regime of frequent, large-scale burns on a cycle of about 300 years, with most stands burning every 100 years (R. Coupé, B.C. Ministry of Forests, pers. comm.). Harvesting of late successional forests, using a variety of techniques, has occurred over the past 40 years. The result is a mosaic of seral stages and stand types throughout the study area. Land clearing for cattle grazing and cultivation has occurred along most valley bottoms.

Fishers have been present historically throughout the study area and have been trapped since at least 1860 (S. Nicol, registered trapper owner, pers. comm.). The trapping season in this area is open from the beginning of November through to mid-February, but most of the trappers in the study area agreed to suspend trapping of martens and fishers, or use live traps in areas with resident fishers, during the course of the study. A small (likely fewer than 7 fishers), low-density population of fishers inhabited the study area before our study began.

### Methods

Trappers live-trapped fishers during the early winters of 1990-91 and 1991-92. All of the fishers were caught in 30 x 30 x 100-cm box livetraps sets in the Chilcotin River drainage, approximately 300 km west of the study area. The trappers transported each fisher in a covered boxtrap from their capture sites to the B.C. Ministry of Environment facilities at Williams Lake. Upon arrival, we monitored the fishers for several hours to assess their physical condition.

We anaesthetized each fisher for 4.5-9.0 min using a 10:1 ketamine hydrochloride-xylazine hydrochloride mixture administered at 22 mg/kg body weight, injected intramuscularly. When required, we injected the fishers with an additional 15 mg/kg of ketamine to maintain anaesthesia. We weighed, sexed, and measured each fisher. We removed a first premolar from healthy fishers for cementum annuli analysis (Strickland et al. 1982), whereas we classed fishers that had worn teeth or lingual erosions as adult or juvenile by palpating the sagittal crest (Powell 1982). Fishers that were less than 1 year of age were considered juveniles, whereas those >1 year were considered adults. We fitted fishers with mortality-sensing, whip antennae radio-collars. We "soft-released" (Davis 1983, Proulx et al. 1994) 14 fishers and "hard-released" 1 fisher at different locations in the study area. In addition to the translocated animals, we live-trapped resident fishers within the study area and fitted them with radio-collars.

Immediately following release, we relocated each fisher twice per week from the air, and when possible, located them daily from the ground. We relocated fishers using standard ground and aerial telemetry procedures (White and Garrot 1990). We estimated ground locations using Locate II software (Nams 1991), which uses the maximum likelihood estimator to calculate transmitter locations and error polygons. We calculated the minimum total distance that each transient fisher could have travelled while transient by tallying the straight-line distances between successive locations during this period. The area traversed by each translocated fisher was calculated as the area of the 100% convex polygon (Mohr 1947) created by all locations obtained during the transient phase. We considered home ranges to be established when translocated fishers began to exhibit permanent site fidelity (Weir 1995).

We estimated home ranges using the adaptive kernel technique, with  $h$  selected by cross validation and the smoothing parameter chosen by the least squares method (Worton 1989, Seaman and Powell 1991). We determined the boundary of each home range from the 90% isopleth of the utilization distribution (UD). We estimated home ranges from a minimum of 20 independent locations.

We delineated stand types within the study area using the biophysical classification system presented by Lea (1992). We classified stands according to biophysical unit, seral stage, and forest phase. Stands were assigned 1 of 7 seral stages ranging from non-vegetated to old growth, and 1 of 4 forest phases (coniferous, deciduous, mixed coniferous-deciduous, or non-forested). We delineated biophysical units using ecosystem associations as determined by Clements (1991) and B.C. Ministry of Forests (1987). We considered stands as relatively homogeneous assemblages of habitat with respect to coarse woody debris, closure of vegetation strata, and other structural attributes.

We estimated the availability of each stand type in the landscape of the SBSdw from 1015 random locations in the study area, using Marcum and Lofsgarden's

(1980) non-mapping technique. Because of financial constraints, we were unable to map the entire study area. Consequently, biophysical mapping was performed for 405 km<sup>2</sup> of the study area, covering the areas in which the home ranges of 9 of 12 fishers occurred. We estimated stand types for aerial locations and for ground telemetry locations at which 95% error polygons (Nams and Boutin 1991) were less than 1.5 ha.

Landscape-level habitat selectivity was assessed during 2 periods: the transient phase and the resident phase (i.e., after home-range establishment). Selectivity during the transient phase was determined by comparing the use of stands prior to home-range establishment to the availability of these stands in the landscape. We compared the use of stands by transient fishers to the availability of those stands, which were classified by seral stage, forest phase, and site association. For the resident period, we overlaid seasonal home ranges on biophysical maps of the study area and used a digital planimeter to estimate the percentage of each stand type within each home range. We considered fishers that were translocated and subsequently established home ranges and non-translocated fishers as residents for this analysis. We assumed that the processes for selecting home ranges were similar among translocated and non-translocated fishers.

We performed chi-square goodness-of-fit tests and Bonferroni-adjusted Z-tests (Neu et al. 1974) on locations pooled for all fishers while transient. We determined trends in landscape selectivity among fishers by comparing the mean Vanderploeg and Scavia's relativized electivity index (Lechowicz 1982) for each stand type in the home range of each fisher to 0 (no selectivity) using *t*-tests. We also compared the composition of each home range to availabilities using chi-square goodness of fit and Bonferroni-adjusted Z-tests (Neu et al. 1974). We limited analyses to those stand types that constituted at least 5% of the landscape to eliminate interpretation problems associated with high use-availability ratios resulting from spurious inclusion of rare stand types within the landscape. We set the acceptable type I error at 0.05.

## Results

We translocated 15 fishers over 2 winters. We released 5 females (2 juvenile, 3 adult) in the winter of 1990-91, and 10 fishers (3 juvenile F, 5 adult F, 1 juvenile M, 1 adult M) in early 1992 (Table 1). In addition, we live-trapped and radio-collared 7 resident fishers within the study area. Two resident females were juveniles at first capture; the others were adults (4 F, 1 M). We located fishers that had functioning radio-collars from 15 December 1990 to 30 May 1993.

The translocated fishers wandered extensively prior to establishing home ranges. While transient, several fishers wandered through areas of more than 700

Table 1. Movements prior to home-range establishment of fishers translocated into the SBSdw subzone, 1990-1992.

ID	Release date	n	Duration of transiency (days)	Minimum total distance moved (km)	Area traversed (km <sup>2</sup> )
F290	11 Feb 1992	16	54	132.4	301.7
F350	02 Mar 1992	8	37	136.0	743.7
F390	15 Feb 1992	14	57	172.3	733.8
F598	13 Dec 1990	22	90	87.2	169.2
F700	23 Jan 1991	5	9	12.5	50.2
F805	25 Nov 1990	34	197	276.3	990.3
F917	10 Jan 1991	17	67	93.8	108.6
M380	27 Jan 1992	11	69	1055.5	188.9
M450	02 Mar 1992	6	34	1038.1	987.0

ID: F = female; M = male.

n: Number of radiolocations obtained while fisher was transient.

km<sup>2</sup> and most of the fishers travelled at least 100 km in total distance before establishing a home range (Table 1). Before establishing home ranges, female fishers traversed an average area of 442.5 km<sup>2</sup> (SE = 141, n = 7), whereas males traversed an average of 1438.0 km<sup>2</sup> (SE = 451, n = 2). The fishers were able to move long distances between locations; 1 male fisher moved 53.2 km in less than 68 h. During the transient phase, fishers crossed the Quesnel River (minimum flow = 99 m<sup>3</sup>/s in January) on several occasions, and many of its smaller tributaries as well. The mean established home ranges ( $\pm$  SE) of female fishers (90% UD) were 26.4  $\pm$  9.2 km<sup>2</sup> (annual, n = 5), 33.0  $\pm$  10.7 km<sup>2</sup> (summer, n = 8), 32.3  $\pm$  18.3 km<sup>2</sup> (autumn, n = 3) and 25.0  $\pm$  2.6 km<sup>2</sup> (winter, n = 6).

We determined landscape use from 116 locations of 15 translocated fishers during their transient phase. We located transient fishers from their respective release dates until either failure of the radio transmitter of each fisher or establishment of their home ranges. All but 1 of the translocated fishers that we monitored for longer than 2 months established home ranges by the April following release (Weir 1995). When we classified stands by seral stage, transient fishers used non-vegetated and early seral stage stands (<10 years) less frequently than expected based upon availability within the landscape, but used the young forest stage (41-80 years) more frequently than expected ( $\chi^2 = 23.87$ , df = 4,  $P < 0.001$ )

Table 2. Selectivity of stands by translocated fishers while transient in the SBSdw subzone during winter 1990-1992, as classified by seral stage. Transient fishers avoided early seral stages and selected later successional forests more frequently than expected ( $n = 116$  locations).

Seral stage	Stand age (years)	Proportion available ( $p_a$ )	Proportion used ( $p_u$ )	Bonferroni-adjusted significance intervals
Non-vegetated	0	0.03	0.00	$0^b$
Herb-Shrub	1-10	0.23	0.06	$0.002 p_u$ 0.119 <sup>b</sup>
Pole-Sapling	11-40	0.09	0.10	$0.027 p_u$ 0.170
Young Forest	41-80	0.33	0.49	$0.359 p_u$ 0.598 <sup>b</sup>
Mature Forest	81-250	0.29	0.36	$0.250 p_u$ 0.480

<sup>a</sup> Interval over which the proportion used is not significantly different from the proportion available at  $\alpha = 0.05$ .

<sup>b</sup> Significant difference between  $p_a$  and  $p_u$ .

(Table 2). When we classified stands by forest phase, transient fishers used non-forested stands less frequently than expected, but used coniferous forests more frequently than expected ( $\chi^2 = 41.35$ ,  $df = 3$ ,  $P < 0.001$ ) (Table 3).

We also determined landscape selectivity by examining the stand composition of seasonal home ranges of resident fishers. Only 9 of 12 resident fishers (7 F, 2 M) were included in this analysis because some of the translocated fishers established home ranges outside of the mapped areas. We did not detect any significant departures from random inclusion of stands within seasonal home ranges of fishers for stands classified by biophysical unit, seral stage or forest phase.

Although trends in selectivity were not consistent, the proportion of stands in the seasonal home ranges of several fishers differed significantly from availability. The composition of 4 of the 16 seasonal home ranges were significantly different from expected, based upon availability, when stands were classified by forest phase. However, the inclusion of the different forest phases in seasonal home ranges varied among fishers (Table 4).

Our study area was a fine-grained mosaic of stands. As a measure of granularity, we developed an index based on the mean stand area compared to home-range area. The mean granularity ratio (mean stand area:home-range area) for the fishers that we examined was 0.011 (SE = 0.040,  $n = 7$ ) during summer, 0.010 (SE = 0.039,  $n = 3$ ) during autumn, and 0.009 (SE = 0.002,  $n = 7$ ) during winter. On average, there were 149 stands within the home ranges of fishers during summer (SE = 44,  $n = 3$ ), 170 during autumn (SE = 93,  $n = 3$ ), and 147 stands during winter (SE = 37,  $n = 7$ ).

Table 3. Selectivity of stands by translocated fishers while transient in the SBSdw subzone during winter 1990-1992, as classified by forest phase. Transient fishers avoided early seral stages and selected later successional forests more frequently than expected ( $n = 116$  locations).

Forest phase	Proportion available ( $p_a$ )	Proportion used ( $p_u$ )	Bonferroni-adjusted significance intervals
Non-forested	0.27	0.06	$0.002 p_u$ 0.115 <sup>b</sup>
Deciduous	0.03	0.04	$0.000 p_u$ 0.080
Mixed coniferous/deciduous	0.38	0.33	$0.220 p_u$ 0.445
Coniferous	0.32	0.56	$0.446 p_u$ 0.683 <sup>b</sup>

<sup>a</sup> Interval over which the proportion used is not significantly different from the proportion available at  $\alpha = 0.05$ .

<sup>b</sup> Significant difference between  $p_a$  and  $p_u$ .

## Discussion

During transiency, translocated fishers were able to access the entire landscape of the SBSdw within the study area. Most translocated fishers wandered extensively following release, but all established home ranges within the SBSdw. Initial movements away from their release sites were large-scale (>6 km), and large rivers and elevation changes of 700 m were not barriers to movement.

While transient, fishers avoided non-forested and early seral stages, which have little overhead canopy closure. This selectivity is consistent with the findings of other studies (Kelly 1977, Powell 1977, Arthur 1987), which suggest that fishers require overhead cover. The preference for overhead cover may also

Table 4. Landscape-level selectivity of forest phase (SBSdw subzone, 1990-1993) in seasonal home ranges of fishers that exhibited selectivity. A consistent trend in the composition of seasonal home ranges was not evident.

ID	Season	Selection for	Avoidance of
F290	Summer	Coniferous	Deciduous, Mixed
F350	Summer	Mixed	Coniferous
F770	Winter	Deciduous, Non-forested	Coniferous, Mixed
F855	Autumn	Coniferous, Non-forested	Mixed

F = female

explain the avoidance of mixed forest stands while the fishers were transient. Proulx et al. (1994) hypothesized that deciduous vegetation cover affected the movement patterns of translocated fishers in central Alberta. In our study, the fishers were released during midwinter, when deciduous trees were bare of leaves. The mixed forest stands had little overhead cover during winter, which may have contributed to their avoidance by fishers. The affinity exhibited by fishers for stands with overhead cover was revealed by the selection of the young forest seral stage and coniferous forests. However, other factors, such as differential mobility because of snow quality or prey vulnerability may have contributed to the patterns of habitat use that we observed.

Ideally, stand types included within a home range should maximize the fitness of the individual (Buskirk and Powell 1994). Maximizing the proportion of good stands comprising the home range, and minimizing the inclusion of poor and marginal stands, should result in increased survival and reproduction of the individual, because energy costs of acquiring resources are lower in good habitat than in poor or marginal habitats (Thompson and Harestad 1994).

The lack of selectivity for inclusion of specific stand types within the home ranges of resident fishers in our study may be a consequence, in part, of the nature of the landscape in the SBSdw. The granularity of the landscape, the ratio of the average habitat unit (i.e., stand) size to home-range size, may affect the ability of researchers to detect selectivity at the landscape scale. In fine-grained landscapes, where stands are small relative to home-range size, landscape-level selectivity is unlikely to be detected because individual animals are not constrained by access to suitable habitat. Because the landscape is composed of many small interspersed stands, any point in the landscape is not far from suitable habitat. In coarse-grained landscapes, however, landscape-level selectivity is likely to occur because animals must search for and include within their home range areas of suitable habitat to ensure access to these stands.

In the SBSdw, fishers may not have exhibited consistent trends in landscape-level selection because habitat granularity was too fine when we examined habitat selectivity using the biophysical habitat classification system. If habitat granularity was coarser and stands were larger, mean stand size relative to home-range size would be greater and selectivity may have become apparent. For example, fishers avoid areas with no overhead cover (Kelly 1977, Powell 1977). Therefore, with respect to overhead cover, had stands in our study area been large homogenous areas, the mean stand size would be large relative to home-range size, and fishers would be expected to include open areas less frequently than expected within their home ranges. However, our study area was a fine-grained mosaic of stands. As the mean size of stands decreases (i.e., granularity of the landscape decreases), fishers likely have to include unsuitable stands within their home ranges to ensure access to stands of suitable habitat.

One other possible explanation for the lack of selectivity for the inclusion of stand types within the home ranges of fishers may be that fishers select for a diversity of habitats. This alternative hypothesis is also consistent with our observations. Diversity of habitats within a home range could be met in many places in our study area. Because of the habitat granularity characteristics of our study area, we cannot discriminate between these 2 hypotheses.

### Management Implications

Fragmentation and alteration of continuous forest landscapes has several potential effects on wildlife populations. Although generalist species are better able to cope with alterations of the landscape (Ebenhard 1991), some habitat specialists, as fishers appear to be in south-central British Columbia (Weir 1995), are dependent upon structural elements associated with late successional forests to fulfill their life requisites. Fracturing of the landscape can affect the dispersal capability of these specialist species (Harris 1984) and decrease populations to points where stochastic events can cause local extinctions (Gilpin and Soule 1986, Hanski and Gilpin 1991). Conservation of the processes of dispersal and home-range establishment are necessary for the persistence of wildlife within a fragmented and altered landscape.

Dispersal habitat is required for the movement of animals through the landscape, which is important for maintaining dispersion of genes through the environment. The rate at which transients are able to successfully navigate the landscape and establish home ranges may be more important than natality rates in determining population persistence within the landscape (Fahrig and Palohimo 1988). Connectivity within a landscape must be maintained or enhanced for populations to stay viable (Fahrig and Merriam 1985). Jones and Garton (1994) speculated that high connectivity of preferred habitats would facilitate the persistence of fisher populations. Our study suggests that forests, which provide overhead cover, are required by fishers for dispersal habitat. Future research should be directed toward quantifying the habitat requirements of fishers during dispersal.

In the landscape in which we conducted our study, the density and dispersion of suitable habitats was sufficient to sustain fishers even though their home ranges included moderate proportions of unsuitable habitat. However, if alteration and fragmentation of late successional forests in our study area continues, the proportion of unsuitable habitat will increase and connectivity among suitable habitats will decrease. Excessive fragmentation and habitat alteration will likely decrease opportunities for acquisition of home ranges by fishers and eventually the landscape will be unable to support a viable population of fishers.

Ecosystem managers should take these factors into consideration when developing landscape-level management plans for fishers. These plans should consider the arrangement and abundance of early seral stages and maintain the connectivity among unfragmented portions of older forest. If ecological processes that occur at the landscape level are retained, it is likely that fisher populations can be maintained in south-central British Columbia.

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## FISHER MATERNAL DEN SITES IN CENTRAL NEW ENGLAND

SHAWN M. POWELL

*Department of Forestry and Wildlife Management, University of Massachusetts, Amherst, Massachusetts 01003-4210, USA*

ERIC C. YORK<sup>1</sup>

*Department of Forestry and Wildlife Management, University of Massachusetts, Amherst, Massachusetts 01003-4210, USA*

JOHN J. SCANLON

*Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts 01581, USA*

TODD K. FULLER

*Department of Forestry and Wildlife Management and Graduate Program in Organismic and Evolutionary Biology, University of Massachusetts, Amherst, Massachusetts 01003-4210, USA*

**Abstract:** During March-July 1992-1995 we characterized 56 maternal dens and adjacent habitat used by 19 radio-collared adult ( $\geq 2$  years old) female fishers (*Martes pennanti*) in north-central Massachusetts and southwestern New Hampshire. We compared these characteristics with those of habitat in a small portion of the study area to assess their usefulness to forest managers seeking to maintain or enhance fisher populations. Fishers tended to den in overstory ( $P < 0.001$ ) and understory ( $P < 0.001$ ) cover types dominated by softwoods. Used individual den trees were not different from forest composition ( $0.05 < P < 0.10$ ). Fishers tended to select larger den-tree diameter classes ( $P < 0.001$ ) and dead trees ( $0.005 < P < 0.01$ ). Significantly larger diameter trees ( $P = 0.02$ ), larger den openings ( $P = 0.028$ ), and lower entrance heights ( $P = 0.012$ ) were used later in the season. Fishers often relocated their maternal dens (0-4 times per litter); possible causes of den abandonment and subsequent relocation are discussed. We present a set of guidelines to identify potential fisher maternal den trees so that they can be protected during timber harvesting.

<sup>1</sup> Present address: United States National Park Service, Santa Monica Mountains National Recreation Area, 30401 Agoura Road, Suite 100, Agoura Hills, California 91301, USA

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*This book is dedicated*

*to*

Marjorie (Midge) Strickland  
1931-1995

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