# Potential Effects of Sudden Oak Death on Small Mammals and Herpetofauna in Coast Live Oak (*Quercus agrifolia*) Woodlands[1]

**Douglas J. Tempel[2] and William D. Tietje[3]**

*Key words:* oak woodlands, sudden oak death, wildlife-habitat relationships, small mammals, forest salamanders, *Quercus agrifolia, Phytophora ramorum*, forest pathogen impacts

## Abstract

Within San Luis Obispo County, California, coast live oak (*Quercus agrifolia*) woodlands provide important habitat for many wildlife species (see Tietje and others, this volume). Unfortunately, many of these woodlands are at high risk of sudden oak death (SOD) infection should the pathogen (*Phytophthora ramorum*) become established in the County (Meentemeyer and others 2004). To assess the potential impacts of SOD on the small mammal and herpetofaunal communities in this high-risk habitat, we surveyed for these taxa at three separate high-risk study sites within the County. We considered the co-occurrence of California bay laurel (*Umbellularia californica*) to be an indicator of high-risk woodlands. We then developed *a priori* regression models relating the abundance of the most common species to habitat structure and compared competing models using adjusted Akaike's Information Criterion ($AIC_c$) values (Burnham and Anderson 2002). Finally, we projected the potential effects of SOD on these species in San Luis Obispo County by comparing vegetation data that we collected at infected and uninfected sites in the San Francisco Bay Area.

At the three high-risk sites in San Luis Obispo County, we established 13, 1.1-ha trapping grids (8 _ 8, 15-m spacing between traps). From 2002-2004, we live-trapped small mammals for three consecutive nights each spring and fall; captured animals were eartagged and released. We later conducted mark-recapture analyses to estimate the abundances of common species on each grid. During January-April of 2003 and 2004, we surveyed for reptiles and amphibians using plywood coverboards (61 _ 61 _ 1.6 cm) placed along every other row of each grid; coverboards were checked every 2-3 weeks. We treated the total number of observations for each species on a grid as an index of species abundance.

During June and July 2004, we collected data on habitat elements of potential importance to small mammals and herpetofauna. On each grid, we randomly selected eight grid intersections at which we

[1] A version of this paper was presented at the Sudden Oak Death Second Science Symposium: The State of Our Knowledge, January 18-21, 2005, Monterey, California.

[2] Staff Research Associate, Integrated Hardwood Range Management Program, University of California Cooperative Extension, 2156 Sierra Way, Suite C, San Luis Obispo, CA 93401

[3] Natural Resources Specialist, Integrated Hardwood Range Management Program, University of California Cooperative Extension, 2156 Sierra Way, Suite C, San Luis Obispo, CA 93401 (e-mail: wdtietje@nature.berkeley.edu)

located 10-m-radius, circular vegetation plots (2 plots per grid quadrat, all plots separated by at least 20 m). Within each 10-m plot, we recorded: 1) the size, species, condition (live or dead), and number of cavities for all trees ≥ 10 cm dbh; 2) canopy cover; 3) vertical obstruction from 0-5 m above ground level (a surrogate for shrub cover; see Griffith and Youtie 1988); 4) amount of fine (< 7.6 cm diameter) and coarse woody debris (≥ 7.6 cm; CWD); 5) depth of the duff and litter layers; and 6) number of dusky-footed woodrat (*Neotoma fuscipes*) dwellings. During October 2004, we used the same sampling protocol to collect habitat data on 10, 10-m plots on each of two additional sites—a site that was heavily infected with SOD in Marin County (China Camp State Park) and an uninfected site in nearby Sonoma County (Helen Putnam Regional Park). At China Camp, each plot was centered three m from a randomly selected, SOD-killed coast live oak tree located on research plots established by Phytosphere Research (see Swiecki and Bernhardt, this volume). At Helen Putnam, the plots were centered three m from healthy coast live oak trees of similar size to the selected trees on the infected site.

After an extensive literature review, we developed a set of linear regression models for each frequently captured species relating its abundance to our measured habitat variables. For the small mammal habitat models, we considered each trapping session on a grid to be a repeated measurement when fitting the regression models (see Littell and others 1996) and included study site as a covariate in all models. For the salamander habitat models, we calculated a single abundance (i.e., no repeated measures) on each grid and included an interaction term(s) between study site and the habitat variable(s) in each model. We then calculated $AIC_c$ values and Akaike weights ($w_i$) for the suite of candidate models for each species. To predict changes in animal abundance should SOD reach San Luis Obispo County, we adjusted the habitat variables for each trapping grid based on the observed differences between the Bay Area sites. For each species, we then used model-averaging based on Akaike weights to calculate a change in abundance due to SOD.

Three species of cricetid rodents—dusky-footed woodrat, brush mouse (*Peromyscus boylii*), and California mouse (*P. californicus*)— dominated the small mammal community in San Luis Obispo County high-risk habitat, comprising 95 percent of all captures. Two forest salamanders—Monterey salamander (*Ensatina eschscholtzii eschscholtzii*) and slender salamander (*Batrachoseps* spp.)—dominated the herpetofaunal community, comprising 98% of all detections. For each of these five species, one candidate model was much more likely than the competing models. The best models suggested that each species responded differently to the measured habitat elements (*table 1*).

On the sampling plots in the Bay Area, we observed differences in several of the habitat variables that were important predictors of species abundance in San Luis Obispo County. For example, CWD volume was nearly 70 times greater in plots at the infected site relative to those at the uninfected site, while canopy cover was lower on the infected plots (79 percent vs. 84 percent). Vertical obstruction was higher on the infected plots (57 percent vs. 31 percent), but this difference was largely due to fallen trunks and branches, rather than increased shrub growth. The abundances of all three small mammal species showed a significant increase ($P < 0.05$), while the two salamander species showed no significant change.

**Table 1**—*Most supported abundance vs. habitat linear regression models for common small mammal and salamander species in San Luis Obispo County coast live oak woodlands at high risk of* Phytophora ramorum *infection. Abundance surveys were conducted during 2002-2004 for small mammals and during 2003-2004 for salamanders.*

| **Species** | **Habitat variables** [1] | **Akaike weight** [2] |
|---|---|---|
| Dusky-footed woodrat | Shrub cover (+), coarse woody debris (–) | 0.91 |
| Brush mouse | Tree density (–) | 0.88 |
| California mouse | Shrub cover (+), coarse woody debris (+) | 0.74 |
| Monterey salamander | Elevation (+) | 0.60 |
| Slender salamander | Litter depth (+) | 0.78 |

[1] For each habitat variable, (+) indicates a positive correlation with abundance, while (–) indicates a negative correlation.
[2] Akaike weight ($w_i$) represents the likelihood of a specific model, given the set of candidate models for each species. The sum of $w_i$ for each species' set of candidate models is 1.00.

For each small mammal and salamander species, the relationship between abundance and the habitat variable(s) in the best habitat model was in general agreement with the literature (see a review for each species in CDFG [2002]). One notable exception was the negative correlation between woodrat abundance and CWD. This relationship was much weaker than the positive correlation with shrub cover, however, as evidenced by the projected increase in woodrat abundance after SOD.

The abundances of the three mammal species were correlated with habitat features (shrub cover, CWD, tree density) that were substantially altered at the infected site, in a manner that would be beneficial for each species. We project that woodrats would benefit from an increase in "shrub cover," California mice would respond favorably to the large increase in CWD, and brush mice would benefit from lower tree densities. In contrast, the two salamander species may be relatively unaffected by the disease because their abundances were correlated with habitat features (litter depth, elevation) that were relatively or completely unchanged by SOD.

On a cautionary note, should SOD become established in San Luis Obispo County high-risk woodlands, the levels of some habitat variables (e.g., amount of CWD) would lie well outside the current range of values. As a result, our habitat models may be less applicable under future conditions. In addition, we note that the disease has been present at the infected site in the Bay Area for less than 10 years, so our results represent short-term wildlife responses. Long-term responses (e.g., over the next 50 years) are uncertain. Nonetheless, our results provide a basis for hypothesis development for future wildlife studies conducted in areas where SOD is present.

## References

Burnham, K.P. and Anderson, D.R. 2002. **Model selection and multimodel inference: a practical information-theoretic approach**. Second edition. New York: Springer; 488 pp.

California Department of Fish and Game (CDFG). 2002. **California Wildlife Habitat Relationships computer program, version 8.0**. Sacramento, CA: California Interagency Wildlife Task Group.

Griffith, B. and Youtie, B.A. 1988. **Two devices for estimating foliage density and deer hiding cover.** Wildlife Society Bulletin 16: 206-210.

Littell, R.C.; Milliken, G.A.; Stroup, W.W.; Wolfinger, R.D. 1996. **SAS system for mixed models**. Cary, NC: SAS Institute Inc.; 633 p.

Meentemeyer, R.; Rizzo, D.; Mark, W.; and Lotz, E. 2004. **Mapping the risk of establishment and spread of sudden oak death in California**. Forest Ecology and Management 200: 195-214.

Swiecki, T.J. and Bernhardt, E. 2005. **Disease risk factors and disease progress in coast live oak and tanoak affected by *Phytophora ramorum* canker (Sudden Oak Death).** This volume.

Tietje, W.D.; Tempel, D.J.; and Winslow, D.E. 2005. **Vegetation and small vertebrates of oak woodlands at risk for sudden oak death in San Luis Obispo County.** This volume.