Individual Legacy Trees Influence Vertebrate Wildlife Diversity in Commercial Forests[1,2]

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Key words: basal hollows, bats, small mammals, and birds, biodiversity, biological legacy, forest management, legacy tree, managed forests, northwestern California, redwood, Sequoia sempervirens, *wildlife communities*

Old-growth forests provide important structural habitat elements for many species of wildlife. These forests, however, are rare where lands are managed for timber. In commercial forests, large and old trees sometimes exist only as widely-dispersed residual or legacy trees. Legacy trees are old trees that have been spared during harvest or have survived stand-replacing natural disturbances. We define legacy trees as having achieved near-maximum size and age, which is significantly larger and older than the average trees on the landscape. This distinguishes them from other 'residual' trees, which may also have been spared from harvest but are not always larger and older than the average trees in the landscape. The value of individual legacy trees to wildlife has received little attention by land managers or researchers within the coast redwood *(Sequoia sempervirens)* region where 95 percent of the landscape is intensively managed for timber production.

We investigated the use of individual legacy old-growth redwood trees by wildlife and compared this use to randomly selected commercially-mature trees. This research was conducted during 2001 and 2002 in Mendocino County, California. At each legacy/control tree pair we sampled for bats using electronic bat detectors, for small mammals using live traps, for large mammals using remote sensor cameras, and for birds using time-constrained observation surveys. Legacy old-growth trees containing basal hollows were equipped with 'guano traps'; monthly guano weight was used as an index of roosting by bats. The diversity and richness of wildlife species recorded at legacy trees was significantly greater than at control trees (Shannon index = 2.81 vs. 2.32; species = 38 vs. 24, respectively). The index of bat activity was significantly greater at legacy trees compared to control trees ($F_{1, 45.7}$ = 17.66, P < 0.0001). There was a significantly greater number of birds observed (t = 16.6, P < 0.0001) and time spent (t = 4.05, P = 0.0004) at legacy trees compared to control trees. Woodpeckers, nuthatches, and some swallows were observed only at legacy trees. There was also twice as much foraging activity by birds at legacy trees

[1] An expanded version of this paper was presented at the Redwood Science Symposium: What does the future hold? March 15-17, 2004, Rohnert Park, California.

[2] This article was published in *Forest Ecology and Management* 193 (2004) 321-334, and can be viewed in full at: http://www.sciencedirect.com/science/journal/03781127

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compared to control trees. We found no statistical differences between legacy and control trees in the numbers of small mammals captured (t = 0.5, P = 0.62) or in the number of species photographed using remote cameras (S = 37.5, P = 0.10). Every basal hollow contained bat guano and genetic methods confirmed use by four species of bats. Vaux's swifts, pygmy nuthatches *(Sitta pygmaea)*, violet-green swallows *(Tachycineta thalassina)*, and the long-legged bat *(Myotis volans)* reproduced in legacy trees.

As measured by species richness, species diversity, and use by a number of different taxa, legacy trees appear to add significant habitat value to managed redwood forests. The use of legacy trees by wildlife was demonstrated by evidence of their nesting, roosting and resting; behaviors which were not observed at control trees. This value is probably related to the structural complexity offered by legacy trees. The presence of a basal hollow, which only occur in legacy trees, was the feature that appeared to add the greatest habitat value to legacy trees and, therefore, to commercial forest stands. Basal hollows were used by every taxa sampled, but appear to be particularly important to bats and birds. Because roost and nest availability can limit the populations of birds and bats, basal hollows may play a critical role in the redwood region if they provide roost and nest sites in forests that are otherwise deficient.

Our traditional view of conservation reserves is of large protected areas. However, few landscapes provide us with the opportunity to preserve large tracts of land and we must consider conserving biodiversity within the matrix of multiple use lands. Given the fragmented nature of mature forests in the redwood region, remnant patches of old-growth and individual legacy trees may function as 'mini-reserves' that promote species conservation and ecosystem function. Therefore, legacy trees may provide some measure of habitat connectivity ('stepping stones') to larger more contiguous tracts of old-growth forests. Because of their rarity in commercial forests, the first step in the management of legacy trees is to determine their locations and protect them from logging or from physical degradation of the site. Because legacy redwoods with basal hollows are even rarer, locating and protecting these should be the highest priority. In addition, the circumstances that lead to their genesis will be difficult to recreate, especially on commercial timberland. Hollows form by repeated exposure of the base of trees to fire, and because most fires on private land are suppressed, prescribed fire would need to be repeatedly applied to trees that would be designated as 'future legacies' and which would be excluded from harvest in perpetuity. Even without management to encourage basal hollows we suggest that managers plan for the recruitment of trees that are destined to become legacies. Although we do not believe that any one tree will protect a species, we do believe that the cumulative effects of the retention, and recruitment, of legacy and residual trees in commercial forest lands will yield important benefits to vertebrate wildlife and other species of plants and animals that are associated with biological legacies.

The results of our study beg us to consider habitat at a spatial scale that is smaller than that of habitat patches or remnant stands; we conclude that *individual trees* can have very important values to wildlife. More research would be helpful, however, to specify the level of individual tree retention required to maintain biodiversity in managed lands. It would help to know, for example, whether the fitness of individual species, and the diversity of wildlife communities, is greater in landscapes in which legacy trees are common compared to landscapes with very few legacy trees. It is possible that because legacy trees are rare—despite their apparent

values to wildlife— that they do not affect wildlife diversity or productivity over large areas. It would also advance our knowledge to determine whether legacy trees in legacy-rich landscapes can function to maintain connectivity between protected stands of mature and old-growth forests. If so, the landscape context will be an important component of managing residual legacy trees and planning their recruitment across landscapes. For now, however, this study makes clear that protecting legacy trees will protect important habitat features that receive disproportionate use by many wildlife species. The protection and management of these trees can enhance wildlife conservation on lands where the opportunities to do so can be limited.