

tion of field data. Many other people helped in many ways. We particularly thank T. S. Burton, J. Gordon, J. Kahl, R. Escano, D. Wright, B. Wulf, C. Powell, R. M. Ensminger, R. G. Botzler, D. E. Craggie, J. M. Allen, P. Collins and J. Dixon. This research was funded by the USDA Forest Service. The California Department of Fish and Game provided traps, immobilization equipment, and postmortem carcass examination. The U.S. Fish and Wildlife Services Division of Animal Damage Control provided additional traps. We thank Humboldt State University for logistical support.

1994
in Buskirk, S.W., A.S. Harestad,
M.G. Raphael, and R.A. Powell
(eds) Martens, Sables, and
Fishers: biology and conservation.
Cornell University Press.

28 Selection of Successional Stages by Fishers in North-Central Idaho

Jeffrey L. Jones and Edward O. Garton

Predicting the effects of forest management on fisher (*Martes pennanti*) populations requires an understanding of their habitat relationships, as well as such characteristics as movements, size of home ranges, and food habits. Allen's 1983 habitat suitability index model was designed to aid managers in evaluating the effects of habitat alteration on fishers, but the model was based on data from eastern North America and is probably not appropriate for western habitats. Little is known about the ecology and behavior of fishers in western North America. Only two studies have described habitat relationships of fishers in California (Buck 1982, Mullis 1985), and none have been conducted in the northern Rocky Mountains. Our study investigated and attempted to explain habitat-use patterns of fishers in north-central Idaho.

Study Area

We conducted our study in the Nez Perce National Forest, Idaho County, Idaho. Boundaries of the area were roughly the South Fork Clearwater River to the south and west, Meadow Creek to the east, and the Selway River to the north. The specific study area of about 1010 km² was defined by the home ranges of 13 radio-collared fishers. Elevations within this study area range from 1006 m to 2165 m.

Most forests within the area are in the grand fir (*Abies grandis*) and subalpine fir (*A. lasiocarpa*) vegetation zones (Cooper et al. 1987). Grand fir habitat types (Cooper et al. 1987) dominate the area (75.9%), whereas subalpine fir, Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and lodgepole pine (*P. contorta*) habitat types occur on approx-

11-19-85

imately 16.7%, 5.0%, 1.8%, and 0.6% of the area, respectively. Other tree species present in the area include western larch (*Larix occidentalis*), Engelmann spruce (*Picea engelmannii*), and a few western red cedar (*Thuja plicata*). Pacific yew (*Taxus brevifolia*) was often a major component of the grand fir-ginger (*Asarum caudatum*) and grand fir-queencup beadiily (*Clin-tonia uniflora*) habitat types and commonly reached heights of 10 m.

Annual precipitation and snowfall at nearby Elk City, Idaho (1230 m), average 85 cm and 353 cm, respectively; annual maximum and minimum temperatures average 13°C and -3°C, respectively (Pierce 1983). Winter snowpacks during our study ranged from about 0.5 m at lower elevations to more than 2.0 m at higher elevations. The study area is generally covered by snow from early November through mid-April.

Methods

Capturing Fishers. Fifty cage-type livetraps baited with meat scraps and scented with a commercial attractant were placed along a trapline at locations expected to have a high trapping success. Trap intervals varied from about 3 km to 12 km. We trapped from 1 September through 15 April, although some trapping occurred during summer. We checked traps daily except when snow conditions delayed inspection. We sometimes set traps in areas where noncol-lared fishers had been observed.

Captured fishers were immobilized with ketamine hydrochloride (Hash and Hornocker 1980). Anesthetized animals were weighed, measured, sexed, tattooed, aged according to sagittal crest development (Wright and Coulter 1967), examined for external parasites and physical abnormalities, and fitted with 78-g radio collars.

Locating Fishers. We located radio-marked animals from fixed-wing air-craft and from the ground, but to ensure accuracy we used only ground locations for habitat analyses. Owing to difficulties in locating animals, a precise sampling design was not used. We tried to locate animals twice each week and to obtain 30 or more observations per animal per season. To increase the independence of observations, we did not record locations if the animal was relocated within eight hours of its previous observation. We approached to within 10 m of resting animals before observations were recorded. Consequently, error polygons (Mech 1983) for resting fishers were generally less than 0.05 ha. In summer, active animals were generally ap-proached to within 80 m, resulting in an error polygon of less than 1 ha. Winter locations were also determined by back-tracking fisher tracks in

snow. When back-tracking, use sites were recorded at 500-m intervals, and were assumed generally to be hunting observations.

Habitat Availability. The study area was defined by pooling all observa-tions of the fishers and circumscribing them within a minimum convex poly-gon. An adequate map depicting successional stages was not available for the study area. Consequently, habitat availability on a broad scale was estimated by randomly distributing points throughout the study area as described by Marcum and Loftsgaarden (1980). Habitat availability for individual animals was estimated by using those random plots falling within an individual's home range determined by the minimum convex polygon technique (Hayne 1949). Random points were distributed within individual fishers' home ranges to ensure that each animal had at least as many random plots as plots at used sites.

Field Methods. Each fisher location and random point was classified into one of six successional stages as described by Thomas et al. (1979)—grass-forb, shrub-seedling, pole-sapling, young forest, mature forest, and old-growth forest—on the basis of dominant and codominant tree heights, distri-bution of tree size classes, stand decadence, and presence of snags and logs.

We distinguished two seasonal periods, based on whether snow covered more than or less than 50% of the study area at about 1230 m. We refer to these periods as winter and summer.

Statistical Analyses. We did not use trap sites for habitat analyses because of the potential bias attributable to baiting, unless a fisher had been previ-ously observed at a location before traps were set.

To minimize the potential Type II error rate when testing for fisher selection of successional stages, we reduced the number of habitats by combining the grass-forb and shrub-seedling types into a nonforest category (Aldredge and Ratti 1986). Chi-square tests were used to determine whether habitat use differed between sexes, seasons (summer and winter), and activities (resting and hunting). Macrohabitat selection was determined by comparing habitat use with habitat availability following the procedure of Marcum and Loftsgaarden (1980); tests were conducted with $\alpha = 0.10$ owing to the conserva-tive nature of the Bonferroni Z statistic (Aldredge and Ratti 1986). We frequently did not have adequate sample sizes for individual animals to approximate a chi-square distribution (Roscoe and Byars 1971). Conse-sequently, chi-square heterogeneity tests (Zar 1984) were conducted to ensure that radio-collared animals could be pooled, which effectively increased sample sizes and allowed adequate approximations of the chi-square distribu-tion.

Results

Nine male and seven female fishers were captured and radio-collared. Of these, five males and four females had sufficient locations for macrohabitat analyses. We obtained 153 summer and 93 winter locations from these animals.

Successional Stages: Vegetation Structure

We determined habitat characteristics of successional stages by measuring overstory canopy cover, tree and snag density by size class, log volumes by size class, and understory cover of trees, shrubs, and herbs (Jones 1991). Old-growth stands were characterized by dense canopies; high densities of large-diameter trees, snags, and logs; high coniferous understory cover; and moderate deciduous understory cover. Mature stands had the highest densities of moderately large trees (34.3–47.0 cm diameter at breast height (dbh)), snags 24.1–34.3 cm dbh, and logs 14.0–34.3 cm in diameter. Ground cover of logs was also highest in mature stands. The highest densities of trees 11.4–34.3 cm dbh and of snags 14.0–24.1 cm dbh were found in young forest stands. Relatively high volumes of 14.0- to 21.6-cm diameter logs also were found in young forest stands. Young forests had the highest understory cover of deciduous shrubs. Large-diameter trees and snags were rare in pole-sapling, shrub-seedling, and grass-forb stands. The pole-sapling stands had the greatest availability of trees 1.3–11.4 cm dbh and the lowest canopy densities of forested sites. Canopy cover in shrub-seedling and grass-forb stands never exceeded 15%.

Seasonal Use and Selection of Successional Stages

Five animals were observed nine or more times in each season (summer and winter) and were evaluated for seasonal differences in cover type use. Use of successional stages shifted significantly between summer and winter ($X^2 = 29.8$, $df = 3$, $P \leq 0.0001$; Table 28.1). Fishers used mature forests more in summer ($X^2 = 4.8$, $df = 1$, $P = 0.028$), whereas young forests were used more in winter ($X^2 = 20.7$, $df = 1$, $P \leq 0.0001$). Use of the other types did not differ between seasons ($P > 0.10$).

Sexual differences in use of successional stages during summer were analyzed for five male and four female fishers and during winter for three males and two females. Use of successional stage did not vary significantly by gender during summer ($X^2 = 3.80$, $df = 3$, $P = 0.28$) or winter ($X^2 = 2.2$, $df = 2$, $P = 0.34$). Therefore, sexes were pooled for all further analyses of successional-stage selection.

Table 28.1. Selection of successional stages by fishers (*Martes pennanti*; $n = 9$) near Elk City, Idaho

Successional stage	Summer observations			Winter observations		
	Use	Random	CI*	Use	Random	CI
Nonforest	0	35	0.04–	0	20	0.04–
Pole-sapling	3	35	0.05–	0	24	0.05–
Young forest	12	88	0.08–	39	61	0.14+
Mature forest	114	135	0.10+	39	107	0.15
Old-growth	24	23	0.08+	6	11	0.07
TOTAL	153	316	---	84	223	–

*90% CI = (% of random locations – % fisher use locations) \pm indicated value. + = preference, – = avoidance at $P < 0.10$ (Z-test).

Nine fishers had 10 or more summer-use observations. Of these summer locations, 90% occurred in either mature or old-growth forest (Table 28.1). No observations of fishers occurred in the nonforest habitat type. Bonferroni confidence intervals showed significant selection or avoidance in each of the five successional stages during summer (Table 28.1). Fishers preferred the old-growth and mature forest types, and avoided the nonforest, pole-sapling, and young forest successional stages.

We observed no winter use in either the nonforest or pole-sapling successional stages (Table 28.1). In winter, fishers used young and mature forest cover types at the same intensity (46%). Use of old-growth forests dropped to less than half that of summer use. Bonferroni confidence intervals indicated that in winter, fishers preferred young forests and avoided nonforest and pole-sapling areas. We detected no selection (preference or avoidance) for mature or old-growth forests. The observed seasonal shift in use of successional stages was readily apparent when the habitat selection patterns were compared between seasons; the most preferred successional stage in winter (young forests) was avoided in summer.

Use of Successional Stages for Resting and Hunting

During summer, only six fishers were located during both resting and hunting bouts. No fishers were located in nonforested sites while resting or hunting. Summer use of successional stages differed significantly ($X^2 = 13.5$, $df = 3$, $P = 0.004$; Table 28.2) between resting and hunting sites for all six animals. Use of pole-sapling forests for hunting was significantly greater than for resting ($X^2 = 11.5$, $df = 1$, $P = 0.001$). Significant differences between resting and hunting use of young ($X^2 = 0.5$, $df = 1$, $P = 0.47$),

Table 28.2. Selection of successional stages by fishers (*Martes pennanti*; $n = 6$) at resting and hunting sites during summer near Elk City, Idaho

Successional stage	Resting observations			Hunting observations		
	Use	Random	CI ^a	Use	Random	CI
Nonforest	0	31	0.05-	0	31	0.05-
Pole-sapling	0	19	0.04-	3	19	0.17
Young forest	7	64	0.10-	3	64	0.18
Mature forest	69	99	0.13+	16	99	0.24+
Old-growth	12	15	0.09	1	15	0.11
TOTAL	88	228	—	23	228	—

^a90% CI = (% of random locations - % fisher use locations) \pm indicated value. + = preference, - = avoidance at $P < 0.10$ (Z-test).

mature ($X^2 = 0.2$, $df = 1$, $P = 0.67$), and old-growth forests ($X^2 = 1.3$, $df = 1$, $P = 0.25$) were not detected.

About 92% of summer resting-site observations occurred in mature or old-growth forest, whereas no such observations occurred in the nonforest or pole-sapling types (Table 28.2). Bonferroni confidence intervals indicated that fishers chose mature forests for resting, avoiding nonforest, pole-sapling, and young forest types (Table 28.2). A significant difference between availability and resting use of old-growth forests was not detected.

Of the summer hunting observations of six fishers, about 74% occurred in mature or old-growth forests, whereas none occurred in the nonforest type (Table 28.2). Fishers used a broader range of successional stages for hunting than for resting, even though we collected fewer hunting observations. Specifically, hunting observations included the pole-sapling cover type, whereas resting observations did not. Bonferroni confidence intervals for summer hunting-site observations (Table 28.2) showed that mature forests were preferred and nonforests were avoided. Use did not differ from availability for the other successional stages.

Comparing selection patterns for resting versus hunting suggested that mature and old-growth forests were used more for resting, whereas pole-sapling and young forests were used more for hunting. Fishers avoided pole-sapling and young forests for resting sites, whereas differences in use and availability were not detected for these types for fishers while hunting. Although old-growth stands were used less for hunting than they were for resting, they were used in proportion to their availability for both activities. Mature stands were preferred and nonforest types were avoided for both activities.

During winter, only four fishers were observed in both resting sites ($n =$

52) and hunting sites ($n = 19$). These four animals used only three successional stages (young, mature, and old-growth forests) during winter for both hunting and resting activities. We could not detect a difference in use of successional stages by activity type (hunting versus resting, $X^2 = 0.5$, $df = 2$, $P = 0.80$).

Discussion

Fishers in north-central Idaho did not use habitats in proportion to their spatial availability. Our findings regarding habitat use concur with those of other studies (Quick 1953; Coulter 1966; Kelly 1977; Powell 1977, 1978; Buck 1982; Mullis 1985; Arthur et al. 1989b) in that fishers did not use nonforested habitats. Evidence of microtines, yellow-bellied marmots (*Marmota flaviventris*), and ground squirrels (*Spermophilus* spp.) in the diet of fishers in our study area, suggested, however, that fishers may have made forays into nonforested or sparsely forested habitats for hunting (Jones 1991). Mature to old-growth coniferous forests have commonly been considered optimal or preferred fisher habitat (de Vos 1951b, Coulter 1966, Ingram 1973, Kelly 1977, Schempf and White 1977, Buck 1982, Allen 1983, Raphael 1984, Mullis 1985, Rosenberg and Raphael 1986) especially in areas with deep snow (Arthur et al. 1989b). Our results suggest, however, that although fishers preferred mature and old-growth forests during summer, young forest was the most preferred successional stage in winter. Even though we did not detect significant selection of mature or old-growth forest in winter, these types were represented by 53% of the winter-use locations and should still be deemed important.

The observed seasonal shift in use of successional stages is further supported by analyses in which the microhabitat structure and vegetative composition also differed between summer and winter habitat (Jones 1991). Although the physical characteristics of snow cover may result in seasonal variations in habitat-use patterns (Buskirk and Powell, this volume), we believe the most plausible explanation for the seasonal shift in habitat use by fishers is a concurrent shift in prey use. Jones (1991) reported that snowshoe hares (*Lepus americanus*), voles (*Microtus* spp. and *Clethrionomys gapperi*), and red squirrels (*Tamiasciurus hudsonicus*) were the primary prey for fishers in north-central Idaho. The importance of voles in the diet may decrease over the winter with a concomitant increase in consumption of red squirrels and possibly snowshoe hares. A similar shift in prey use has been reported for American martens (*Martes americana*) (Zielinski et al. 1983). Additional

research on the habitat relationships of important prey of the fisher is needed to fully understand seasonal variation in habitat use by fishers. Until the completion of additional studies, the observed seasonal variation should not be mistaken for habitat flexibility (Buskirk and Powell, this volume).

In general, sites used in winter differed less from random sites than did sites used in summer. Compared with summer, for which we found significant selection or avoidance of all five successional stages, use in winter differed from availability for only three of five stages. Furthermore, one less successional stage (young forests) was avoided in winter. This suggests that fishers use a more diverse array of habitats and are less selective of habitats in winter than in summer. In contrast, Buskirk and Powell (this volume) suggested that fishers use a wider range of cover types in summer than in winter. These apparent contradictions in habitat-use observations may be due to differences in thermoregulatory costs, prey availability, and the effects of snow cover on habitat use among study areas from widely separated geographic areas (i.e., the northeastern United States and the northern Rocky Mountains).

Similarly, fishers appeared to use a wider variety of habitats when hunting than when resting, at least in summer. The apparently random use of the pole-sapling, young, and old-growth forests for hunting may, however, have been due to inadequate sample sizes (Dixon and Massey 1969, Allredge and Ratti 1986). Arthur et al. (1989b) also reported that active fishers probably used a wider variety of forest types than resting fishers and found little evidence to suggest that hunting fishers strongly selected for particular forest types. After a review of several fisher studies, Buskirk and Powell (this volume) similarly suggested that fishers were more selective of habitats used for resting than for foraging. We found that younger-aged forests appeared suitable for hunting but were rarely used for summer resting sites. More structurally complex forests seemed to have been preferred for both activities, but simpler stand structures were used for hunting (Jones 1991).

Although fishers preferred young forests in winter, they selected localities with higher availability of large-diameter trees (≥ 47 cm dbh), snags (> 52 cm dbh), and logs (≥ 47 cm) relative to sites 50 m distant (Jones 1991). When using young forest stands, fishers often sought areas with at least one large tree, snag, or log that had survived the stand replacement fires from earlier in the century. Because large-diameter logs often were used as temporary dens in winter (Jones 1991), it is not surprising that fishers selected winter sites with many available logs. Thus, even though many sites used in winter were classified as young forests, they contained several characteristics commonly associated with older forests.

Management Implications

Landscape Management

Although fishers in north-central Idaho preferentially selected mature to old-growth forests, their population density and stability most likely respond to overall resource abundance (i.e., macrohabitat structure; Morris 1987, Adler 1988). Therefore, as Harris (1984) suggested, fisher habitat management must involve the management of a system of mature forests as opposed to the management of individual stands. Management at a landscape scale should incorporate a variety of young- to midsuccessional stages to promote a diversity of prey species, in conjunction with late-successional stages to provide key resting habitat. In a managed forest, the habitat factor we believe most likely to limit fisher populations is the availability and connectivity of mature and old-growth forests that provide optimal resting habitat.

Fishers in the northern Rocky Mountains have evolved under a fire regime that created numerous small openings within a matrix of mature-forested habitats. Mean fire-free intervals (mostly between surface fires) in north-central Idaho range from six years in ponderosa pine-Douglas-fir/bunchgrass areas to 40 years or more in subalpine-fir habitat areas (Arno and Petersen 1983). Consequently, timber harvest practices that mimic natural landscape patterns and processes may not be detrimental to fisher populations. In fact, conversion of some areas of older age classes to younger age classes may promote a diversity of prey species and thus have long-term benefits for fishers. On the other hand, Rosenberg and Raphael (1986) reported that fishers were very sensitive to forest fragmentation in northwestern California. Additional research on the relationships among forest fragmentation, timber management, and fishers in the northern Rockies is needed to develop a conservation strategy for this species.

In our study, fishers avoided openings and forested areas with 40% or less canopy cover (Jones 1991). Preferred resting habitat patches should therefore be linked by travel corridors of closed-canopy forest. High connectivity of preferred habitats would allow the landscape to support such wide-ranging species as the fisher (Harris 1984; Buskirk and Powell, this volume). Some evidence from our study area suggests that fishers preferred forested riparian areas for resting sites and used them extensively for traveling (Jones 1991). In addition, forested riparian sites likely provide optimal habitat for two preferred prey in our study area: snowshoe hares (Bookout 1965, Bittner and Rongstad 1982, Pietz and Tester 1983) and southern red-backed voles (Koehler et al. 1975, Koehler and Hornocker 1977, Campbell 1979). Thus, riparian forests would likely make excellent corridors to connect preferred habitats.

Stand Management

Fishers seemed to prefer large-diameter Engelmann spruce trees and hollow grand fir logs as resting sites in north-central Idaho (Jones 1991). These two species should therefore dominate stands to be managed for fisher habitat in this region. Stands containing, or adjacent to, riparian areas seem to be particularly important to fishers during all seasons (Jones 1991), and should be managed conservatively if maintaining fisher habitat is a goal.

Fishers' tolerance of habitat islands is not well understood (Buskirk and Powell, this volume). Large isolated stands probably have a lower probability of fisher presence than smaller, less insular stands. We recommend that mature to old-growth forest stands, to be considered effective fisher habitat, should be at least 51 ha and have 50% or more of their perimeter in contact with pole-sized or older forests. Stands with these attributes should have about a 70% probability of fisher occurrence (Rosenberg and Raphael 1986).

At the stand scale, fisher habitat capability would be degraded in the short term by clear-cut logging. Although we did not evaluate fisher habitat selection with respect to stand age, fishers likely would avoid clear-cut areas for at least 50 years (through the pole stage), use them occasionally for another 60–100 years, and likely not preferentially select them until the trees were 80–100 years old in the case of lodgepole pine (during winter) or 120–160 years old in the cases of mixed-conifer forests. Although we found that fishers prefer young forest in winter, it is important to note that these stands regenerated under natural circumstances, after fires. Consequently, they retained several structural characteristics—a few residual large-diameter live trees, snags, and logs—that would not be expected in most recently harvested stands.

The process of recovery of a clear-cut stand, from the standpoint of fisher habitat, could be accelerated by the following practices:

1. Retaining of an abundance (≥ 12.3 trees/ha) of cull grand fir trees for future den logs. The objective would be to have trees at least 45.7 cm dbh that would begin to fall 80–100 years after logging.
2. Retaining at least 54 but no more than 109 metric tons/ha of large-diameter logs. An abundance of logs should aid the recovery of southern red-backed voles, providing prey that fishers may begin to use once the regenerated stand has reached the pole stage.
3. Retaining decks of cull logs and a few slash piles for potential fisher resting sites and for habitat for snowshoe hares.

Uneven-aged management would better maintain fisher habitat at the stand level. Harvesting individual trees or small (≤ 5 ha) plots would likely not

reduce fisher habitat capability, and could in fact increase within-stand diversity, which might improve prey diversity and abundance.

We currently lack the information needed to develop a conservation plan for fishers in the northern Rockies. Therefore, adequate management of fishers and their habitats may require adoption of a landscape-based approach. Two advantages of a broader strategy are that it has the ability to maintain the integrity of ecological systems and that it can operate with relatively little information (Hunter 1991). Applying such an approach would require land managers to adopt a long-term, large-scale plan (Thompson and Harestad, this volume), one that would mimic natural landscape patterns and processes. This in turn would involve management that would keep certain proportions of a forest in various successional stages, together with a specific frequency distribution of various patch sizes and linkages across the landscape. Such an approach would help insure the viability of fisher populations within a managed landscape.

Acknowledgments

This research was funded by the Idaho Department of Fish and Game through Federal Aid in Wildlife Restoration Project W-160-R, and the USDA Forest Service. Additional support was provided by the University of Idaho Forest, Wildlife and Range Experiment Station (Contribution no. 583) and the Idaho Trappers' Association. We thank D. D. Gale, A. Hubbs, and M. Wright for help with the fieldwork.