

Sonoma Tree Vole Habitat on Managed Redwood and Douglas-fir Forestlands in North Coastal California¹

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Abstract

The Sonoma Tree Vole (*Arborimus pomo*) – a small arboreal mammal associated with mature forests – is a California Species of Special Concern due to concerns regarding loss of habitat from harvest, fire, and conversion. By counting their nests, we examined *A. pomo* use of pole to mature forest seral stages from 2001 to 2005 using line transects at 64 study sites distributed across redwood (*Sequoia sempervirens*), mixed conifer, Douglas-fir (*Pseudotsuga menziesii*), and hardwood dominated stands. A total of 441 nests were found including 215 active and 226 inactive nests. The highest percentage (33 percent) of nests was in unharvested and partially harvested old growth Douglas-fir stands. All pole and young stands, and stands that were predominantly redwood, had 77 percent fewer nests. This study suggests that *A. pomo* could benefit from forest management strategies aimed at retaining a mature Douglas-fir stand component.

Key words: conservation, Douglas-fir, forest inventory, habitat, modeling, redwood, Sonoma tree vole

Introduction

Tree voles (*Arborimus* sp.) are small nocturnal mammals that primarily inhabit coniferous forests dominated by Douglas-fir, but they also live where Douglas-fir co-occurs with other species, including redwood, Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*) or grand fir (*Abies grandis*) (Jones 2003). Even in such forests, populations appear to have a patchy distribution (Carey 1991).

With their arboreal nature and diet almost entirely of Douglas-fir needles, tree voles are among the most unique and highly specialized rodents in the world. Further, their habitat use patterns and behavior make studies problematic. As a result, tree vole presence and relative abundance is most commonly inferred by their nests, distinguishable from other nests by discarded resin ducts from the needles they have consumed (Carey 1991, Thompson and Diller 2002).

The abundance and distribution of suitable habitat may be a limiting factor for tree voles (Carey 1989). Although some studies (Swingle 2005, Thompson and Diller

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2002, Wooster and Town 1998⁵) have shown that tree voles nest in younger forests, several studies (Aubry and others 1991, Corn and Bury 1986, Gillesberg and Carey 1991, Gomez and Anthony 1998, Huff et al. 1992, Martin 1998) suggest that the species is most abundant in older forests. Thus, timber harvest may impact the species.

In northwestern California, the Sonoma tree vole is restricted to coastal forests of Humboldt, Mendocino, and Sonoma Counties (Jones 2003). The Sonoma tree vole is recognized in California as a Species of Special Concern (California Department of Fish and Game 2011). In addition to its status, tree voles are important prey species of the northern spotted owl (Forsman and others 1984), the Humboldt marten (*Martes americana humboldtensis*), and the Pacific fisher (*Martes pennanti pacifica*)⁶.

The Sonoma tree vole is a covered species of the Humboldt Redwood Company (HRC) Habitat Conservation Plan (HCP) (PALCO 1999). A HCP management objective for the Sonoma tree vole is to sustain viable tree vole populations through retention of suitable habitat. Given the difficulties surrounding the study of this species and the questions concerning its habitat, we developed this study to test the assumptions regarding the availability and distribution of habitat that then could inform models relating timber management to vole abundance, and map current distribution on HCP lands.

For this case study we: (1) examined Sonoma tree vole use of pole to mature forest seral stages from 2001 to 2005 at 64 study sites distributed across redwood, mixed conifer, Douglas-fir and Douglas-fir/hardwood stands, (2) conducted a statistical analysis to quantify the relationship between the number of nests and forest stand features, and (3) applied them to the current (2011) forest inventory to assess the availability and distribution of Sonoma tree vole habitat.

Study area

HRC lands encompass approximately 84,000 ha, and are located in coastal Humboldt County, California. These lands are characterized by mountainous terrain, a maritime climate, and dense coniferous forests, primarily dominated by coastal redwood and Douglas-fir, with an understory typically composed of tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), salal (*Gaultheria shallon*), and sword fern (*Polystichum munitum*). Elevations range from 45 m on river or creek benches to over 800 m along ridges.

Methods

Study sites (n = 64) were randomly selected based on the following stand types: (1) Douglas-fir, (2) redwood, (3) Douglas-fir/hardwood, and (4) Douglas-fir/redwood. All sites contained canopy closure >25 percent and were a minimum of 10 ha in area. Within each type, 16 sites were selected among three seral stages: pole (15 through 28 cm Diameter at Breast Height [DBH]), young-growth (29 through 61

⁵ Wooster, T.W.; Town, P. 1998. **California red tree voles within a coastal second-growth forest.** State of California, Department of Fish and Game, Yountville, CA. Unpublished report.

⁶ Slauson, K. 2011. Unpublished data on file, USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA.

cm DBH), and mature (>61 cm DBH).

From 2001 to 2005, we surveyed according to the draft study plan developed by the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station⁷. Following Anderson and others (1979), surveyors recorded tree vole nests along five 100 m transects in each stand. We attempted to distribute transects 60 m apart and parallel to elevation contour lines. The UTM locations of each transect's mid-point was located with a GPS.

We attempted to locate Sonoma tree vole nests with a visual search of trees along both sides of the transect line. When a suspected nest structure was detected, the ground below the nest was searched for resin ducts, evidence indicative of tree vole activity (Jones 2003). If a nest could not be confirmed as belonging to a tree vole from the ground, the tree was climbed and the nest was inspected.

A general linear mixed-model analysis of variance (ANOVA) was used to quantify the relationship between the number of nests and habitat type as derived from forest inventory information. The number of nests per transect was the dependent variable. Tree size class (20 to 40 cm, 40 to 60 cm, 60 to 80 cm, and 80 to 100 cm) and density of Douglas-fir by canopy cover (trace [<25 percent], sub-dominant [25 to 50 percent], dominant [50 to 75 percent], and pure [>75 percent]) were linear continuous effects. Site was treated as a random effect. The variance component was selected for the covariance structure. The full maximum likelihood estimation was used to model the fixed effects.

To address the habitat mapping objective using 2011 forest inventory information, the Sonoma tree vole nest model was applied to HRC lands in the Mattole River watershed near Petrolia, CA using current vegetation type mapping and forest inventory data.

Results

Field study

A total of 441 Sonoma tree vole nests in the 64 sites were found, with 215 active and 226 not active. Occupancy was detected in 57 of the 64 surveyed sites (89 percent). The sites varied widely in terms of stand area and vegetative characteristics. Stand size ranged from relatively small stands of 10 ha (minimum stand size) to relatively large contiguous stands of 898 ha. Stand characteristics ranged from un-harvested old growth stands with dense canopies, to thinned pole sites with thick brushy understory vegetation.

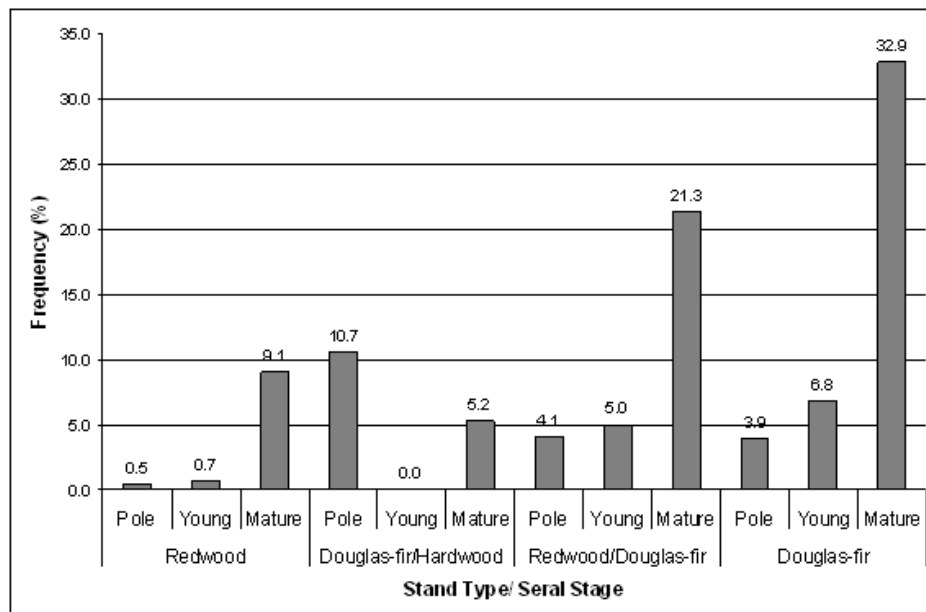
The greatest numbers of nests were in Douglas-fir trees (*table 1*). Twenty-nine trees were found to contain multiple vole nests. The diameter breast height (DBH) of trees with active nests ranged from 10.5 to 226.3 cm (mean 100.6 cm).

⁷ Biswell, B.; Blow, M.; Finley, L.; Madsen, S.; Schmidt, K. 1999. **Survey protocol for the red tree vole *Arborimus longicaudus***. (Interim Version 2.0). U.S. Forest Service, Pacific Northwest Research Station. Portland, OR. 31 p. Unpublished.

Table 1—Percentage of *Arborimus pomo* nests by tree species on HRC land in northwestern California, 2001 to 2005 (n = 395).

Common name	Scientific name	# <i>A. pomo</i> nests	Percent of total nest trees
Douglas-fir	<i>Pseudotsuga menziesii</i>	337	85.3
Grand fir	<i>Abies grandis</i>	29	7.3
Tan oak	<i>Lithocarpus densiflorus</i>	17	4.3
Redwood	<i>Sequoia sempervirens</i>	8	2.0
Pacific madrone	<i>Arbutus menziesii</i>	2	0.5
Interior live oak	<i>Quercus wislizenii</i>	1	0.3
Pepperwood	<i>Umbellularia californica</i>	1	0.3

Sonoma tree vole nests were in all seral stages except the young growth Douglas-fir/hardwood type (*fig. 1*). By stand type and seral stage, the largest number (33 percent) of vole nests was in mature Douglas-fir stands, followed by mature redwood/Douglas-fir stands (21 percent). Within stand types, mature stages contained the most nests and pole had the least. Approximately 11 percent of Sonoma tree vole nests were in pole Douglas-fir/hardwood stands. Contrary to the general positive relationship of nest density with seral stage, this finding may be due to the presence of residual old growth Douglas-fir trees at a density that did not affect stand classification but still provided the structure for nesting and an adequate food source. Sonoma tree vole nests were not found in three of the hardwood pole sites, two of the redwood pole sites, and two of the redwood young growth sites.

**Figure 1**—Percent of *Arborimus pomo* nests in pole, young, and mature stands relative to species composition for stands surveyed on HRC land in northwestern California, 2001 to 2005 (n = 441).

Habitat analysis

When the stand size class increased, the number of nests per transect also increased (*fig. 2*). The estimated slope describing the relationship between tree size

class and number of nests ($b = 0.659 \pm 0.174$ ($\pm 1\text{SEM}$)) was significantly greater than zero ($t_{62} = 3.79$, $p < 0.001$). When the relative density of Douglas-fir increased from stand to stand, the number of nests per transect also increased (*fig. 3*). The estimated slope describing the relationship between relative density of Douglas-fir and nests ($b = 0.519 \pm 0.177$ ($\pm 1\text{SEM}$)) was significantly greater than zero ($t_{62} = 2.931$, $p = 0.005$).

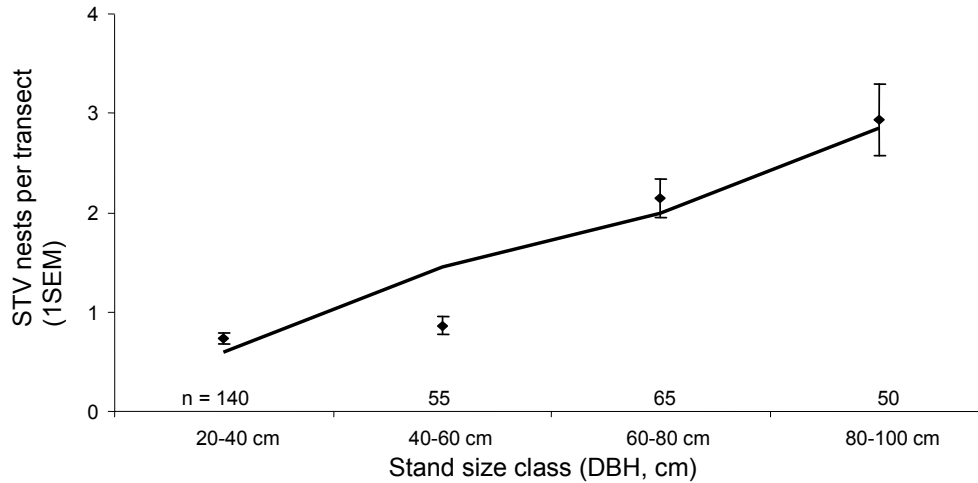


Figure 2—Number of Sonoma tree vole (STV) nests in relation to a stand's tree size class. Each point is the mean number of nests across transects, error bars are $\pm 1\text{SEM}$, n is the number of transects that were surveyed.

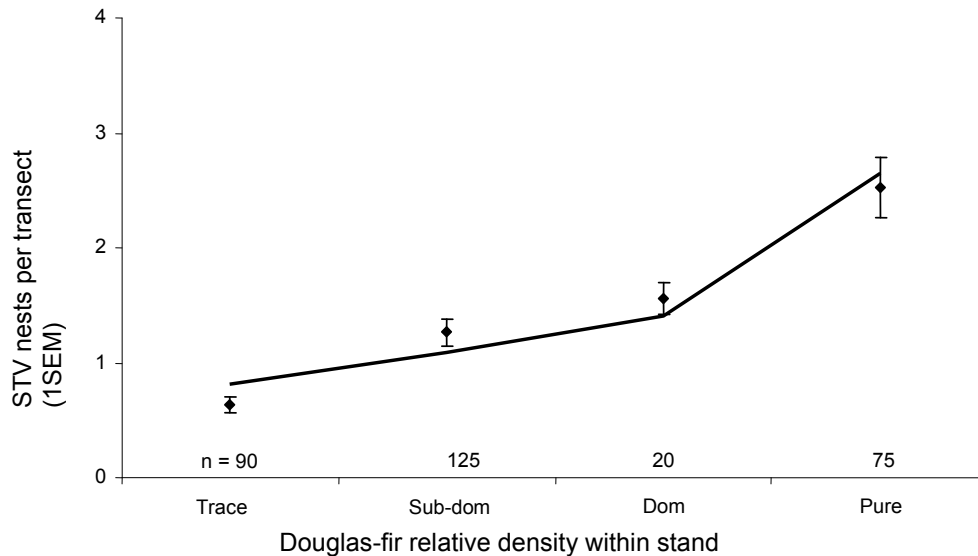


Figure 3—Number of Sonoma tree vole (STV) nests in relation to Douglas-fir relative density within stand. Each point is the mean number of nests across transects, error bars are $\pm 1\text{SEM}$, n is the number of transects that were surveyed.

The following equation describes the model:

$$Nests = -1.934 + 0.659(SIZECLASS) + 0.519(DFRANK)$$

Where *Nests* is the number vole nests along a 100 m transect. SIZECLASS is the tree size class where 3 = 20-40 cm; 4 = 40-60 cm; 5 = 60-80 cm, and 6 = 80-100 cm. DFRANK is the relative density of Douglas-fir where 0 = trace; 1 = sub-dominant; 2 = dominant; and 3 = pure.

Application of habitat model to current (2011) timber inventory

The Sonoma tree vole nest model was applied to HRC lands using current (2011) vegetation type mapping. As an example, the estimated number of Sonoma tree vole nests per transect and the area of relative tree vole habitat are shown for the Mattole River watershed (*table 2*).

Table 2—*Relative density of Sonoma tree vole nests predicted per 100 m transect and habitat area relative to Douglas-fir size and rank from the 2011 HRC forest inventory in the Mattole River watershed on HRC land in Humboldt County, CA.*

Size Class	DF Rank	Nests/transect	Acres	Hectares
3	0	0.0	4847.3	1938.9
3	1	0.6	644.4	257.8
4	0	0.7	255.7	102.3
3	2	1.1	576.3	230.5
3	3	1.6	726.3	290.5
4	3	2.3	1702.5	681.0
5	3	2.9	2047.7	819.1
6	3	3.6	529.4	211.8

The habitat information resulting from the vegetation typing was used to map the estimated density per transect of vole nests on HRC lands in the Mattole River watershed (*fig. 4*). On *figure 4* black and dark grey areas represent locations where nests should be dense or moderately dense respectively. Stippled areas represent places the model predicts nests to be absent or few, or are non-forested.

In the Douglas-fir dominated Mattole River watershed, approximately 38 percent of habitat (1711.2 ha) is in the high density category and is scattered throughout the forestlands, with some relatively significant concentrations to the northwest on Long Ridge and near Taylor Peak (*table 2* and *fig. 4*).

With the exception of Long Ridge and Taylor Peak, the best habitat appears to be relatively scattered but connected by stands with lower suitability and riparian zones. Thus, in this watershed retention of clumps of habitat and the connectivity between them would likely benefit Sonoma tree voles.

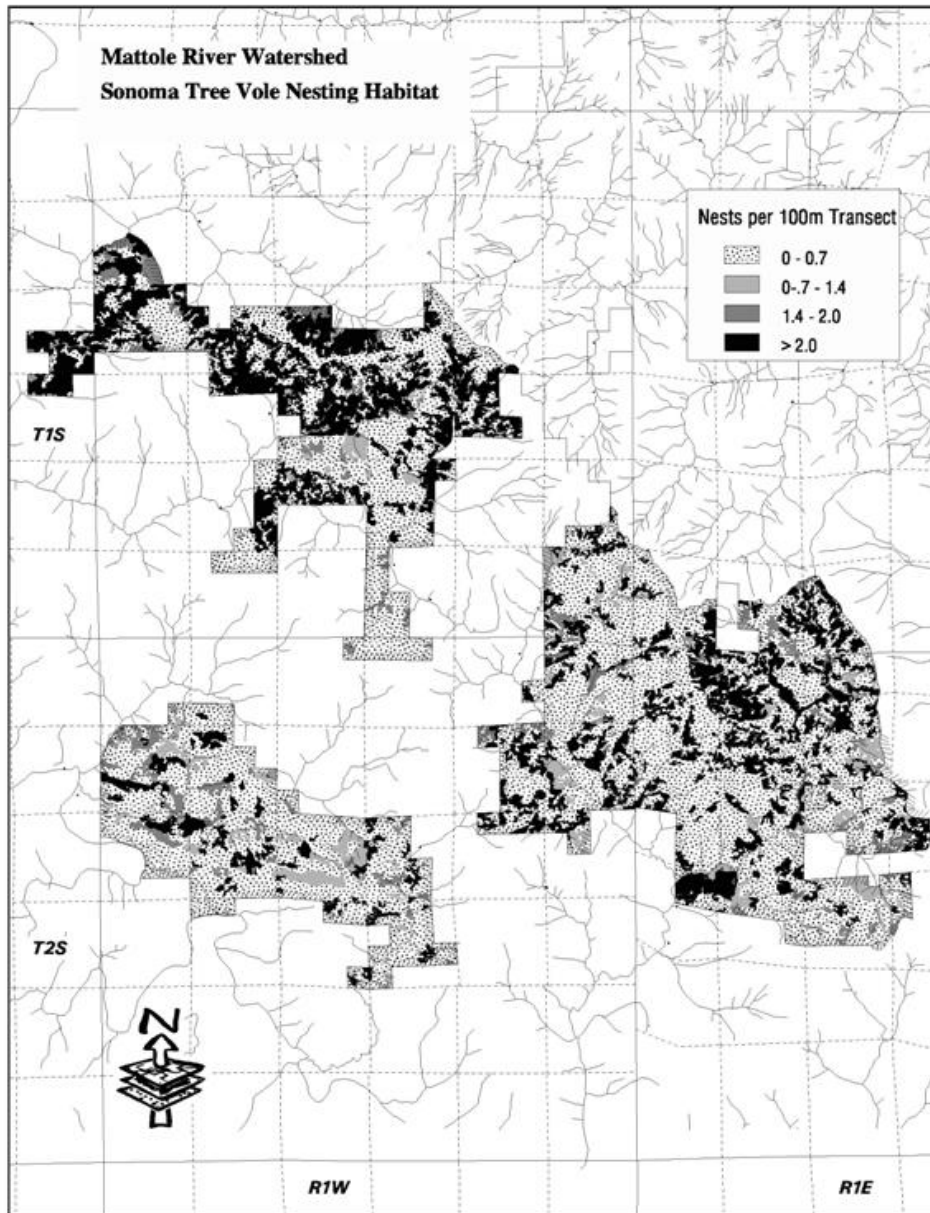


Figure 4—Relative density of Sonoma tree vole nests on HRC lands in the Mattole River Watershed, Humboldt County, CA.

Management implications

Swingle (2005) found through comparisons of nests located by visual searches from the ground versus nests located by following radio collared voles that many active nests could not be seen from the ground, and that nests located by visual searches were biased towards larger nests. Thus, our surveys should best be considered indices to relative abundance because we do not know the true number of nests in any stand type. Findings of this study relative to Sonoma tree vole habitat are consistent with others (e.g., Jones 2003, Thompson and Diller 2002). Mature stands with larger Douglas-fir trees and those with higher densities of Douglas-fir tend to

have the most nests while pole and young stands with relatively few or no Douglas-fir trees tend to have fewer nests (*fig. 2* and *fig. 3*). The retention of large Douglas-fir trees combined with other conservation strategies such as riparian protection, other species protection measures (e.g. northern spotted owl nest zones), or as part of a structural element retention strategy wherein large trees with complex structure are retained may help maintain Sonoma tree vole populations.

Maps of Sonoma tree vole habitat derived by applying the habitat model to timber inventory (e.g., *fig. 4*) as the inventory is renewed over time can enable changes in Sonoma tree vole habitat to be visualized and monitored. Validating the model by predicting Sonoma tree vole nest density in stands outside the stands and watersheds where the model was developed would add confidence to its use for monitoring purposes.

Looking forward, HRC plans to use the ForSee growth and yield model (California Growth and Yield Modeling Cooperative 2009) to project future stand conditions under planned management scenarios. The ForSee model produces present and future stand characteristics that can be used as input to the vole nest model enabling forecasts of tree vole habitat value. Next steps for HRC will be to explore opportunities for refinement of the model using new or different inputs. Other forestland ownerships that have forest inventory data and Geographic Information System technology may be able to use these techniques as a tool for evaluating species conservation programs.

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