IMPORTANCE OF OBSERVER EXPERIENCE IN FINDING DESERT TORTOISES

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Abstract: Because surveys for the desert tortoise (*Gopherus agassizii*) are usually conducted by experienced observers, we conducted 2 experiments in which observers of differing experience levels searched for desert tortoises and tortoise "sign" (burrows, scat) in replicated 1-ha plots. Each plot was seeded with a known number of tortoise scat, realistic-looking tortoise burrows, and 9 lifelike styrofoam tortoises of 3 size classes. When observers were divided into 2 groups, experienced and inexperienced, the groups did not differ ($P \geq 0.17$) in their ability to find tortoises of several size classes, total tortoises, scat, or burrows. Additional analyses divided experience into novice, beginner, intermediate, and advanced levels based on previous survey experience. Again, tortoise-finding was unaffected by experience level ($Ps > 0.15$). Observers overestimated numbers of burrows, mistakenly counted holes made by other animals, and consistently found fewer tortoises and scat than were actually seeded in plots. Tortoise-finding skill is probably part inclination and part aptitude. We cannot say which factors may affect a person's ability to find tortoises, but previous experience, in these experiments, did not.

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Field techniques for counting animals rely on unbiased data usually collected by a human observer. Because of human frailties, there is a rich literature on observer bias (Colgan 1978, Ralph and Scott 1981), reliability of observations (Dunbar 1976, Lehner 1978), and sampling methods for diverse and often challenging field situations (Altmann 1974, Sackett 1978).

The desert tortoise was listed as threatened in 1990, and a recovery plan was completed 4 years later (U.S. Fish and Wildlife Service 1994). The plan requires managers to census large areas, a task involving long walks across kilometers of desert. Tortoises are most active aboveground during a short, mild weather period and are difficult to find because they may sit motionless as rocks, shelter under shrubs, or retreat to burrows. Finding tortoises provides the truest measure of their abundance, but because they are hard to find, alternative methods such as the 2.4-km triangular transect (Turner and Berry 1984) rely instead on detection of "sign" such as scat or burrows.

Intuitively, experience in developing a search image and familiarity with tortoise biology would make an observer more likely to find tortoises and their sign. Because of this intuition, contracts for tortoise surveys often include a requirement that the work be conducted only by experienced tortoise biologists. Because experienced observers are hard to find, a dilemma is created, particularly if many teams must be fielded during the brief, spring time period. The goal of the present study was to test the assumption that previous survey experience increases observer likelihood of finding tortoises and associated sign. Our motivation was to determine whether the experience criterion could be relaxed so that potential surveyors could be recruited from previously inexperienced students or volunteers.

STUDY AREA AND METHODS

We conducted studies on replicated plots within a 30-ha fenced enclosure in the Mojave Desert at Ridgecrest, California. The site is nearly level and dominated by creosote bush (*Larrea tridentata*). E. L. LaRue conducted field experiments on 22 October 1994 and 29 October 1995, with the help of instructors from the Desert Tortoise Council's handling methods workshop. In 1991, we searched the site and found neither tortoises nor their sign. In 1992, the site was enclosed with a 1.2-m-high wire fencing and was again checked to be free of tortoises and sign.

Within the fenced area, we established replicate 1-ha plots with colored lathes to guide the

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searchers in the experiment. We placed matching lathes of red, blue, and green at opposite ends of each plot so that searchers could walk from 1 colored lathe to the next matching color and thus complete 10 100-m transects spaced 10 m apart. The replicate plots were close together but were not contiguous in 1994; some boundaries were contiguous in 1995. We used 8 plots in 1994 and added 2 additional plots in 1995.

Seeded "StyroTorts," Scat, and Burrows

We seeded each plot with 9 styrofoam tortoise models ("StyroTorts"); 3 juveniles (9 cm maximum carapace length [MCL]), 3 immatures (17 cm MCL), and 3 adults (28 cm MCL). The StyroTorts were excellent, realistically painted replicas of live tortoises. We placed the models in locations where live tortoises might be found, typically under bushes; only 1 was placed in a burrow. Participants were shown the StyroTorts during the workshop, so they were familiar with their sizes and appearance before the experiment.

Each plot was further seeded with real tortoise scat (1994: $\bar{x}$ = 19 scats/site; 1995: 25 scats/site) and burrows (1994: $\bar{x}$ = 4 immature burrows/site, range = 2–5, and $\bar{x}$ = 6 adult burrows/site, range = 5–8; 1995: 10 adult burrows/site). The burrows were artificially constructed with a power auger and were hand-finished for realism. After burrow construction, the areas around them were swept clear of human tracks. Density of seeded tortoises and sign were 10 times higher than those typically found in the Mohave Desert (U.S. Fish and Wildlife Service 1994) to ensure that participants would find significant numbers within the small plots required for this experiment.

Observers

Desert Tortoise Council workshops are intended to provide training for persons interested in conducting tortoise survey work, including biological consultants, agency workers, or wildlife biologists. The workshop included a slideshow lecture illustrating the appearance of tortoises, burrows, and scat, and explicitly discussed how to find them.

Each plot was supervised by an instructor from the workshop staff. The searchers included all the other workshop participants. We divided searchers into 2 groups: (1) inexperienced observers, and (2) observers with varying amounts of experience (see below). We used equal numbers from the 2 groups in assigning participants to plots. There were 78 searchers in the 1994 experiment and 66 in 1995.

Participants searched the plot for any length of time they desired and were asked to note the time of beginning and ending (but some failed to do so). We started searchers at all 4 corner points of the plot so that several observers could be on the same plot at the same time. To reduce the chance that a tortoise or sign could be found by seeing someone else detect it, searchers were specifically asked to avoid watching other participants. The searchers were not told the actual number of signs or StyroTorts present.

Experience Groupings

Before searching for tortoises, each participant completed a questionnaire that assessed the following: (1) number of sites previously surveyed, (2) number of hours of previous survey experience, and (3) percentage of sites surveyed where tortoise sign was found. In 1995, we replaced 1 and 2 with the following: (1) number of parcel sites, hectares, and hours an individual surveyed for tortoises; and (2) number of pipelines, kilometers of pipeline, and hours an individual surveyed for tortoises.

For data analysis, participant experience was grouped a priori by both subjective and arithmetic means. In 1994, we used number of hours surveyed to break the participants into 4 alternate groupings and used these groupings to conduct 4 separate analyses of sign found. The 4 groupings were (1) 2 groups: inexperienced (0 hr) and experienced (1–7,200 hr); (2) 5 groups: novice (0 hr), beginner (1–10 hr), intermediate (11–100 hr), advanced (101–1,000 hr), expert (>1,000 hr); (3) 5 groups: novice (0 hr), beginner (1–99 hr), intermediate (100–250 hr), advanced (251–1,000 hr), expert (>1,000 hr); and (4) 4 groups based on $ln(x + 1)$ transformation of hours surveyed: novice (0), beginner (1.23–4.34), intermediate (4.35–5.8), and expert (5.89–8.9). Numbers of participants in each experience class varied among the grouping schemes (Table 1).

These groupings represent alternative, if arbitrary, ways of dividing the experience. For example, Group 3 categories were assigned by dividing the frequency distribution into 5 bands and choosing break points to approximate a normal distribution (excluding novices). Group 4,

Table 1. Numbers of observers in each experience class under alternative grouping schemes.

Grouping		Novice		Beginner		Intermediate		Advanced		Expert	
1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
1		33	37							45	29
2		33	37	5	15	15		20		5	14
3		33	37	17	15	15	9	8		5	5
4		33		12		22				11	

based on log transformation, was used to normalize the hours provided by experienced observers whose very large numbers were assumed to be rough approximations.

In 1995, with fewer experienced participants (29 of 66 total searchers; 44%), experience groupings were made with arbitrary breakpoints: (1) 2 groups: inexperienced (0 hr) and experienced (3–2,180 hr); (2) 3 groups: novice (0 hr), intermediate (3–100 hr), advanced (134–2,180 hr); and (3) 4 groups: novice (0 hr), beginner (3–100 hr), intermediate (134–300 hr), advanced (500–2,180 hr). As in 1994, numbers of participants in each experience class varied among the grouping schemes (Table 1).

Statistical Treatment

Most data proved resistant to transformation, so we used the nonparametric Kruskal-Wallis test to test for differences among groups. Analyses of 2 groups (i.e., inexperienced vs. experienced) were done with Mann-Whitney *U*-tests. We used chi-square tests to test the assumption of equal scores among observers in the replicate plots.

RESULTS

The 1994 Experiment

Of the questions asked about personal background, the most useful question was number of hours of previous survey experience. The 78 participants were divided between inexperienced (n = 33) and experienced (n = 45). The experienced people varied widely in hours of experience ($\bar{x}$ = 253 hr, SE = 98, range = 1–7,200 hr). Number of sites surveyed was less helpful, because the question did not distinguish site size. Twenty of 24 (83%) advanced and expert participants reported seeing tortoises or sign in ≥50% of sites they had surveyed. In contrast, only 7 of 18 (38%) beginners and intermediates saw sign in ≥50% of the sites they surveyed.

Times to survey the sites varied widely among the 57 participants who provided time data ($\bar{x}$ = 68 min, range = 30–181 min). Novices took longer than experienced observers (73 vs. 64 min; U = 225, P = 0.01; Table 2). Using the 5-group break-out (Group 2; Table 1), novices spent more time searching than other groups ($\bar{x}$ = 73 min), followed by the advanced group ($\bar{x}$

Table 2. Mean numbers of tortoises and sign found and times taken to perform the tortoise survey, 1994. *P*-values for 2-group comparisons are from Mann-Whitney *U*-tests, others are Kruskal-Wallis tests.

		Two groups				Five groups (Grouping 2; Table 1)						
Category	Actual number present	Novice (n = 33)	Experienced (n = 45)	U	P	Novice (n = 33)	Beginner (n = 5)	Intermediate (n = 15)	Advanced (n = 20)	Expert (n = 5)	H_4	P
Tortoises:												
Juveniles	3	0.8	1.0	614	0.17	0.8	0.6	1.0	1.1	1.2	3.30	0.51
Immatures	3	1.4	1.7	617	0.18	1.4	2	1.4	1.7	2.2	4.91	0.30
Adults	3	3.0	2.9	694	0.58	3.0	2.6	3.0	2.9	3.2	2.22	0.70
Adult + immature	6	4.4	4.6	648	0.33	4.4	4.6	4.4	4.6	5.4	3.03	0.55
Total	9	5.2	5.6	611	0.17	5.2	5.2	5.4	5.7	6.6	4.44	0.35
Burrows:												
Immatures	4	3.6	2.6	533	0.03	3.6	3.4	2.5	2.7	2.0	6.58	0.16
Adults	6	3.4	3.2	693	0.61	6.7	6.4	6.5	7.3	7.4	2.17	0.70
Scat	19	3.2	3.4	688	0.58	3.2	2.8	3.3	3.1	6.0	5.07	0.28
Survey time (min)		73	64	225	0.01	73	58	61	71	52	10.22	0.04

= 71 min). Beginners (58 min) and experts (52 min) took the least time to complete the survey (H_4 = 10.22, P = 0.04). Perhaps surprisingly, longer search times did not lead to discovery of more tortoises (all searchers: r^2 = 0.03, P = 0.21); the same was true when 7 participants with search times >90 min were excluded (r^2 = 0.01, P = 0.55).

Observer experience did not differ among the 8 sites (χ^2_{28} = 24.70, P = 0.64), so all plots were pooled for analysis of sign discovered. In comparing experienced versus novices, all comparisons were nonsignificant (P > 0.20), with the exception of immature burrows detected (Table 2). More immature burrows were found by novices ($\bar{x}$ = 3.6) than experienced observers ($\bar{x}$ = 2.6; U = 533, P = 0.03). When 4 experience classes were used (Group 4, above), the test for immature burrows was marginally significant (H_3 = 6.81, P = 0.07; Table 2).

We were surprised that many participants did not correctly distinguish between small, medium, and large tortoises, despite having been shown the animals and having had the 3 size classes discussed in class. Many observers counted subadults as adults, which inflated the tally of the latter. To correct this bias, we performed additional analyses on adults and immatures combined (Table 2), although results did not differ from those obtained for 3 size categories.

Regardless of experience, observers were not especially adept at detecting tortoises and sign under controlled conditions. The tortoises and burrows detected were only a fraction of the true number placed in the sites (Table 2). Observers found ≤33% of the scat present ($\bar{x}$ = 17% in the 2-group comparison).

The 1995 Experiment

In 1995, 66 participants searched for tortoises; 37 participants were novices and 29 were previously experienced (range = 3–2,180 hr). Experienced observers were asked to summarize the number of sites (or pipelines) surveyed and to give an area (or linear distance) for them. Unfortunately, these numbers varied widely and without correlation. For example, 3 observers reported surveying 3 sites totaling 2, 8, and 120 ha, yet they reported 20, 15, and 25 hr of previous experience, respectively. Because this example is typical, we decided to accept the reported total hours of experience by the observers as our measure of their experience level (as in 1994). We classified participants by hours of experience and grouped them into 2, 3, and 4 experience categories (Table 1).

In contrast to our earlier experiment, there was no difference among groups in the time taken to search the plots (2 experience categories: U = 359, P = 0.08; 4 experience categories: H_3 = 5.40, P = 0.15). Search times were normally distributed, with the mean nearly identical to 1994's time ($\bar{x}$ = 69 min, SD = 22, range = 15–120 min). As in 1994, there was no difference in observer experience among plots (χ^2_{18} = 0.86, P = 0.52), so data from all plots were pooled for analysis. Once again, longer search times did not lead to discovery of more tortoises (r^2 = 0.04, P = 0.14), nor was there correlation between search time and tortoises found when 10 subjects with search times >90 min were excluded (r^2 = 0.01, P = 0.47). One "intermediate" subject found 4 of 6 possible adult and subadult tortoises in only 15 min.

No difference was found between the ability of novice and experienced observers to find tortoises or their sign (Ps ≥ 0.15; Table 3). In contrast to the earlier experiment, no differences were found between tortoise or sign tallies among any of the other groupings (Ps ≥ 0.28; Table 3). As in 1994, observers discovered ≤33% ($\bar{x}$ = 22% among 2-groups) of the scat actually present, and smaller tortoises were greatly underrepresented (Table 3).

Both juvenile and adult burrows were made in 1994, but because little emphasis was placed on discriminating between these classes, we made only adult-sized burrows in 1995. An unexpected result in 1995 was that all groups were markedly poor at discerning tortoise burrows from other holes in the ground. There were no differences among the groups at detecting burrows (H_3 = 1.56, P = 0.67; Table 3), and observers of all experience levels mistakenly counted holes that were actually rodent burrows, dog diggings, etc. Using the map of known burrow locations and the respondents' data sheets, we attempted to discover if particular individuals or experience levels were more prone to error. The results were inconclusive; all experience levels were equally imprecise, greatly overestimating the true numbers of tortoise burrows (Table 3).

DISCUSSION

Importance of Experience

Regardless of the grouping method used for observers, experience level was not a predictor

Table 3. Mean numbers of tortoises and sign found and times taken to perform the tortoise survey, 1995. *P*-values for 2-group comparisons are from Mann-Whitney *U*-tests, others are Kruskal-Wallis tests.

		Two groups				Four groups					
Category	Actual number present	Novice (n = 37)	Experienced (n = 29)	U	P	Novice (n = 37)	Beginner (n = 15)	Intermediate (n = 9)	Expert (n = 5)	H_3	P
Tortoises:											
Juveniles	3	1.3	1.2	526	0.89	1.3	1.3	1.0	1.4	0.87	0.83
Immatures	3	1.5	1.5	513	0.75	1.5	1.5	1.6	1.4	0.21	0.98
Adults	3	2.6	2.8	483	0.45	2.6	2.6	3.0	3.2	1.77	0.56
Adult + immature	6	4.1	4.3	506	0.68	4.2	4.1	4.6	4.6	1.96	0.58
Total	9	5.5	5.5	509	0.71	5.5	5.4	5.6	6.0	1.16	0.76
Burrows	10	14.6	15.2	481	0.47	14.6	15.8	14.2	15.4	1.56	0.67
Scat	25	5.2	6.4	425	0.15	5.2	5.6	7.8	6.0	3.83	0.28
Survey time (min)		73	63	359	0.08	73	63	68	53	5.40	0.15

of tortoise or sign-finding ability, suggesting that experience alone will not ensure an accurate tortoise survey. Hence, our study questions the value of requiring "experienced tortoise biologists" for surveys.

Participants in this study represented a wide range of experience. A possible criticism of the study is the subjective nature of the questions asked, especially how many "sites" were surveyed and how many hours of experience each person had. Furthermore, because the workshop was designed to help beginners, less-experienced people were more numerous than experts, particularly in 1995 (Table 1). Our response to both concerns is that the data showed no difference among any of the experience classes, regardless of how searchers were grouped. We found no grouping that differed from the simple contrast of "experienced" with "inexperienced." This finding alone is persuasive evidence that previous experience was not related to ability to find tortoises.

Problems Encountered

This study revealed 2 consistent problems in detecting tortoises and their sign: (1) only a fraction of the true number of tortoises or signs were located in either year, and (2) observers (particularly in 1995) overestimated tortoise burrows by mistakenly counting other holes.

Most tortoise biologists would probably agree that scat and juvenile tortoises are the hardest to detect, and would thus present the best test of an expert's advantage. However, these difficult categories of tortoises and sign were not found significantly more often by experienced observers. In 1994, more scat was found by experts ($\bar{x}$ = 6.0) than by any other category ($\bar{x}$ = 2.8–3.3) when observers were divided into 5 experience classes (Groups 2, 3), but the difference was not significant (H_4 = 5.07, P = 0.28; Table 2), because of within-group variance. Similarly, advanced and expert observers found more juvenile tortoises than other classes, but the overall test of these data was not significant (H_4 = 3.30, P = 0.51; Table 2).

More burrows than scat were found, although there were many more scat than burrows in the sites (Table 2). This failure is not surprising, as burrows are large and conspicuous, whereas scat are small and easily overlooked. However, note that no group came close to the actual number of scat in the plots in either year (Tables 2, 3). In both experiments, observers located only 15–32% of the scat present, and no group discovered significantly more scat than another group.

The single "sign" with a significant difference in either year was the 1994 tally of immature burrows. Here, novices found significantly more immature burrows than any other experience class (2-groups: U = 533, P = 0.03; 5-groups: H_4 = 6.60, P = 0.16). Mean number of immature burrows was 4/site, of which novices found an average of 3.6/site and experts found an average of 2.6/site. The significant difference between groups was only found in Group 1 (experienced vs. inexperienced) and Group 4 (4 groups based on log transformation). The 5-group breakout shown in Table 2 was not significant (H_4 = 6.58, P = 0.16). The higher mean number found by novices was probably due to their being less selective in deciding what to count (e.g., erroneously counting burrows of kangaroo rats [*Dipodomys merriami*]). This likelihood was confirmed when we examined the 1995 burrow data (Table 3). All observers overestimated the numbers of burrows present, erroneously reporting rodent burrows, dog digging, and other holes as tortoise burrows. A look at the data sheets of the most experienced participants showed they mapped the same errors as novices. Hence, instructors clearly need to place greater emphasis on this aspect of the course.

In 1994, experts found 5–8 total tortoises, but no expert found all 9. Novices did better: 2 novices found all 9 tortoises (range = 2–9). Overall, experts did tend to see more tortoises than novices, but novices found a wider range of numbers. In 1995, a similar pattern occurred, with novices and beginners showing a wide range of ability, and 1 novice finding all 9 tortoises. The wider range of scores for novices is at least partly attributable to the higher numbers of novices than other groups, but these data clearly show that some novices were excellent tortoise-finders. One expert observer found only 2 tortoises.

Although these results do not support the conclusion that prior experience makes a person a reliable tortoise-finder, results should not be taken as suggesting that all observers are equal. Some experienced biologists are remarkable for their ability to find tortoises. Moreover, only experienced tortoise biologists can instruct and supervise the searchers in a survey. Nonetheless, some novices clearly showed excellent tortoise-finding ability.

With the need to survey large areas for tortoises, time is usually limited. Tortoise searching is not usually performed against the clock. Field workers move at a speed dictated by terrain and numbers of tortoises encountered. Although this exercise was likewise conducted without time limits, longer search times did not lead to discovery of more tortoises in either year, suggesting that aptitude and motivation are more important determinants of success than either experience or simple time spent searching.

MANAGEMENT IMPLICATIONS

Biologists need a metric to rate tortoise-finding ability of observers, and some attention has been paid to this question. For example, interobserver bias is considered in the calibration phase of "triangular transect" tortoise surveys (Turner and Berry 1984, Krzysik 1994). However, more attention should be directed to defining these biases and developing observer "scores."

One such attempt was Rodda's (1993) use of "*Where's Waldo?*" (Handford 1987) as a measure of snake-finding ability. He was moderately successful at correlating the ability of participants to find brown tree snakes (*Boiga irregularis*) with their ability to find a given object on a busy page of this children's book (Rodda 1993). We tried a similar exercise during this study, but results were inconclusive. More attention should be devoted to developing a measurable, searching task that might be correlated with tortoise-finding success.

Alternatively, perhaps a workshop could be designed to more specifically teach students how to find tortoises. There is a body of psychology literature supporting the general idea that perception is fallible, often in systematic, predictable ways (Witkin 1950, Witkin et al. 1954, Leibowitz 1971). For example, Biederman and Shiffrar (1987) showed that although sexing chicks is difficult for the novice, subjects quickly learned the task if given careful instruction. Such thinking was part of the Desert Tortoise Council's motivation in establishing these workshops. After a weekend workshop, however, a test such as we conducted should be used, perhaps to "certify" the good performers.

Overall, this study suggests that observers differ widely in their searching ability, and both motivation and aptitude need to be considered when choosing workers. These factors, more than previous experience, should be carefully considered or test-evaluated when selecting people for tortoise survey work.

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LITERATURE CITED

ALTMANN, J. 1974. Observational study of behavior: sampling methods. Behaviour 49:227–267.

BIEDERMAN, I., AND M. M. SHIFFRAR. 1987. Sexing day-old chicks: a case study and expert systems analysis of a difficult perceptual-learning task. Journal of Experimental Psychology: Learning, Memory and Cognition 13:640–645.

COLGAN, P. W., editor. 1978. Quantitative ethology. John Wiley & Sons, New York, New York, USA.
DUNBAR, R. I. M. 1976. Some aspects of research design and their implications in the observational study of behaviour. Behaviour 58:78–98.
HANDFORD, M. 1987. Where's Waldo? Little, Brown, Boston, Massachusetts, USA.
KRZYSIK, A. J. 1994. The desert tortoise at Fort Irwin, California: a federal threatened species. U.S. Army Corps of Engineers, Construction Engineering Research Laboratory Technical Report EN-94/10.
LEHNER, P. N. 1978. Handbook of ethological methods. Garland STPM Press, New York, New York, USA.
LEIBOWITZ, H. 1971. Sensory, learned, and cognitive mechanisms of size perception. Annals of the New York Academy of Sciences 188:47–62.
RALPH, C. J., AND J. M. SCOTT. 1981. Estimating numbers of terrestrial birds: proceedings of an international symposium. Cooper Ornithological Society, Los Angeles, California, USA.
RODDA, G. 1993. Where's Waldo (and the snakes)? Herpetological Review 24:44–45.
SACKETT, G. P., editor. 1978. Observing behavior. Volume 2. Data collection and analysis methods. University Park Press, Baltimore, Maryland, USA.
TURNER, K., AND K. BERRY. 1984. Methods used in analyzing desert tortoise populations. Appendix III *in* K. Berry, editor. The status of the desert tortoise (*Gopherus agassizii*) in the United States. Report to the U.S. Fish and Wildlife Service from the Desert Tortoise Council, Order 11310-0083-81.
U.S. FISH AND WILDLIFE SERVICE. 1994. Desert tortoise (Mojave Population) recovery plan. U.S. Fish and Wildlife Service, Portland, Oregon, USA.
WITKIN, H. A. 1950. Individual differences in the ease of perception of embedded figures. Journal of Personality 19:1–15.
———, H. B. LEWIS, M. HERTZMAN, K. MACHOVER, P. B. MEISSNER, AND S. WAGNER. 1954. Personality through perception. Harper Press, New York, New York, USA.

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SELECTION OF DAY ROOSTS BY FEMALE LONG-LEGGED MYOTIS IN THE CENTRAL OREGON CASCADE RANGE

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Abstract: We radiotracked 16 female long-legged myotis (*Myotis volans*) in the central Oregon Cascade Range that used a total of 41 day roosts. Large Douglas-fir (*Pseudotsuga menziesii*) snags averaging 97 ± 7 (SE) cm diameter at breast height (dbh) and 38 ± 3 m in height were the most commonly used roost structures (88%). The odds that a snag was used as a day roost increased as snag height increased ($P < 0.001$); after snag height was accounted for, the odds of use decreased as stand height within 20 m of the snag increased ($P = 0.024$). The frequency of occurrence of roosts between young and late seral stands did not differ from that by chance in these 2 stand conditions ($P = 0.76$). Day roosts generally occurred in upland habitats associated with streams that contained night roosts. Management of large diameter, tall snags that extend above the canopy will provide 1 component of day-roost habitat for long-legged myotis in managed landscapes.

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Long-legged myotis are found in montane forests across the western United States and Canada and less frequently in arid rangeland (Warner and Czaplewski 1984, Nagorsen and Brigham 1993), and this species is 1 of 12 insectivorous bats that inhabit Douglas-fir forests of the Pacific Northwest. Habitat relations for these species are poorly understood (Christy and West 1993, U.S. Forest Service and Bureau of Land Management 1994); however, 11 of these species, including the long-legged myotis, were identified by the Forest Ecosystem Management Assessment Team (FEMAT) as being associated with old-growth forest, in need of further study, and of concern because of the reduced extent of old-growth habitat within

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