

SPILOGALE GRACILIS IN UPLAND FORESTS OF WESTERN WASHINGTON AND OREGON

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ABSTRACT—During surveys of upland forests in the *Tsuga heterophylla* Zone in Washington and Oregon, 1986 to 1996, we caught 192 *S. gracilis*. In the Oregon Coast Range, more (85%) *S. gracilis* were caught in old-growth to Coast Range old growth ($P = 0.60$) with no differences between seral stages ($P = 0.74$). No *S. gracilis* were caught in upland forests > 500 m in Washington or at low elevations in the Puget Trough. *Spilogale gracilis* was widely distributed in upland forests, but may be tied to riparian areas at elevational extremes. Old growth provides good habitat in some dry areas (Coast Range), perhaps through better developed forest floors (coarse woody debris, litter, humus) than are found in young stands. Absence from the Puget Trough study areas may reflect dryness, disturbance history, and forest fragmentation by agriculture and urban development. Future research on *S. gracilis* may lead to a better understanding of forest-floor processes and differences in ecosystem processes that occur elevationally within relatively small geographic areas.

The western spotted skunk (*Spilogale gracilis*) is found west of the Continental Divide from southern British Columbia to Central America, and in parts of Montana, North Dakota, Wyoming, Colorado, and western Texas (Howard and Marsh 1982). To the East, its range abuts that of the eastern spotted skunk (*Spilogale putorius*). *Spilogale gracilis* generally occupies lowland areas but has been recorded at high elevations (2560 m; Orr 1943). Although the western spotted skunk is now recognized as *S. gracilis* (Jones and others 1992), Hall (1981) listed the spotted skunk west of the Cascade Crest in British Columbia, Washington, and Oregon as a distinct subspecies (*S. p. latifrons*) and it is this form (subspecies) that we address in this paper.

The habitat of *S. gracilis* has been described as thickets and deep woods with heavy brush cover in Washington (Dalquest 1948) and *Alnus rubra*/*Rubus spectabilis*, riparian *Alnus rubra*, riparian hardwood, and *Lithocarpus densiflorus* types in Oregon (Maser and others 1981). Brown (1985) listed primary habitats as streamside riparian areas and early, shrubby, stages of forest development. However, quantitative data on the patterns of abundance of *S. gracilis* in western Oregon and Washington are lacking.

Spilogale gracilis is omnivorous, but insects

and rodents constitute most of its food (Grinnell, and others 1937, Pearson 1964, Ingles 1965) and *S. gracilis* will take small mammals from traps (Dalquest 1948, Hooven and others 1979). *Spilogale gracilis* may range up to 1 km in search of food, but will forage in smaller areas if prey is abundant. *Spilogale gracilis* will share dens with conspecifics, especially in the winter. Requirements for dens include exclusion of light and protection against inclement weather and enemies; hollow logs, hollows in trees, old burrows, and crevices in rock outcrops are commonly used (Grinnell, and others 1937, Dalquest 1948).

In our review of the literature, we found little information on the natural history of *S. gracilis* in the Pacific Northwest. Our objectives were to describe: (1) the distribution of *S. gracilis* in the uplands of western Washington and in the Oregon Coast Range; (2) patterns of abundance across seral stages within physiographic provinces; (3) differences in habitat characteristics among seral stages in the Olympic Peninsula (northern end of its range) and Coast Range (southern end of its range); (4) habitat elements that were correlated with abundance of *S. gracilis*; (5) differences in correlates between physiographic provinces; and (6) differences in patterns of abundance between physiographic provinces.

MATERIALS AND METHODS

We caught *S. gracilis* while trapping northern flying squirrels, *Glaucomys sabrinus* (Carey 1995; Carey and others, in press). We sampled only closed-canopy, upland forest (without riparian vegetation) in 4 seral stages: 40- to 70-yr old second growth in stem exclusion (even-aged, little understory; SE) or understory reinitiation (developing a tall understory; UR) stages of forest development; naturally regenerated stands 90 to 120 yr old with understory reinitiation (UR) or well-developed understories and substantial legacies of live and dead old-growth trees from preceding old-growth stands (diversification stage, DV); and old growth (OG) that was > 200 yr old. We sampled 56 stands in areas ranging from the North Cascades in Washington through the southern Oregon Coast Range. Elevations of stands in Washington were 365 to 610 m in the North Cascades, 85 to 610 m on the Olympic Peninsula, and 100 to 160 m in the Puget Trough; stands in the Oregon Coast Range were 79 to 610 m. All stands were trapped following a standard protocol (Carey and others 1991a), generally with 100 trap stations, 40-m apart, with 2 wire box traps per station, for 6 to 8 nights (1200 to 1600 trap nights/sampling period); Puget Trough stands had 64 trap stations (1024 trap nights/sampling period).

We compared *S. gracilis* abundances among seral stages within and between the Olympic Peninsula and Oregon Coast Range (northern and southern extremes of the range of the subspecies in Washington and Oregon) with Kruskal-Wallis one-way analysis of variance. For statistical comparisons among seral stages we used 2 values: an activity index calculated as the mean proportion of trapping periods in which *S. gracilis* was caught (mean of stand means for each seral stage) and catch per unit of effort (10,000 trap nights) corrected for sprung traps and captures of all species (Nelson and Clarke 1973). Catch and effort were summed over all trapping periods by stand. Because *S. gracilis* may stay in a small area until food sources are exhausted (Dalquest 1948) and captures in adjacent traps within short time periods (<10 nights) are probably recaptures of the same individual and not independent, we defined catch as a cluster of captures > 100 m from any other cluster of captures within a trapping period.

We described the vegetation (55 variables) in stands in the Olympic Peninsula and Coast Range using nested plots around each trap station (Carey 1995; Carey and Johnson 1995). We selected 7 structural variables, derived from the original variables, to include in statistical analyses. These variables represented 3 aspects of stand structure that

accounted for much of the variation among stages of forest development and that explained substantial variance in the abundance and composition of small-mammal communities (Carey 1995, Carey and Johnson 1995): understory development, abundance of coarse woody debris (logs and snags), and overstory structure. We hypothesized that these variables would be of biological importance to *S. gracilis*. Ericaceous shrubs, low (< 2 m) berry-producing shrubs, could provide food and cover directly and were good predictors of small mammal abundance. Dead trees, fallen and standing, are habitat for beetles (Coleoptera), grubs (Lepidoptera), and small mammals and provide den sites (cavities and hollows) for *S. gracilis*. Canopy structure indicates stage of forest development (i.e., SE, UR, DV, or OG) and is related to overall stand diversity.

Normal distribution and other assumptions were tested using descriptive statistics and normal probability plots. We used Kruskal-Wallis nonparametric one-way analysis of variance to compare structural variables among stand conditions and between provinces. Multiple regression analyses used all-possible-subsets regression with step-wise regression as a check on the effectiveness of the equation (Dixon 1992).

RESULTS

In > 400,000 trap nights, we caught 144 *S. gracilis* in the Oregon Coast Range, 45 on the Olympic Peninsula, 2 in the North Cascades, 1 in the Black Hills just southeast of the Puget Trough, but none, despite intensive sampling, in the Puget Trough (Table 1). No *S. gracilis* were caught in 2 OG *Pseudotsuga menziesii*/*Tsuga heterophylla* (PSME/TSHE) stands on the west slope, in one DV PSME/TSHE near the crest, or 6 of 8 SE PSME stands (west and east slope) of the Coast Range. No *S. gracilis* were caught in the 2 OG and 1 DV *Abies amabilis*/TSHE stands that were > 500 m elevation in Washington or in the youngest stand (40-yr old TSHE, no shrubs in the understory, forest floor covered with a carpet of moss) on the Olympic Peninsula. Captures of *S. gracilis* otherwise were well-distributed across the Olympic Peninsula. No *S. gracilis* were caught in low-elevation SE, UR, and OG stands of the Puget Trough, but one was caught in the Black Hills (Table 1).

Based on the activity index ($P = 0.08$; Table 1) and catch per unit of effort ($P = 0.02$; Table 2), there was less activity by *S. gracilis* in SE than in OG in the Coast Range. Activity did not differ among stages on the Olympic Peninsula ($P = 0.74$; Tables 1 and 2), but SE on the Olympic Peninsula had higher activity

TABLE 1. Sampling effort, captures, and activity indexes for *Spilogale gracilis* in seral stages (stem exclusion, understory reinitiation, mixed-age diversification, old growth) and physiographic provinces of Oregon and Washington.

Province and location	Seral stage	Number of stands	Trapping periods	<i>S. gracilis</i> captures ^a		
				(n)	(ps)	(mptp)
North Cascades, Washington			1991–1992			
Baker Lake	old growth	3	2	2	1/3	
Darrington	stem exclusion	2	1	4	1/2	
Olympic Peninsula, ^b Washington			1987–1989			
Quilcene, Quinault, and Forks	old growth	6	2–3	16	4/5	0.6
	diversification	2	2	3	1/2	
	stem exclusion	6	2–3	14	6/7	0.6
Puget Trough, Washington			1991–1996			
Lewis & Clark ^c	old growth	1	2	0	0/1	
Fort Lewis	unders. reinit.	8	10	0	0/8	0.0
	stem exclusion	8	10	0	0/8	0.0
Black Hills, Washington			1995–1996			
Capitol Forest	diversification	1	2	1	1/1	
Coast Range, ^d Oregon			1985–1991			
Roseburg to Coos	old growth	8	2–9	48	6/8	0.4
Bay to Drain	diversification	3	2–5	4	2/3	0.2
	stem exclusion	8	1–5	17	2/8	0.1

^a Codes: n = numbers of captures, ps = proportion of stands with captures, mptp = mean proportion of trapping periods with captures.

^b Three disjunct locations with old-growth and stem exclusion stages at each; diversification stage at Quilcene and Forks.

^c Lewis and Clark State Park, Lewis County, Washington.

^d Stands scattered throughout the area bounded by these three cities.

than either SE in the Coast Range ($P = 0.01$) or SE, UR, and OG in the Puget Trough. Capture rates in old growth did not differ between the Olympic Peninsula and Coast Range ($P = 0.60$). The principal structural differences among SE-UR stands was that Olympic Peninsula SE had moderately high levels of coarse woody debris and ericaceous shrub cover, whereas Coast Range SE had moderate shrub cover and low coarse woody debris (Table 3); Puget Trough SE had low shrub cover and high coarse woody debris and UR had high shrub cover and little coarse woody debris (Carey and others, in press).

Despite significant variation in captures of *S. gracilis* (Tables 1 and 2) and in vegetation structure among seral stages and physiographic provinces (Table 3), the results of our regression analyses were not useful for explaining observed patterns of abundance even though the regressions explained 61% of the variation in CPUE in the Olympic Peninsula and 80% in the Coast Range. The equations had little apparent biological meaning and were probably unique to our data sets (that is, artifactual). This may be a result of methodology (no mark-recapture estimates), the low levels of activity recorded, or lack of relationships with measured habitat variables.

DISCUSSION

We found *S. gracilis* widely distributed throughout upland coniferous forest in the Pacific Northwest, contrary to habitat associations previously reported (for example, Brown 1985). Our results provide insight into the association with riparian areas (Brown 1985). We did not find *S. gracilis* in upland forest > 500 m in Washington (we did in southern Oregon). *Spilogale gracilis*, however, has been trapped regularly at 560 to 880 m in riparian habitats (creeks, rivers, marshes, and swamps) on the Olympic Peninsula and the west slope of the Washington Cascade Range (L. Jones, PNW Research Station, Olympia, WA, pers. comm., 20

TABLE 2. Mean captures/10,000 trap nights (and standard errors) of *Spilogale gracilis* by seral stage (stem exclusion, diversification, and old growth) in the Coast Range of Oregon and the Olympic Peninsula of Washington and results of Kruskal-Wallis one-way analyses of variance for provinces and seral stages.

Stand condition	Captures per 10,000 trap nights		<i>p</i>
	Olympic Peninsula	Oregon Coast Range	
Old growth	0.09 (0.03)	0.12 (0.04)	0.60
Diversification	0.03 (0.03)	0.04 (0.02)	0.88
Stem exclusion	0.09 (0.03)	0.02 (0.01)	0.01
<i>p</i>	0.74	0.02	

TABLE 3. Mean (standard error) of vegetation variables measured in stem-exclusion, diversification, and old-growth forests on the Olympic Peninsula (1404 350-m² plots) and Oregon Coast Range (287 plots), 1986 to 1989; **bold** indicates significant difference between provinces ($p < 0.10$) and * indicates significant differences between stand conditions within the province at * ($p < 0.01$); ** ($p < 0.05$); *** ($p < 0.01$).

Vegetative characteristic	Olympic Peninsula			Coast Range		
	Old growth N = 5	Diversifica- tion N = 2	Exclusion N = 7	Old growth N = 8	Diversifica- tion N = 3	Exclusion N = 8
Conifers < 50 cm dbh/ha	266 (54)*	416 (8)*	588 (102)*	300 (37)	227 (31)	363 (31)
Conifers ≥ 50 cm dbh/ha	113 (20)**	68 (6)**	31 (11)**	862***	813***	390***
Snags < 50 cm dbh/ha	28 (8)**	85 (25)**	105 (23)**	30 (6)**	39 (13)**	122 (10)**
Snags ≥ 50 m dbh/ha	23 (3)***	11 (3)**	3 (1)**	14 (4)***	32 (20)**	4 (1)**
Deciduous trees/ha	11 (11)*	48 (11)*	34 (8)*	65 (23)**	68 (34)**	187 (45)**
Woody debris cover (%)	13 (4)	9 (3)	9 (1)	7 (1)*	11 (5)*	4 (1)*
Ericaceous shrub (%)	40 (1)	4 (2)	30 (10)	12 (2)	16 (12)	23 (6)

June 1996). There may be elevational limits operating in upland forests; these may be associated with either heavy snowfall or cold temperatures that are mitigated in riparian habitats. Shrub cover tends to be high in riparian areas, riparian areas tend to accumulate coarse woody debris, and surface water ameliorates temperatures and reduces snow cover (Oakley and others 1985). Thus, riparian areas may provide *S. gracilis* with cover from predation, den sites, and abundant prey (and other foods) even at elevations generally subjected to low temperatures and high snow fall.

Although *S. gracilis* was common in SE stands on the Olympic Peninsula, we did not find it in 1 stand we sampled that was devoid of shrubs (protective cover). Even though we found the greatest *S. gracilis* activity in OG in the Coast Range, we found relatively less activity in SE in the Coast Range (despite high shrub cover) than on the Olympic Peninsula. Shrub cover may be important to *S. gracilis*, but apparently it is not sufficient to maintain populations under a variety of conditions. Despite intensive sampling (and the ease of capture of *S. gracilis* when present, as evidenced by repeated captures), we caught no *S. gracilis* in the Puget Trough. Abundance in the wet, cool forests of the Olympic Peninsula and the moist (relative to SE, unpublished data) OG and DV forests of the Coast Range, low abundance in the dry SE Coast Range forest and dry SE and UR Puget Trough forests, and absence from upland forests > 500 m in elevation suggests relatively local variation in climate and disturbance history may be important determinants of the abundance of *S. gracilis*. Riparian areas, in otherwise dry regions, may enhance habitat for *S. gracilis* through the same mechanisms we listed for high elevations.

The differences in stand conditions that we found among physiographic provinces reflected climate and history of natural and anthropogenic disturbances.

Frequent small fires and large, catastrophic fires with comparatively short (250-yr) return intervals are the major natural disturbances affecting stand composition, structure, and development in the Coast Range and the Puget Trough. On the Olympic Peninsula, the climate is cooler, precipitation greater, and catastrophic fires less frequent. Wind storms, not small-scale fires, are the major stand-shaping influences operating between large fires. Clearcutting in dry areas (Coast Range and Puget Trough) may mimic the results of severe fires (or repeated fires), by destroying coarse woody debris and forest floor organic matter. Thus, second-growth forests in the Coast Range and Puget Trough tend to be drier and dominated by Douglas-fir, with less development of litter and humus layers, than old growth on similar sites and, especially, forests in the mountainous areas of Washington (Spies and Franklin 1991; Carey and Johnson 1995; Carey and others, in press). Coarse woody debris and other forest-floor organic matter provide den sites for *S. gracilis* and habitat for its prey, arthropods and small mammals (Carey and Johnson 1995). In addition, forests in the Puget Trough are mostly second growth, fragmented by urban and agricultural lands, and dissected by roads. These dry second-growth forests have little coarse woody debris and thin soil organic layers (Carey and others, in press). Fragmentation and roads could make dispersal of *S. gracilis* hazardous.

Little information on the ecology of *S. gracilis* in the Pacific Northwest is available. We hypothesize that our inability to develop meaningful predictive models from general structural variables that are proximate measures of habitat (e.g., shrub cover, coarse woody debris cover) suggests that understanding the ecology of

S. gracilis might require more precise measures of forest-floor variables (e.g., moisture, litter and humus depth, arthropod abundance, small mammal abundance). Because *S. gracilis* appears sensitive to microclimatic and structural differences in the forest floor in upland sites, future research on the interactions between *S. gracilis* and the forest-floor could help our understanding of forest-floor processes and the differences in ecosystem processes that occur elevationally within a relatively small geographic area.

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