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Supplemental Information: Red tree vole nest site characteristics and persistence in young and old Douglas-fir forests: implications for canopy-dependent species

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Recommended Citation

Piasecki, J., J. Bailey, and K. Moriarty. 2026. Red tree vole nest site characteristics and persistence in young and old Douglas-fir forests: implications for canopy-dependent species. Stacks Journal: 26002. https://doi.org/10.60102/stacks-26002.

Accepted by 2 of 3 reviewers

Conflicts of Interest
The authors declare no conflicts of interest.

Publishing History
Submitted April 17 2025
Accepted January 20 2026
Published March 27 2026

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Supplemental Information

Table S1. Definitions of nest supporting structures quantified in this study as determined by prior classifications for red tree vole (*Arborimus longicaudus*) and canopy structure studies (Swingle 2005; Michel and Winter 2009; Marks-Fife 2016), central Coast Range, Oregon, 2019-2022.

Tree Structure	Definition
Broken Top	Structure created when main stem of tree partially or completely shears off creating one or more new leaders
Cavity	Hole in bark or wood where the opening is at least 5cm wide in which an arboreal nest could be constructed
Epicormic	Developed branch formation from a dormant bud on the main stem below the main canopy
Mistletoe	Dense aggregation of branchlets resulting from an infection or parasite
Split Trunk	'V' shaped structure formed from two or more diverging main stems
Moss Mat	Thick blanket of moss covering the top portion of a large diameter (>5cm) limb
Large Branch	Branch larger than 5cm in diameter
Whorl*	Annual growth of multiple branches growing in a circular pattern from the main stem
Defect	Structural deformity capable of supporting arboreal nest construction not classified in an aforementioned category

*While branch whorls can support arboreal nests, they are not distinctly classified as tree structures in relevant literature and are only defined here because they are included in our data as a type of nest platform.

Table S2. We sampled unique and resurveyed stands (parentheses = sample size of resurveyed) from 2019 to 2022 to evaluate arboreal and red tree vole (*Arborimus longicaudus*) nest survival. Although we aimed for a balanced design, stands ranging 40-80 years, and especially 50-80 years of age were rare in the Oregon Coast Range at the time of our study due to younger average harvest rotation ages and publicly owned forests typically exceeding 80 years of age.

	Stand Age Class						
Year	**20 - 29**	**30 - 39**	**40 - 49**	**50 - 59**	**60-79**	**80+**	**N**
2019	6	4	0	2	0	0	12
2020	12 (6)	9 (4)	5 (0)	7 (2)	2 (0)	5 (0)	40
2021	13 (12)	12 (9)	6 (5)	7 (7)	4 (4)	6 (5)	48
2022	15 (11)	15 (12)	7 (4)	8 (6)	1 (1)	7 (4)	53

Table S3. We report median and interquartile range (IQR) nest volume in cubic meters measured at the time of initial survey for all nests in each age class (20 - 29, 30 - 39, 40 - 49, 50 - 59, 60 - 79, > 80 years) for red tree vole (*Arborimus longicaudus*) nests across forest age classes.

Age	Sample Size	Nest Volume Median	Volume IQR
20	437	0.02	0.03
30	338	0.02	0.03
40	37	0.03	0.04
50	52	0.02	0.03
60	11	0.01	0.02
>80	169	0.01	0.01

Table S4. Number and proportion of supporting tree structures by age class (20 - 29, 30 - 39, 40 - 49, 50 - 59, 60 - 79, > 80 years) for red tree vole (*Arborimus longicaudus*) nests across forest age class during 2022, which was a year with our highest effort (n = 564 nests).

Tree structure	**20**, n = 180	**30**, n = 169	**40**, n = 23	**50**, n = 25	**60**, n = 5	**80**, n = 162
Broken top	51 (28%)	56 (33%)	14 (61%)	9 (36%)	1 (20%)	5 (3.1%)
Cavity	-	-	-	-	2 (40%)	18 (11%)
Defect	9 (5.0%)	12 (7.1%)	-	5 (20%)	-	3 (1.9%)
Epicormic	-	-	-	-	-	53 (33%)
Large branch	1 (0.6%)	1 (0.6%)	-	1 (4.0%)	-	40 (25%)
Mistletoe	1 (0.6%)	-	-	3 (12%)	-	-
Moss mat	-	-	-	-	-	29 (18%)
Split	35 (19%)	30 (18%)	4 (17%)	2 (8.0%)	1 (20%)	5 (3.1%)
Branch whorl	83 (46%)	70 (41%)	5 (22%)	5 (20%)	1 (20%)	9 (5.6%)

Table S5. Mean, standard deviation and sample sizes of estimated density of recently occupied tree vole nests for each stand age class from 2019 to 2022. Detection rates of 0.84 and 0.055 were used in young forest and old forest respectively (Piasecki, 2023). N is the total number of stands surveyed in each age class whereas n is the number of stands used in the mean calculation where the estimated density of recently occupied tree vole nests was > 0. Stands in the 60-year age class were omitted because overall occurrence of arboreal nests was low to none, no recently occupied tree vole nests were found, and detection rates were not quantified in that age class.

	Stand Age Class					
Year	**20**[1]	**30**[1]	**40**[1]	**50**[1]	**60**[1]	**80**[1]
2019	0.92 (0.41) {3/6}	1.19 (0.53) {3/4}	NA	0.61 (NA) {1/2}	NA	NA
2020	0.90 (0.38) {4/12}	0.79 (0.18) {3/9}	0.81 (NA) {1/5}	0.50 (NA) {1/7}	NA	51.1 (NA) {2/5}
2021	0.77 (0.49) {4/13}	1.62 (0.60) {3/12}	2.02 (NA) {1/6}	0.95 (NA) {2/7}	NA	40 (57.56) {6/6}
2022	1.04 (0.94) {6/15}	1.37 (1.14) {3/15}	0.40 (NA) {1/7}	NA {0/8}	NA	69.41 (28.73) {5/7}
All Years	**0.91 (0.11)**	**1.24 (0.35)**	**1.08 (0.84)**	**0.68 (0.24)**	**NA**	**53.5 (14.9)**

[1]Mean (SD) {n/N}

Table S6. Characteristics of 63 stands surveyed in the Oregon Coast Range to determine arboreal nest persistence. We report the proportion of surveyed arboreal nests that became absent, or were no longer functional as a nest, between years during our study.

Age class	**2019 - 2020**	**2020 - 2021**	**2021 - 2022**
20 - 29	0.14 (n = 77)	0.11 (n = 148)	0.19 (n = 216)
30 - 39	0.11 (n = 46)	0.14 (n = 116)	0.18 (n = 193)
40 - 49	-	0.08 (n = 13)	0.12 (n = 17)
50 - 59	0.18 (n = 11)	0.22 (n = 23)	0.22 (n = 23)
60 - 79	-	0.4 (n = 5)	1 (n = 1)
80+	-	0.36 (n = 25)	0.11 (n = 66)

Figure S1. Example of a multi-layer nest with signs of recent red tree vole occupancy. In this case, the original nest was primarily composed of moss and contained a spherical chamber characteristic of nests constructed by Humboldt's flying squirrel. It was later occupied by a red tree vole. Green resin ducts, freshly harvested Douglas-fir cuttings, and fecal pellets were present inside and just below the initially constructed nest.

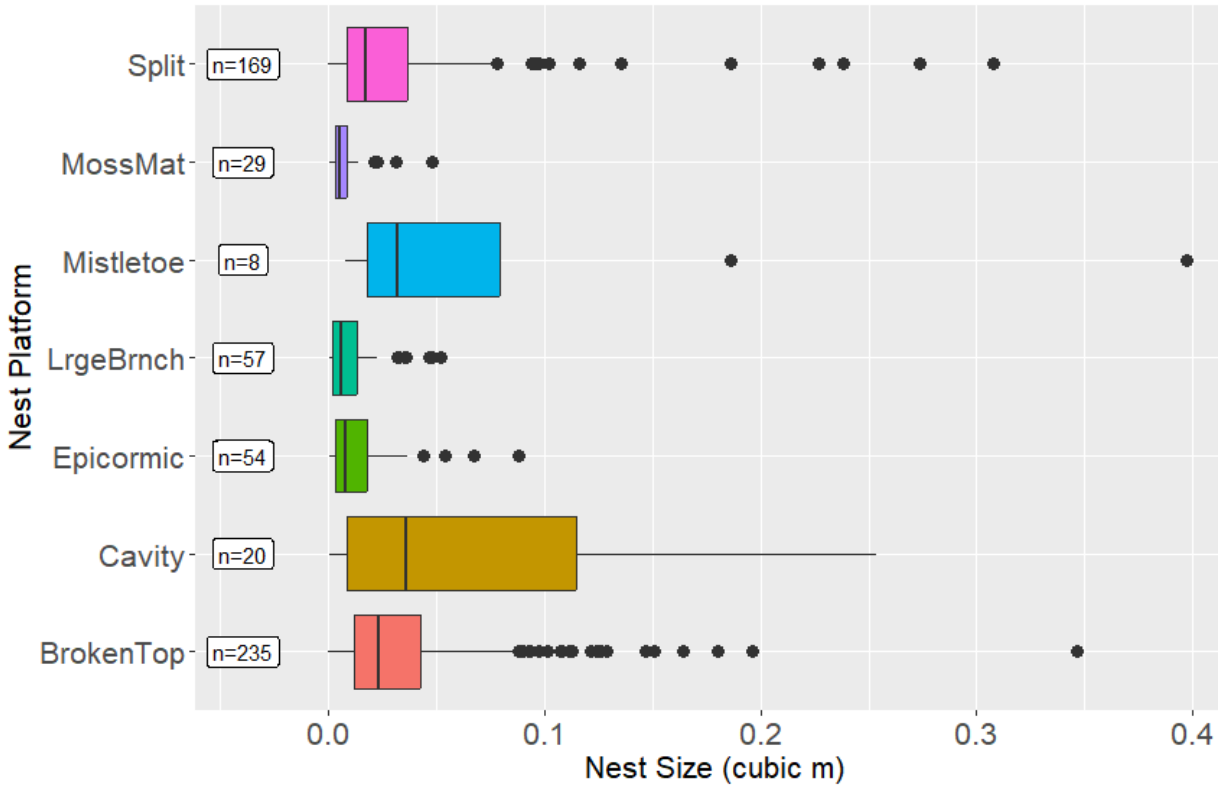

Figure S2. Measured arboreal nest volume (x-axis) using boxplots for each type of tree structure (See descriptions within Table 2, n = 572). We removed data from nests > 0.4 m^3 (n = 8) to better visualize data.

Figure S3. Interspecific nest use between bald eagles (*Haliaeetus leucocephalus*) and red tree vole (*Arborimus longicaudus*). Signs of recent tree vole activity were found in the hollow tree cavity created by a decaying broken top that was supporting an active bald eagle nest. Tree vole sign was also interspersed throughout the structure of the eagle nest. The eagle nest was confirmed to be active during the bald eagle breeding season prior to climbing (August 2020).