Contribution of Downed Woody Material by Blue, Valley, and Coast Live Oaks in Central California[1]

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Abstract: *Information on downed woody material (DWM) is necessary to produce guidelines to manage and maintain faunal diversity in California oak (*Quercus *spp.) woodlands. We sampled DWM within circular plots, one each centered on 122 blue (*Quercus douglasii*), 112 coast live (*Q. agrifolia*), and 74 valley (*Q. lobata*) oak trees in central California. Most DWM pieces that occurred within plots were small. Of large (≥25 cm diameter) pieces, 83 percent occurred under coast live (40 percent) and valley (43 percent) oaks. Mean diameter, length, number, and volume of pieces of DWM under blue, coast live, and valley oaks were not statistically different across the three tree species (all* P *>0.10). However, for each variable, mean values of pieces were lower under blue oaks versus under coast live and valley oaks. Approximately 50 percent of the pieces under each species were moderately decayed, compared to approximately 25 percent either sound or soft. Management practices in oak woodland may alter the abundance and distribution of DWM. Therefore, emphasis should be given to maintenance of DWM for vertebrate and invertebrate wildlife.*

Downed woody material (DWM) (defined herein as the dead branches, stems, and boles of trees that have fallen and lie on or above the ground [Brown 1974]) is an important component of wildlife habitat in California's 3.1 million ha of oak (*Quercus* spp.) woodlands. A query we conducted of version 5.0 of the California Wildlife Habitat Relationships (CWHR) System (Timossi and others 1994) produced a list of 278 terrestrial vertebrates that use oak woodlands. Of these, 28 percent (80; 15 of 22 amphibian species, 23 of 38 reptile species, 13 of 144 bird species, and 29 of 78 mammal species) use DWM for feeding, reproduction, or cover (Timossi and others 1994). Downed wood also functions as a moisture and nutrient reserve and perhaps as natural protection for emerging oak seedlings (Barnhart and others 1991)

Studies in forests of the Pacific Northwest show that the size (Ruben 1976), amount, distribution (Winn 1976), and state of decay of DWM influence wildlife use. Management practices in California oak woodlands and changing land-use patterns can alter the characteristics and distribution of DWM, thereby affecting dependent wildlife species. Baseline knowledge of DWM in oak woodlands is required to manage this important resource

The objectives of this study were to determine the relative contribution of DWM by the three predominant oak species (blue oak [*Quercus douglasii*], coast live oak [*Q. agrifolia*], and valley oak [*Q. lobata*]) in oak woodlands of central California. Study results will provide information for management of DWM and will be used by others for input to the CWHR System, a computerized wildlife information system used by many natural resource managers (Airola 1988).

Study Area

During summer and fall 1995, we sampled DWM in oak woodlands on 11 livestock ranches in central California (*fig. 1*). The ranches were chosen primarily for the existence of an active livestock production enterprise on the ranch, our

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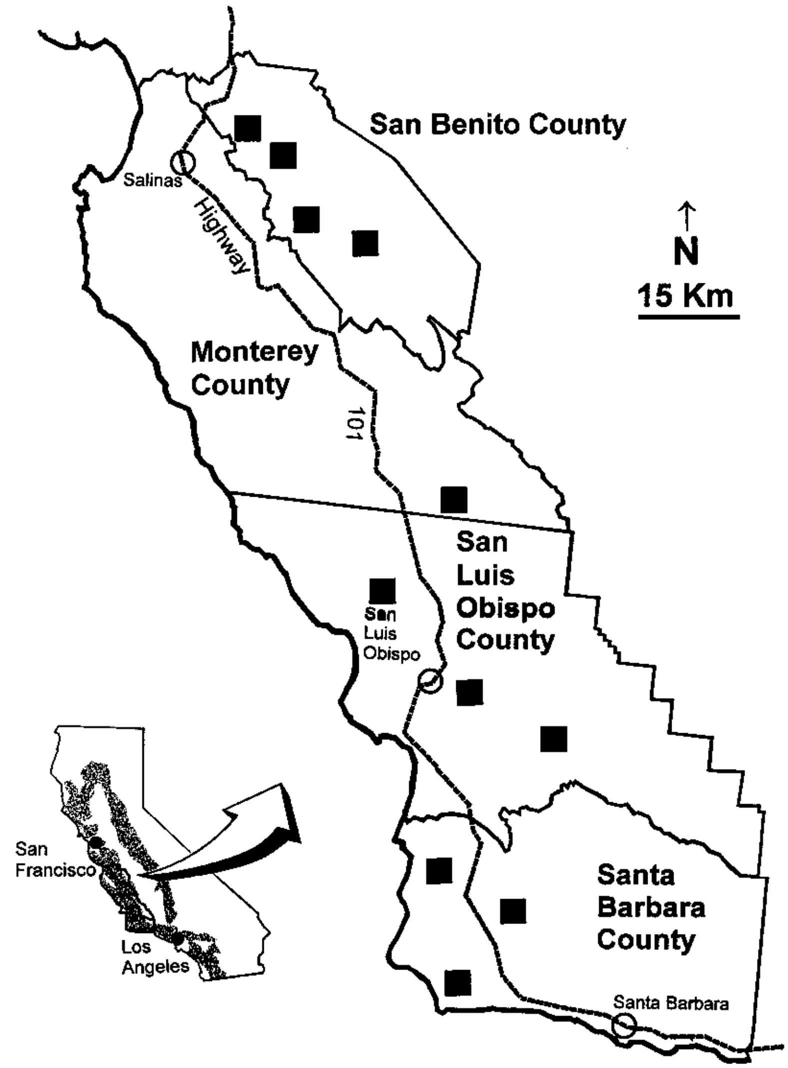
Figure 1—Ranch locations in coastal California in which downed woody material was sampled on 308 0.01-ha plots in oak woodlands, 1995. The inset map shows the composite distribution of blue, coast live, and valley oak trees in California (after Griffin and Critchfield 1976).



ability to gain access, and their somewhat even spacing from south Santa Barbara County to north San Benito County. These ranches are typical of central California oak woodlands and represent a continuum of stand densities and tree species compositions. Topography on the 11 ranches is generally hilly. Climate of the area is Mediterranean, characterized by warm, dry summers and cool, wet winters. Typically, all precipitation occurs during October to May

Blue oaks and coast live oaks predominate in the woodlands we sampled. Valley oaks occur as scattered individuals or in small groups in valley bottoms. Western sycamore (*Platanus racemosa*) and cottonwood (*Populus* spp.) predominate in intermittent and perennial riparian zones. Chaparral, dominated by chamise (*Adenostoma* spp.), occupies many south-facing slopes. When present, understories of the oak woodlands consist mostly of toyon (*Heteromeles arbutifolia*), California coffeeberry (*Rhamnus californica*), poison oak (*Toxicodendron diversilobum*), and deerweed (*Lotus scoparius*). Wild oats (*Avena* spp.), bromes (*Bromus* spp.), and fescues (*Festuca* spp.) predominate on woodland floors.

Methods

Field

On each ranch, the ranch headquarters or a ranch gate formed a starting point for selecting oak stands at regular intervals (0.5 km) along access roads on alternate sides. We paced 50 m off the road along a line approximately perpendicular to the road. In like manner to the point-centered quarter method (Cottam and Curtis 1956), the end formed a sampling point. The nearest living tree 10 cm diameter at breast high (dbh; 1.4 m above the ground) within each quadrant (NE, SE, SW, and NW) around the sampling point was termed a "mother tree" under which we measured DWM.

We measured the dbh of each mother tree with a Biltmore stick; height (m) was measured with a clinometer. We measured DWM within a 6-m radius sampling plot (0.01-ha circular plot) centered on each mother tree. In four instances where circular plots around two mother trees intersected, overlap was eliminated by selecting the next nearest tree of ≥10 cm dbh. The length (cm), widest diameter (cm), and decay state of all DWM ≥5 cm diameter were recorded. For DWM that intersected the plot perimeter, we measured DWM length only to its intersection. Volume of DWM was calculated as the volume for a cylinder using the length (cm) and largest diameter (cm) of pieces. Because DWM pieces were, on average, <1 m long (mean = 88.4 cm, n = 1,349, SE = 2.4 cm), disparity between largest and smallest diameters on individual pieces was likely not great and therefore represents only a potentially slight overestimate of volume. We based our classification of decay state on a system defined for Douglas-fir (*Pseudotsuga menziesii*) by Maser and others (1979) and modified by Bingham and Sawyer (1988). By this method, we placed downed oak wood into one of three decay classes: (1) sound wood or only slight surface breakdown, with bark and branches intact; (2) moderately decayed wood and small branches missing, but bark usually present; and (3) soft DWM, often too rotten to support its own weight.

Data Analysis

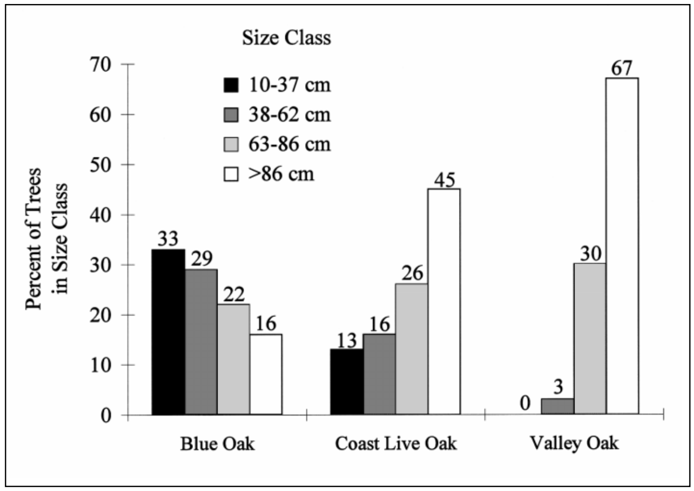
Because sample sizes were small, normality could not be assumed; therefore, we used Kruskall-Wallis non-parametric single-factor analyses of variance to assess differences among tree species. Chi-square was used to assess differing proportions of DWM by species in each of three decay states. Differences were considered significant when $P \leq 0.10$. Statistical procedures were conducted in PC-SAS (SAS Institute Inc. 1988).

Results

Mother Trees

We measured DWM in 308 0.01-ha circular plots centered on 74 valley, 112 coast live, and 122 blue oak trees located in four counties (Santa Barbara, San Luis Obispo, Monterey, and San Benito Counties on 76, 80, 68, and 84 plots, respectively). Most mother trees were large: 64 percent were 63 cm dbh (range 10-218 cm dbh). Seventy-one percent of coast live oak and 97 percent of valley oak mother trees were 63 cm dbh, compared to 38 percent of the blue oak trees (*fig. 2*).

Figure 2—Size-class distribution by tree species of 308 blue, coast live, and valley oak trees in coastal California, 1995, under which downed woody material was sampled within a 0.01-ha plot centered on each tree.



Downed Wood

A total of 1,351 DWM pieces was sampled. Of the 308 plots, 79 percent had ≥1 piece of DWM ≥5 cm diameter. Categorizing DWM as small (5-14 cm diameter), medium (15-24 cm), or large (≥25 cm diameter), 88 percent of DWM pieces were small. Of 53 large pieces, 40 and 43 percent occurred under coast live and valley oaks, respectively (*table 1*).

Analysis among the three oak species of mean diameter and length of DWM pieces and mean number and volume of pieces under mother trees produced no statistically significant differences (all P>0.10, *table 2*). There was a notably consistent trend, however, of smaller average size and lesser average amount of DWM under blue oak mother trees compared to that under coast live and valley oaks: diameter = 8.3 ± 1.3 (mean ± SE) vs. 9.8 ± 0.9 and 9.3 ± 1.3 cm, respectively; length = 87.7 ± 7.4 vs. 117.9 ± 9.6 and 106.4 ± 19.3 cm, respectively; number = 3.7 ± 0.8 vs. 7.1 ± 1.8 and 5.6 ± 1.3, respectively; and volume = 0.04 ± 0.02 vs. 0.16 ± 0.07 and 0.11 ± 0.05 m^3/plot, respectively (*table 2*).

Among blue, coast live, and valley oaks, DWM exhibited a similar pattern of decay state: approximately 50 percent of the pieces under each species were moderately decayed (58, 51, and 50 percent, respectively), compared to approximately 25 percent either sound (15, 23, and 22 percent, respectively) or soft (27, 26, 28 percent, respectively). Within only the sound decay state, significantly more DWM under valley (22 percent) and coast live (23 percent) oaks was sound than under blue oak (15 percent) trees (χ^2 = 18.35, df = 2, $P \leq$ 0.0001) (*fig. 3*).

Discussion

Selection of mother trees using the quarter method (Cottam and Curtis 1956) may have resulted in autocorrelation among the four trees we selected within a point. Therefore, we did not treat these four trees as independent samples in our analyses. Rather, we generated mean values from the four trees within a point and then generated a mean for each species for each ranch. The fact that the 11 ranches had the same primary management practice (cattle grazing), were within the oak woodland type, had similar fire histories, and that samples within ranches were taken from stands on various aspects, slopes, and soils all indicate that ranches constituted independent replicates

Table 1—Number of pieces of downed woody material (DWM) in three diameter (cm) classes under three species of oaks on 11 ranches in central California oak woodlands, 1995.

Species	Trees with no DWM present	Piece size: Small (5-14 cm)	Medium (15-24 cm)	Large (≥25 cm)	Total pieces
Blue oak (*Quercus douglasii*)	36	373	22	9	404
Coast live oak (*Quercus agrifolia*)	21	448	45	21	514
Valley oak (*Quercus lobata*)	8	369	41	23	433
Total	65	1,190	108	53	1,351

Table 2—Characteristics of downed woody material (DWM) on 11 ranches in central California, 1995.

	Piece diameter	Piece length	Pieces per tree	Volume per tree
	cm	*cm*	*no.*	*m³*
Blue oak ($n = 7$)[1]				
mean	8.3	87.7	3.7	0.04
SE	1.3	7.4	0.8	0.02
Coast live oak ($n = 11$)				
mean	9.8	117.9	7.1	0.16
SE	0.9	9.6	1.8	0.07
Valley oak ($n = 9$)				
mean	9.3	106.4	5.6	0.11
SE	1.3	19.3	1.3	0.05
χ^2 (Approximation)	1.2030	3.7094	2.8649	3.9494
df	2	2	2	2
P (Kruskal-Wallis χ^2 approximation)	0.5480	0.1565	0.2387	0.1388

[1]Over 1,350 pieces were observed on 308 0.01-ha plots centered on 74 valley, 112 coast live, and 122 blue oak trees. Samples were considered independent only at the ranch level: means represent values averaged (piece diameter and length) or summed (volume/tree and number of pieces/tree) by tree, averaged across trees of the same species within sample points, then averaged across points within ranches. Sample sizes (*n*) are the number of ranches on which that species occurred.

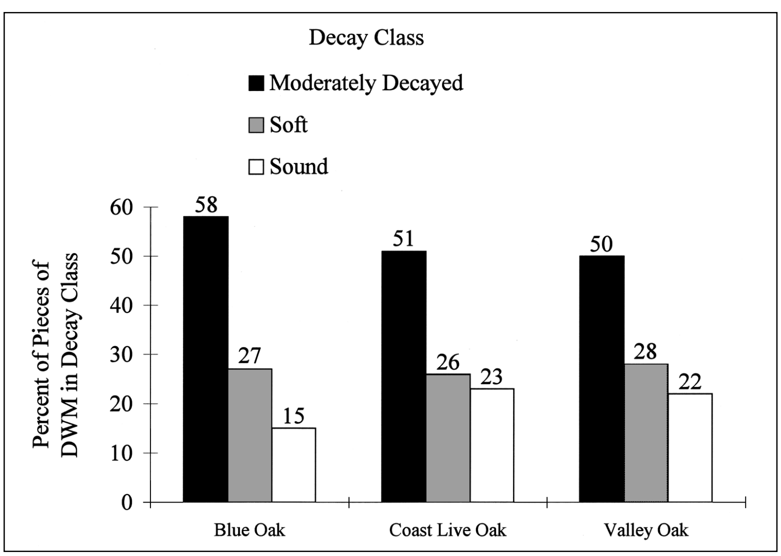


Figure 3—Percent by decay class of 1,351 pieces of downed woody material (DWM) sampled in coastal California in 1995 on 308 0.01-ha plots under blue, coast live, and valley oak trees. Proportions of pieces exhibiting the three decay states differed significantly among the three species (χ^2 = 11.37, df = 4, P = 0.0227). Subdivided chi-square tests resulted in differences within all three species across decay states and within only the "sound" decay state across species.

Lack of statistically significant ($P \leq 0.10$) results using the ranches as replicates apparently was due to the relatively high variability of the DWM data within and among ranches compared to among oak species. If we could justifiably have used individual trees as replicates and thereby discounted within- and among-ranch variability, perhaps the subsequent analysis would have substantiated the consistent trends apparent in our results and demonstrated that DWM was more numerous and larger (diameter, length, and volume) for coast live and valley oaks compared to blue oak. This difference, if real, could be attributed to the larger size of the coast live and valley oak trees we sampled, in conjunction with the tendency of valley oak to drop limbs. Limb dropping apparently results from increased brittleness after rehydration on hot days (Dias 1989). Our sampling of predominantly large valley and coast live oak trees was not an artifact of the sampling design. Rather, it likely represents the actual size-class distribution of these species in oak woodland: trees 74 cm dbh and larger account for 12 and 40 percent of the standing volume of coast live and valley oak, respectively, in California oak woodland compared to only 3 percent for blue oak (Bolsinger 1988)

We recognize that there is some bias in our data which complicates interpretation and limits application of the results. Sampling under trees rather than across woodlands precludes extrapolating DWM to area estimates across woodlands. The 0.01-ha plot of fixed radius (6 m) probably captured most DWM under blue oak trees, but may have been too small to do the same for many valley and coast live oaks under which we sampled. Because we measured DWM only to the plot intersection, mean length measurements are an index of piece length, not an absolute length of DWM. Nonetheless, this study is one of the first to characterize and quantify DWM in oak woodlands. Although many studies on DWM have been conducted in western North America in conifer-dominated habitats (Graham and Cromack 1982, Harmon and others 1987, Larson 1992, Maser and others 1979), other than Borchert and others (1993), no information exists on DWM presence and characteristics in oak woodland. In two blue oak stands in San Luis Obispo County, Borchert and others (1993) found an average of 6.2 and 3.5 pieces/ha of small DWM and 2.0 and 3.5 pieces/ha of large DWM. They defined "small" as 8-20 cm diameter and ≥0.9 m long and "large" as >20 cm diameter and ≥0.9 m long.

Management Implications

This study demonstrates the substantial contribution of DWM by large valley and coast live oak trees, and probably in lesser amount, blue oak, in central California oak woodlands. However, current information indicates that larger trees are sometimes cut for firewood (Standiford 1996). If firewood must be cut, we recommend leaving some slash piles and some larger pieces of wood to mitigate the removal of DWM. Further concern about the long-term presence of DWM arises from the prevalent notion that it provides habitat for rodent and snake pests. Downed wood is also used for firewood, and its removal is sometimes encouraged for aesthetic reasons. Naturally occurring DWM (i.e., fallen limbs and fallen snags) should be left in place.

Downed wood is an important habitat component for at least 80 of the 278 wildlife species predicted by our CWHR query to occur in oak woodlands, so it is important for maintaining faunal diversity. We cannot yet make prescriptions for the amount of DWM necessary to maintain wildlife values. At this time, however, we recommend that landowners and managers maintain DWM wherever possible.

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