CHARACTERISTICS OF TREES USED BY NESTING AND ROOSTING VAUX'S SWIFTS IN NORTHWESTERN CALIFORNIA

JOHN E. HUNTER, U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, 1655 Heindon Road, Arcata, California 95521

M. J. MAZUREK, U.S. Forest Service, Pacific Southwest Research Station, Redwood Sciences Lab, 1700 Bayview Drive, Arcata, California 95521

ABSTRACT: Given the limited information available on trees used by Vaux's Swifts (*Chaetura vauxi*) in the coast redwood (*Sequoia sempervirens*) zone of California, we gathered information regarding site, tree, and nest characteristics at nest and roost trees that were found opportunistically by various observers. All 14 nest trees and four roost trees were redwoods. Twelve of the nests were found in basal hollows in large live trees [mean diameter at breast height (dbh) 306 cm], one was in a cavity formed at the base of two small live trees (dbh about 50 cm) that had grown together, and one was in a stump (height 1.3 m, dbh 128 cm). Three of the four roost trees were dead with broken tops; their mean height and dbh were 20.0 m and 229 cm, respectively. The fourth was a live tree 33.9 m in height and 297 cm in dbh. These trees were in areas experiencing varying levels of human activity. All nests were located well away from cavity entrances. Our findings suggest that fire plays an important role in the creation of suitable nest and roost trees and that the swifts' tradition of using specific suitable trees lasts for many years.

The Vaux's Swift (*Chaetura vauxi*) occurs as a migrant and summer resident in western North America from southeast Alaska south to central California and east through parts of British Columbia, Idaho, and Montana, nesting exclusively in preexisting natural or man-made cavities (Bull and Collins 1993). Although the swift also uses smokestacks, chimneys, and other structures, typical nest and roost sites are large hollow trees (Bendire 1895, Dawson 1923, Bent 1940, Bull and Collins 1993). With the exception of descriptions of nest and roost trees in grand fir (*Abies grandis*) forests of northeastern Oregon by Bull (1991), Bull and Cooper (1991), and Bull and Collins (1993), quantitative data on nest and roost sites are relatively limited. The majority of California's Vaux's Swift population breeds in the coast redwood (*Sequoia sempervirens*) zone (Sterling and Paton 1996), on the western side of the Coast Ranges from the Oregon border south to Monterey County (Küchler 1977). Because there is little information on the biology of this species in redwood forests, we sought to provide information on nest and roost trees used by Vaux's Swifts in the redwood zone of northwestern California.

METHODS

Between April 2000 and October 2001 we solicited information from birders, foresters, and wildlife biologists on the location of trees used by nesting or roosting Vaux's Swifts throughout northwestern California, since during the course of their activities these observers occasionally discovered trees hosting swifts. We returned to these reported locations to record detailed data. Although these opportunistic observations of swift trees could be biased toward more conspicuous sites, because existing data are so scanty, we believe the resulting information to be useful to biologists and land managers interested in this species.

We considered the presence of used nests or eggshell fragments, or direct observations of active nests or birds repeatedly carrying food to hidden nests, as evidence of confirmed nesting. We considered trees to be roosting sites when numerous birds were observed simultaneously entering them at dusk or exiting them in the morning. Not all cavities were accessible for examination, and some roost trees may have also functioned as nest trees without our knowledge. Some trees were used for roosting or nesting in the one or two years immediately preceding, but not during, our study period. We included these trees in our dataset because the variables we measured change little over the course of a year or two. At each site we recorded the history of the stand (categorizing it as old growth, second growth, recently harvested, or nonforest), elevation, slope, aspect, and distance to human activity. "Nonforest" areas were forested historically but when we visited them were being maintained as open and generally treeless habitat. We estimated percent total canopy closure at each tree with a spherical densiometer (Lemmon 1956) by averaging four measurements taken at 4.5 m from the tree at each of the cardinal compass directions. For each tree we recorded species, total height, and diameter at breast height (dbh). For cavities with accessible nests, we measured the maximum height of the hollow chamber above the ground, height of the nest above ground, and internal diameter of the hollow chamber at the nest. Height measurements were made with a clinometer or a laser ranging instrument. For each nest we recorded a compass bearing for the cavity entrance and a compass bearing for the nest location within the cavity in order to calculate the angle at which nests were located with respect to the cavity entrance. Following Zar (1974), we then calculated the mean angle between cavity opening and nest location. When possible, we checked trees with active nests the following year to determine if nest trees were reused.

RESULTS

Between August 2000 and October 2001, we located and measured 18 trees that were used by Vaux's Swifts for nesting or roosting in Del Norte, Humboldt, and Mendocino counties. All trees used by swifts were redwoods. Although the redwood was the dominant tree species at all locations, other species such as Douglas fir (*Pseduotsuga menziesii*) and grand fir were also present. The elevation at trees used by swifts ranged from 15 to 549 m [mean 160 m, standard deviation (SD) 154 m, $n = 18$). Eleven of the 18 trees (61%) were on flat ground; this high proportion may have been related to our biased method of finding swift trees rather than any site-selection criteria used by the swifts. Of the 18 trees we examined, 14 (78%) were confirmed as nest sites, either during data collection or in prior years. Of these 14 nest trees, 11 (79%) had nests present and accessible for measurement when we visited them. Two (14%) had nests in prior years but did not contain nests at the time of our visit, and one (7%) had an active nest but the cavity was inaccessible. All accessible hollow chambers confirmed as nest sites contained only a single nest. Four of the 18 trees (22%) were roost trees.

Nine of the 14 nest trees (64%) were in old-growth stands, three (22%) were in second-growth stands, and two (14%) were in recently harvested areas. Total canopy closure ranged from 6 to 97% (mean 82%, SD 26%, n = 14). Five of the nest trees (36%) were within 20 m of trails, roads, or campsites with their potentially high levels of human use and disturbance throughout the swifts' breeding season. Of the seven nest trees (50%) that were active in the first year and rechecked in the second year, five (71%) contained active nests in both years.

Twelve of the 14 nests (86%) were located in basal hollow cavities in old-growth trees. Basal hollows are cavities formed at the base of a redwood bole when fire injury to a live tree allows the entry of fungal rot to the base of the tree bole, which then causes internal decay that is burned out during a subsequent fire. The process is repeated as partial healing occurs around the margins of the cavity, while the inner rotten area expands only to be consumed in each recurring fire (Fritz 1931). This process results in a progressively larger hollow chamber over time; these chambers often extend up into the tree bole well beyond the height of the external entrance to the cavity. Nest trees with basal hollows ranged in height from 49.1 to 96.2 m (mean 69.6 m, SD 21.6 m, n = 12). Their dbh ranged from 195 to 510 cm (mean 306 cm, SD 137 cm, n = 12). All nests but one were accessible for measurement. The total height of these basal hollows (from the bottom, typically at ground level, to the top of the cavity) ranged from 4.3 to 14.8 m (mean 9.5 m, SD 2.8 m, n = 11). Nest height (above the bottom of hollow) ranged from 3.7 to 13.8 m (mean 8.3 m, SD 2.5 m, n = 11). All nests in basal hollows were located above the upper end of the cavity's entrance; nest heights averaged 88% of the total height of the cavity. The diameter of the hollow chamber at the nest ranged from 25 to 125 cm (mean 56 cm, SD 32 cm, n = 11). Nests in basal hollows tended to be located at right angles from the cavity openings; the mean angle between cavity openings and nests was 93° (mean angular deviation 38.3°, n = 11, range 6° to 134°). Six of the 11 nests (55%) were located within 20° of a 90° angle from the cavity opening.

Two of the 14 nests (14%) were found in cavities other than basal hollows, but neither of these structures had nests in them when we collected data. One was in a chamber formed by two second-growth redwoods (dbh of each about 50 cm) that were growing together at their bases and extended up to a height of 3.0 m on both trees. Between these two trees was a cylindrical cavity 1.2 m deep, diameter 42 cm, that extended downward. The swifts entered it from the top. The other nest not in a basal hollow was in a hollow redwood stump, dbh 128 cm, that was partially buried and cleanly cut off at 1.3 m above ground level prior to use by swifts. This stump contained a cylindrical cavity 4.6 m deep, diameter 38 cm, that extended downward. The swifts entered it too from the top. Although this site was not used for nesting during our study, the original observer noted that the nest's previous location was below ground level. Since our study the stump has been used again by nesting swifts. Although both of these nest structures showed some evidence of fire, the role of fire in cavity formation was not clear.

All four roost trees were located in open areas (two were in recently harvested stands and two were in nonforest areas) with little or no vegetation obstructing the cavity entrances. Two of these were within 50 m of buildings. Of the four roost trees, three (75%) were dead with broken tops, ranging in height from 15.3 to 23.4 m (mean 20.0 m, SD 4.2 m). The dbh for these trees ranged from 173 to 262 cm (mean 229 cm, SD 49 m). Swifts entered each of these trees through a hole at the top. All three were in advanced states of decay, lacked bark and lateral limbs, and showed evidence of past fire. The fourth roost tree, measuring 33.9 m tall and 297 cm in dbh, was green but charred and slowly dying. The entrance to the cavity in this roost tree was a round hole 9.4 m above the ground where a limb had broken off from the bole. We were unable to measure the hollow chambers of roost trees.

DISCUSSION

The nest trees we studied differed from the few that have been described previously from the redwood zone, although many details about the early nests were not provided. Bendire (1895) mentioned a nest site in a burned-out sycamore (*Platanus* sp.) near Santa Cruz, California. All other nest trees previously reported from the redwood region more closely resembled the three dead, top-entry roost trees that we measured. Taylor (1905) described a nest in Humboldt County in a dead hollow "stub" (from his sketch, almost certainly a redwood) that was ≤ 9 m tall, with the nest situated about 0.6 m above the ground. Dawson (1923) discussed and provided photographs of redwood stubs and other dead redwoods in which swifts nested in logged-over areas of Humboldt County. He noted that, regardless of the height of the structure, nests were typically located within about 0.5 m of the ground, with some even below ground level. Bent (1940) provided some details on four nests from Humboldt County that were in redwood stubs ranging in height from 5.5 to 18.3 m; one of these stubs was 3 m in diameter at its base. It is possible that the nest trees discussed by Bent (1940) were some of the same trees discussed by Taylor (1905) and Dawson (1923). These nest trees, like the three dead roost trees we described, are likely the result of intensive logging of old-growth redwood stands, followed by burning.

Bull and Cooper (1991) found the average canopy closure at 20 nest trees in old-growth grand fir forests in northeastern Oregon to be 70.8%. Canopy closure was also high at most of the nest trees we measured, but since two of our active nests were in recently harvested stands, high canopy closure could be correlated simply with the presence of large trees with cavities rather than being an attribute actually favored by Vaux's Swifts.

Flight maneuverability within a cavity may influence cavity suitability and nest placement. In the trees we studied, swifts generally appeared to locate nests as far from the cavity entrance as possible (either above or below), while still allowing some room for flight at the nest. Swifts also appeared to locate nests on either side of the cavity at right angles to the entrance, avoiding the areas directly above or opposite the cavity opening. Thus, while swifts may accept or become habituated to some level of human activity around a tree, within the cavity they apparently seek a secluded location for the nest.

Given the bias in our methods for finding nests, we were unable to estimate the overall proportion of swifts that use old-growth trees for nesting or roosting, or the overall proportion of nests in basal hollows. However, old-growth trees, especially those containing basal hollows, are likely important to swifts in northwestern California. Because of the role of fire in forming basal hollows, fire in redwood stands is probably an important force creating and maintaining Vaux's Swift nest sites.

Bull and Collins (1996) reported that 70% of nest trees were reused for nesting in subsequent years, a rate similar to that in our limited sample. Repeated use of traditional nest and roost trees would be expected when suitable sites are relatively rare and long-lasting, suggesting that land managers should identify and maintain these important trees. In addition, managers should act to ensure the recruitment of suitable nest and roost trees.

ACKNOWLEDGMENTS

We thank Alan Barron, Mark Bailey, Sal Chinnici, Dan Dill, Lowell Diller, Chris Hayder, Laura Nelson, Chuck Powell, Myrna Rosseau, Bill Stevens, Joel Thompson, Brad Valentine, Tom Wodetski, and Bryan Yost for providing information on trees used by swifts. Amedee Brickey, Susan Neel-Goodsir, Haiganoush Preisler, and Bill Zielinski provided support and assistance. Evelyn Bull, Charles Collins, Jeff Dunk, and Kathy Molina provided useful reviews of an earlier draft.

LITERATURE CITED

Bendire, C. 1895. Life Histories of North American Birds from the Parrots to the Grackles, with Special Reference to their Breeding Habits and Eggs. U.S. Govt. Printing Office, Washington, D.C.

Bent, A. C. 1940. Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. U.S. Natl. Mus. Bull.176.

Bull, E. L. 1991. Summer roosts and roosting behavior of Vaux's Swift in old-growth forests. Northwest. Naturalist. 72:78–82.

Bull, E. L., and Collins, C. T. 1993. Vaux's Swift (*Chaetura vauxi*), in The Birds of North America (A. Poole and F. Gill, eds.), no. 77. Acad. Nat. Sci., Philadelphia.

Bull, E. L., and Collins, C. T. 1996. Nest site fidelity, breeding age, and adult longevity in the Vaux's Swift. N. Am. Bird Bander 21:49–51.

Bull, E. L., and Cooper, H. D. 1991. Vaux's Swift nests in hollow trees. W. Birds 22:85–91.

Dawson, W. L. 1923. The Birds of California, vol. II. South Moulton Co., Los Angeles.

Fritz, E. 1931. The role of fire in the redwood region. J. Forestry 29:939–950.

Küchler, A. W. 1977. The map of the natural vegetation of California, in Terrestrial Vegetation of California (M. G. Barbour and J. Major, eds.), pp. 909–938. Wiley, New York.

Lemmon, P. E. 1957. A new instrument for measuring forest overstory density. J. Forestry 55:667–668.

Sterling, J., and Paton, P. W. C. 1996. Breeding distribution of Vaux's Swift in California. W. Birds 27:30–40.

Taylor, H. R. 1905. The nest and eggs of the Vaux Swift. Condor 7:177, 179.

Zar, J. H. 1974. Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, N.J.

Accepted 20 January 2004