OBSERVATIONS OF WEASELS IN SECOND-GROWTH DOUGLAS-FIR FORESTS IN THE PUGET TROUGH, WASHINGTON

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ABSTRACT—Mustela *frenata* and M. *erminea* are common mammalian predators in Pacific Northwest forests, yet very little is known about their ecology in this region. Forty-five *Mustela* spp. were captured in >200,000 trap nights. *Mustela erminea* were most often captured in thinned stands with dense understory but little coarse woody debris; *M. frenata* were most often captured in unthinned stands with little understory development but high levels of coarse woody debris. Management history may influence *Mustela* spp. abundance and diversity. Eight *M. frenata* dens were located; 2 were in arboreal stick nests. Evidence from 4 yr of small mammal research in second-growth *Pseudotsuga* menzeisii stands, including recovery of 58 radio transmitters placed on Glaucomys sabrinus, suggests that Mustela spp. are important predators of *G. sabrinus* in the Puget Trough.

Our knowledge of wildlife ecology in Pacific Northwest forests is rapidly growing. Substantial information has been accumulated on game animals, threatened species, management indicator species, and vertebrate communities (Szaro and others 1988, Ruggiero and others 1991). However, little information exists on species without special legal status or species that are not sampled effectively with techniques used for study of vertebrate communities, such as weasels (*Mustela* spp.).

Two weasels, *M. frenata* (long-tailed weasel) and *M. erminea* (short-tailed weasel), are sympatric in the Pacific Northwest (Ingles 1965). Incidental records of road-killed *M. frenata* suggest they are relatively abundant in some areas of the Puget Trough (Buchanan 1987). Little is known, however, of the ecological roles played *by M. frenata* or *M. erminea* in this region.

Weasels are predators and, sometimes, prey; they consume small to medium-sized mammals and birds and, in turn, can be preyed upon by larger predators (for example, owls, hawks, and canids; Fagerstone 1987). Mustelids prey on a variety of species (King 1983, 1989); the size of prey seems related to the size of the species of mustelid. Both *M. frenata* and *M. erminea* exhibit sexual dimorphism, with males much larger than females (King 1989). *M. erminea* are small (males are 70 to 206 g, females are 28 to 85 g; Fagerstone 1987), and can easily enter the burrows of small prey, thus *M. erminea* specialize in preying on small rodents, particularly microtines (Erlinge 1981, King 1989). The larger *M. frenata* (males are 160 to 450 g, females are 80 to 250 g; Fagerstone 1987) also prey on microtines but seem to be less specialized; they hunt above ground more often, and they prey on larger species (for example, squirrels and lagomorphs) than do *M. erminea* (Fagerstone 1987). Weasels have been shown to be arboreal, but most observations of arboreal activity describe escape behavior or pursuit of prey (Nams and Beare 1982). In areas of sympatry, *M. erminea* are reported to be more abundant than *M. frenata* (Fagerstone 1987).

We have been live-trapping arboreal and forest-floor small mammals in the Puget Trough for 4 yr (Carey and others, in press b). We recorded incidental captures and occurrences of weasels during live-trapping, and during radio-telemetry studies of *Glaucomys sabrinus* (northern flying squirrels). Our objectives here are to summarize our records of weasel captures and weasel predation in the Puget Trough, and speculate on the role *M. frenata* and *M. erminea* play in the region's forest ecosystems.

STUDY AREA

Our study was conducted between November 1991 and October 1995 in the Puget Trough physiographic province (Franklin and Dyrness 1973) near Olympia, Washington. Two second-growth *Pseudotsuga menziesii* forests were studied: an intensively manages 65-yr old thinned forest that had been thinned twice over the past 20 yr, including removal of coarse woody debris to facilitate forest operations, which resulted in a well-developed understory of *Gaultheris shallon, Corylus cornuta* var. *californica,* and *Polystichum munitum*; and a 56-yr old unthinned forest with large residual live, dead, and fallen trees carried over from the previous stand, having little understory development. The 2 study areas are approximately 3 km apart. In each forest, eight 13-ha stands were delineated for study. Four of the stands in each forest were thinned experimentally in the spring of 1993 (see Carey and others, in press b for additional details).

The number of species of arboreal rodents (sciurids) and forest-floor small mammals (cricetines, microtines, and insectivores) was similar in both forests. However, densities of *Tamias townsendii* (Townsend's chipmunk) were > 6 X higher in thinned forest than in unthinned forest and captures (densities were not calculated for forest-floor small mammals) of *Peromyscus maniculatus* (deer mouse) and *Microtus oregoni* (creeping vole) were much higher in thinned forest (up to 4 X and 26 X, respectively). In contrast, the density of *Glaucomys sabrinus* was 2 X higher in unthinned forest. *Tamiasciurus douglasii* (Douglas' squirrel) were equally abundant in the 2 forest types (Carey and others, in press b).

METHODS

Trapping

Trapping grids for arboreal rodents were 8 X 8 with 40-m spacing, with 2 Tomahawks 201 traps (12.7 cm X 12.7 cm X 40.6 cm) per station. Small mammal grids were 10 X 10 with 20-m spacing with 2 Sherman traps (1 large 7.6 X 8.9 X 22.9-cm trap and 1 small 5.1 X 6.4 X 16.5-cm trap) per station. Trapping sessions for arboreal rodents were 6 to 9 nights each spring and fall in all 16 stands. Trapping sessions for small mammals were 8 nights each summer from 1992 to 1994 in 8 randomly selected stands (4 in each forest). All traps were baited with peanut butter, oats, and molasses.

We radio-collared and monitored 171 adult *G. sabrinus* between December 1991 and May 1995 (Carey, unpubl. data). We occasionally recovered collars when movements stopped. We categorized these recovery sites as: (1) with or without squirrel remains (hair, bones, whole or partial carcasses, etc.), (2) above or below ground, or (3) collar intact or broken. Because collars were individually fitted, and too small to fit over skulls of *G. sabrinus,* we assumed transmitters found with collars intact were direct evidence of mortality (separation of the head from the body). We also attached 4-g radio collars to 2 adult male *M. frenata.* Diurnal dens (resting sites) of *M. frenata* were located at irregular intervals using triangulation with hand-held telemetry equipment.

[1] The use of trade names or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

RESULTS

We captured *45 Mustela spp.* in 200,064 trap nights. We caught 15 *M. frenata* in Tomahawk traps; 1 in thinned forest and 14 in unthinned forest. In contrast, of 30 *M. erminea* captured, 23 were in thinned forest and 7 in unthinned forest. Five large male *M. erminea* were captured in Tomahawk traps; the remaining 25 were caught in Sherman traps (24 in large, 1 in small). We ear-tagged 8 *M. erminea* and 3 *M. frenata* but recaptured only 1 male M. frenata. This individual was caught 5 times in an 18-mo period.

Mustela erminea were most often captured in Sherman traps; some were able to enter and exit closed Tomahawk traps at will through the space between the front door and the sides of the trap (pers. obs.). Several observations were made of *M. erminea* leaving a trap that contained a partially consumed rodent. We also found partially-consumed rodents in the rear of Tomahawk traps (n = 29) consistent with weasel predation (King 1989); most of these mortalities (n = 21) were in thinned forest. Male *M. frenata* were most often caught in Tomahawk traps; their large skull size prohibited exit from a closed trap. Adult male *M. frenata* are generally too large to fit into Sherman traps, thus were not captured during forest-floor small mammal studies.

We recovered 58 collars from *G. sabrinus* (Table 1); 42 (72%) were on the surface of the ground, and 16 (28%) were underground, in burrows, in logs or stumps, or in burrows under slash piles. Ten of the 12 underground burrows were in hollow roots of dead trees or stumps. Four burrows had moss nests; 3 nests contained fur and bones. One of the burrows contained the carcass of a *T. douglasii* in addition to the carcass of the collared *G. sabrinus.* Mortality of radio-collared flying squirrels was highest during the winter (25 to 58%) and lowest during the summer (0 to 36%). During the winter of 1992-1993, following the trapping period in which *M. frenata* captures were highest (n = 5), 32% of the collared squirrels (6

TABLE 1. Recovery sites of 58 radio transmitters attached to *Glaucomys sabrinus* in 8 unthinned and 8 thinned stands in the Puget Trough, Washington, from 1991 to 1995.

Recovery Type	Unthinned	Managed	Total
Underground or Internal Structures			
Underground dens/tunnel systems	8	4	12
Slash piles	2	0	2
In stumps or fallen trees	2	0	2
Surface/Above Ground Recoveries			
With squirrel remains (whole or partial)	7	3	10
Collar intact, no remains	7	9	6
Owl pellet	1	1	2
Collar broken, no remains (no proof of mortality)	2	4	6
Undescribed/undetermined	6	2	8
Total	35	23	58

of 19) were found preyed upon, consistent with weasel predation.

We placed radio collars on 2 adult male *M. frenata*. One male was recollared twice during the study. Because *M. frenata* damaged the collars (either the potting around the battery or the antennas), signal range was reduced within a few days of release and we were only able to find the animals sporadically for up to 2 mo after collaring.

We located 8 dens of *M. frenata*: 3 in burrows in hollow roots of stumps, 3 in slash piles, and 2 in stick nests in trees (nests were 6 m and 21 m above the ground). Seven were the dens of 1 individual. Once, we tracked a *M. frenata* and a *G. sabrinus* to the same location (< 1-m radius) under a slash pile; the *G. sabrinus* transmitter did not move again, and we assumed the *G. sabrinus* was dead.

Discussion

Trapping

There have been several hypotheses to explain the selection of habitat by weasels. Simms (1979) suggested that *M. erminea* preferred early successional communities because of prey abundance. Maser and others (1981) suggested cover was an important habitat feature for *M. erminea*. Gamble (1980, 1981) suggested that *M. frenata* preferred late seral stages near freestanding water because of prey diversity. We hypothesize that understory development, *G. sabrinus* abundance, and coarse woody debris may also influence diversity and abundance of weasels.

The higher capture rates we found for *M. erminea* in thinned forest may reflect a preference for small rodents-thinned forest had more *T. townsendii, P. maniculatus,* and *M. oregoni* than unthinned forest. *M. frenata* were caught almost exclusively in unthinned forest, which had little understory development but relatively high abundance of *G. sabrinus,* compared to thinned forest. Male *M. frenata,* as above-ground generalist predators, may be more likely to take advantage of relatively large prey like *G. sabrinus* than would *M. erminea* and, thus, habitat with high densities of *G. sabrinus* may represent higher quality habitat for *M. frenata* than for *M. erminea* (in the absence of competition from larger mustelids). Few *Ma frenata* were captured in the thinned forest, where *M. erminea* presumably were specializing on microtines, despite abundant *T. townsendii* populations.

In the Pacific Northwest, where much of the primeval forest has been harvested, management history may be more important in determining weasel abundance than seral stage, particularly in relation to promoting understory development. *Mustela erminea* may prefer forests with well-developed or developing understories (similar to early seral stages) and *M. frenata* may occur more often in closed-canopy forests with little understory, abundant coarse woody material (hollow roots and logs) for resting sites, and abundant *G. sabrinus.* The effect of habitat features on abundances of both *M. erminea* and *M. frenata*, however, is likely complex. Prior studies in the Oregon Coast Range and Olympic Peninsula showed captures of weasels were low (2 *M. frenata* and 2 *M. erminea* captures in 149,510 Tomahawk trap nights) compared to the Puget Trough (Carey, unpubl. data). In these provinces, weasels were only captured in old (200- to 400-yr old) stands with high levels of coarse woody debris, abundant understory vegetation, and high flying squirrel abundance (Carey and others 1992, Carey 1995); weasels were not captured in young

(40- to 67-yr old) stands. Additionally, within-trap predation on rodents, indicative of weasel predation, was much higher in old stands than in young stands (Carey, unpubl. data).

Because our sampling was directed primarily towards arboreal rodents and small mammals (high densities of traps in small areas), and not specifically designed for mustelids, our trap success for weasels was low. Although we used traditional baits for small mammals, weasels may have been attracted to our traps primarily because of the rodents in our traps. Additionally, small weasels can escape from Tomahawk 201 traps. These open-mesh style traps can be modified to enhance weasel captures by enclosing the trap with small fine mesh and creating a barrier to prevent escapes between the door and sides of trap. These modifications have the added advantage of excluding weasels from closed traps, thus reducing predation on trapped animals, an important consideration for small mammal trapping.

Telemetry Studies

It is difficult to study predation by weasels. Several approaches have been tried with limited success (King 1989). Our indirect studies of weasel predation (recovered transmitters) suggests that weasels may be major predators of *G. sabrinus* in second-growth stands in the Puget Trough. Over 27% of transmitter recoveries were from underground structures characteristic of weasel dens, identifiable as such because: (1) the tunnel sizes leading to recovery sites precluded larger predators; (2) the underground burrows matched descriptions of weasel dens (Fitzgerald 1977, King 1989, Fagerstone 1987) and were similar to the dens of *M. frenata* that we located; (3) we found evidence of weasels caching prey in the dens (King 1989); (4) *Spilogale gracilis* (western spotted skunk), the next largest forest carnivore, was not found in the Puget Trough sites; and (5) live, radio-collared *G. sabrinus* did not use underground dens with extensive tunnel systems in the same study area (Carey and others, in press a). In the unthinned forest, where most *M. frenata* captures occurred, a higher proportion of retrieved *G. sabrinus* collars were found underground. Some of the transmitters found above ground (collars intact) may have been from squirrels which were consumed on site, rather than cached underground. Apart from 2 transmitters found in owl pellets, however, we could not conclusively determine predator species by examining surface recoveries.

Weasels may suppress *G. sabrinus* populations in young stands. In our study area, female *G. sabrinus* often used structures near the ground (stumps, logs, etc.) as maternal dens (Carey and others, in press a), which may have increased the risk of nest predation. In addition, relatively high winter predation of *G. sabrinus* by weasels reduced the number of breeding adult *G. sabrinus* each spring.

The 2 observations of the use of stick nests as resting sites (telemetry signals in both cases indicated the animal was not moving) provides additional evidence of arboreal activity by *M. frenata*. *Mustela erminea* has been shown to use trees as resting sites (Nams and Beare 1982), but we believe these are the 1st records of wild *M. frenata* using arboreal stick nests as resting sites. It is noteworthy that almost 50% of the *G. sabrinus* dens in these forests were stick nests (Carey and others, in press a).

With current trends toward ecosystem management, it is important that we strive to understand the roles that all predators play in forested ecosystems, regardless of their legal status or the difficulties involved in studying them. Observations in the Puget Trough suggest that weasels play an important role as predator. However, a more thorough understanding of the ecology of weasels, obtainable only by intensive field research, is needed in the Pacific Northwest.

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