Using Site-Specific Habitat Information on Young to Late-Successional Avifauna to Guide Use and Management of Coastal Redwood and Douglas-Fir Forest Lands[1]

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Abstract

Conservation of avifauna in coastal redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudosteuga menziesii*) managed forestlands has historically involved two opposing goals. First, landowners want to minimize restricted acreage in order to maximize commercial utilization of forest products. Second, poor scientific understanding of species habitat needs has often led to conservation strategies that are overly conservative, and therefore restrictive. One solution to this conundrum is to better define critical species habitat needs. The Pacific Lumber Company (PALCO) has been collecting data on a variety of avian species that require different levels of protection based on their conservation status and habitat needs. In this paper, we report on the specific habitat requirements of marbled murrelets (*Brachyramphus marmoratus*), golden eagles (*Aquila chrysaetos*), and Cooper's hawks (*Accipiter cooperii*). For each species, we examined the habitat characteristics surrounding nesting areas and compared them to random locations. We discuss how this research can be used in modifying species-specific conservation strategies.

Key words: avifauna, conservation, Cooper's hawk, Douglas-fir, golden eagle, habitat, marbled murrelet, redwood

Introduction

Land management and conservation of species has traditionally involved resource managers attempting to find compromise between competing, and even opposing interests. For threatened, endangered, or other critical species, management solutions often involve land restrictions or set-asides on public or private land, for example the Late Seral Reserves of the Northwest Forest Plan (USDA and others 1993), or the Marbled Murrelet Conservation Areas (MMCAs) of the PALCO Habitat Conservation Plan (HCP) (PALCO 1999).

Conservation solutions involving land restrictions or set-asides can result in the loss of economic use of private lands. As a result, the development, or negotiation of restrictions on the use of land for the benefit of species can be contentious. Decisions

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involving land use restrictions should be based on the best available scientific information (National Research Council 1995).

Unfortunately, there is often little scientific information available relevant to the specific habitat needs, or potential for disturbance to an individual species. Thus, habitat retention or seasonal buffers for species protection may be extremely conservative and restrictive for the landowner and may also be an inefficient conservation strategy. In addition, it is difficult to assess the efficacy of mitigation without feedback through effectiveness monitoring, or enhanced knowledge of a species habitat needs through surveys and habitat investigations. Therefore, in an attempt to address this ongoing conundrum, we conducted surveys, monitoring, and research on the habitat needs of various listed and other sensitive species over the last several years. In this paper we report on our research of the specific habitat requirements of marbled murrelets, golden eagles, and Cooper's hawks, and discuss how that research can be used to modify species-specific conservation strategies.

Study area and species

PALCO lands encompass approximately 87,817 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)*. For this study, we examined site-specific habitat information for species primarily associated with late successional habitat (marbled murrelet), mid-successional habitat (Cooper's hawk), and young successional habitat (golden eagle).

The marbled murrelet is a small seabird that nests in large trees. The marbled murrelet is listed federally as a threatened species in Washington, Oregon, and California, and is a California state endangered species. Within the study area, marbled murrelets have been primarily associated with old growth or late seral habitat and were most likely to be detected near old growth dominated by redwood (Meyer and others 2004, Stauffer and others 2004).

In 1999, PALCO entered into an agreement with the federal and state governments that included the sale of the Headwaters Forest, a large, un-entered old growth stand of murrelet habitat. This agreement also set-aside for 50 years approximately 3,237 ha of habitat and buffers in a series of MMCAs (PALCO 1999). The MMCAs not only included most of the remaining old growth murrelet habitat on PALCO lands, but also included large buffers of young growth with scattered old growth trees as a conservative measure for habitat retention. Murrelet nesting habitat in the MMCAs is currently protected from disturbance during the nesting season by 0.40 km radius buffers, containing approximately 36.4 km in which timber harvest operations and other land management is restricted for six months each year.

Golden eagles are a California Fully Protected Species, a California Species of Special Concern, and are federally protected under the Bald Eagle Protection Act. In the study area they are inhabitants of the interface of the Douglas-fir, hardwood, and prairie ecotypes. In these mountainous zones, they find suitable nesting substrate in predominant Douglas-fir trees, juxtaposed with large areas of suitable foraging habitat in prairies and young seral stage forest.

Although golden eagles have been extensively studied throughout much of their distribution, (for example, Watson 1997), relatively little is known about golden eagles in north coastal California. We started to extensively survey for golden eagles in 2002. During the breeding season (January to May or June), we conducted intensive stand searches covering >9,308 ha. Stand searches consisted of from four to five biologists traversing forest stands in a transect pattern, searching the forest floor, trees, and canopy for any sign of raptors and their nests. We also conducted ocular surveys from 178 observation stations covering >34,803 ha. Ocular surveys consisted of biologists positioned at prominent viewpoints on ridges and in watersheds conducting stationary surveys of the surrounding landscape with binoculars and spotting scopes. As a result of these efforts, we found eight previously unknown golden eagle nests on or near PALCO lands.

The Cooper's hawk is listed as a California Species of Special Concern whose breeding numbers are thought to have declined in recent decades. Nest site characteristics of Cooper's hawks in the coastal redwood region of northern California are not well known due to the scarcity of nests recorded in the region (Harris 1996). To our knowledge, our work is the first to explore Cooper's hawk nest site selection in the coastal redwood region. PALCO's surveys for other species (for example, northern spotted owls [*Strix occidentalis caurina*]), as well as follow-up stand searches conducted in response to incidental sightings, have led to the discovery of 27 Cooper's hawk nests representing 14 nesting territories, between 1999 and 2003.[6] Because little is known about the ecology of Cooper's hawks in our region there has been little information available on which to base nest protection measures.

Methods

For marbled murrelets, we used 21 confirmed nesting locations. These included 17 sites with eggshells on the ground, three actual nest sites, and one downed chick site. Across the landscape, we randomly selected 63 sites within old growth redwood forests to compare with habitat attributes of murrelet nesting locations. We used Geographic Information System (GIS) technology to describe the type and amount of old growth near each site, distance to nearest stream, and percent canopy closure at each site. We then conducted *t*-tests to compare habitat features between murrelet nesting sites and random sites.

For golden eagles, we collected plot information at eight nests at four spatial scales: 16 m, 0.85 km, 1.6 km, and 3.0 km radius plots. We measured diameter at breast height (d.b.h.) and tree height at the six 16-m plots. For the remaining spatial scales, vegetative types were grouped into foraging and non-foraging habitat, or nesting habitat. The foraging habitat included open ground, prairies, brush lands, scattered oak woodlands, and young forests <10 years old (Madders and Walker 2002, Watson and Whitfield 2002). Forests >10 years old were classified as nesting habitat. We then compared nest plots to 31 random plots. Each random plot was within potential golden eagle nesting habitat and ≥ 3.0 km from a known nest. There was no plot overlap. We conducted independent *t*-tests to compare nest and random plots.

[6] This information was gathered as a result of wildlife surveys of PALCO's forested stands from 1999 to 2003.

For Cooper's hawks, habitat variables were recorded at the most recently used nests in each nesting territory (n = 14). The nest site was defined as an 11.3 m radius (0.04 ha) plot centered on the nest tree. Variables recorded at the nest tree included: tree species, d.b.h., tree height (m), and crown percent (crown depth/tree height). Habitat variables recorded at nest sites included: mean canopy cover, tree height, crown percent, tree density, and understory height (m). Random points were selected that were within forested habitat containing trees ≥ 20.5 cm in diameter. Fifty points were generated and a subset of 14 were selected as site level vegetation plots for comparison as paired sites with the most recently used nest in each territory. A paired random site was between 1.6 and 3.2 km, from a nest site.

Again using GIS, we examined habitat level features surrounding the nest and random sites. These variables included: distance to water, edge, and road, stand area, and approximate stand age. We also examined the amount of habitat within different stand types and size classes within 61 m. This is the protection buffer required by CDFG during the breeding season (1 March to 31 August). We used t-tests to compare different structural characteristics and habitat features between nest and random sites.

Results

Several marbled murrelet nest site attributes differed significantly from random sites, suggesting that marbled murrelet preference for nesting habitat may be more specific than previously thought (for example, Evans Mack 2003). First, approximately twice as much un-harvested old growth forest surrounded nest sites than random sites *(table 1)*. Further, proportionally more nest sites (0.857 ± 0.076 *s.e.*) were within 500 m of residual old growth stands compared to 0.619 ± 0.061 of the random sites (G_1 = 4.54, P = 0.03). Proportionally more nest sites (0.714 ± 0.099) were in stands with ≥ 75 percent canopy closure than random sites (0.429 ± 0.062; G_1 = 5.28, P = 0.02), and nest sites were closer to a perennial stream (67 m) than random sites (121 m, t_{82} = 1.894, P = 0.06).

Table 1—*Mean (s.e.) ha of un-harvested old growth near marbled murrelet nesting and random sites.*

Distance from site	Nest	Random	*t*	*P*-value
100 m	2.2 (0.2)	1.3 (0.3)	-2.598	0.012
500 m	35.8 (3.8)	15.1 (7.1)	-2.752	0.008

All golden eagle nest trees were in live large Douglas-fir trees. On average, the d.b.h. of nest trees were greater (182.5 cm ± 18.1) than trees in random plots (27.1 ± 11.3, paired-t = 8.857, P = 0.000). Nest trees were also taller (67.9 m ± 5.1) than trees in random plots (19.4 ± 4.0, paired-t = 6.408 P = 0.001). Finally, across different spatial scales, nest plots on average contained 31 percent more foraging habitat than the random plots *(table 2)*.

New Cooper's hawk nests were within 125 m of the previous year's nest and all nine nesting territories receiving more than one visit in the years following nest discovery were reoccupied in subsequent years. All Cooper's hawk nests were in live trees, 57 percent in hardwood, 29 percent in Douglas-fir or Grand fir *(Abies grandis)*, and 14 percent in redwood. The d.b.h. of nest trees ranged from a 25.4 cm grand fir to a 116.8 cm redwood with a mean of 51.1 cm. The mean d.b.h. and height of hardwood nest trees was significantly greater than random, and nest trees also had significantly shallower crowns than random trees *(table 3)*. At the nest site scale (11.3 m from nest tree), Cooper's hawks selected even-aged, mid-seral sites containing larger diameter hardwoods, taller trees with shallow crowns, and a tall understory *(table 4)*. The nest sites were also twice as far from roads as random sites *(table 4)*. Within 61 m of a Cooper's hawk nest, there were three times more hardwood (0.55 ha) than random sites (0.17 ha, U = -2.719, P = 0.007) and there was significantly less conifer-dominated habitat (0.61 ha) compared to random sites (1.00, U = -2.699, P = 0.007).

Table 2—*Mean (s.e.) ha of foraging habitat around golden eagle nest (n = 6), and random sites (n = 31).*

Distance from site	Nest	Random	*t*	*P*-value
0.85 km	81.6 (10.1)	52.9 (5.7)	2.325	0.026
1.60 km	324.7 (44.7)	220.0 (19.2)	2.386	0.022
3.00 km	1072.3 (87.2)	811.1 (45.8)	2.599	0.013

Table 3—*Mean (s.e.) values of tree characteristics at Cooper's hawk nests (n = 14) and random trees (n = 14).*

Characteristic	Nest	Random	*t*	*P*-value
Nest tree height - hardwood (m)	25.0 (1.0)	12.1 (1.4)	7.698 [1]	0.000
Nest tree height - conifer (m)	29.0 (3.9)	33.2 (5.8)	-0.551 [1]	0.564
d.b.h. - hardwood (cm)	46.7 (2.8)	27.4 (8.1)	2.523 [1]	0.027
d.b.h. - conifer (cm)	57.2 (13.5)	49.0 (8.9)	0.505 [1]	0.623
Crown percent	29.1 (3.4)	49.2 (5.3)	-3.322 [2]	0.006

[1] Independent sample *t*-test
[2] Paired *t*-test

Table 4—*Mean (s.e.) values of habitat characteristics at Cooper's hawk within 11.3 m of nest sites (n = 14), and random sites (n = 14).*

Characteristic	Nest	Random	*t*	*P*-value
Tree height (m)	27.8 (2.0)	21.7 (2.5)	2.635	0.021
Crown percent	34.3 (3.6)	53.97 (6.1)	-2.743	0.017
Understory height (m)	8.7 (1.5)	5.6 (1.0)	2.077	0.062
Hardwood density (trees/ha >28-cm d.b.h.)	266.4 (128.4)	61.8 (21.8)	2.164	0.050
Distance to road (m)	191.4 (41.4)	87.1 (19.3)	2.159	0.050

Discussion

Due to the extreme difficulty in locating marbled murrelet nests, most of the information on marbled murrelet inland nesting habitat is based on presence/absence information obtained from audio-visual surveys in old growth and residual old growth forests. However, these surveys are designed simply to categorize old growth forests as 'nesting' or 'non-nesting' murrelet habitat (Evans Mack and others 2003), and not designed to assess relative suitability of old growth forests for nesting (reviewed by Lank and others 2003).

Clearly, not all old growth forests are equally suitable for nesting marbled murrelets. In southern Humboldt County, marbled murrelets selected nesting habitat that had proportionally more un-harvested old growth, a closed canopy, and near streams. In contrast, scattered residual old growth was not selected. These results were consistent with the findings of other studies that compared nesting sites (located by radio telemetry) to randomly generated points on the landscape (reviewed by Lank and others 2003). Although radio telemetry has been considered the most rigorous and unbiased method for locating murrelet nest sites, our results demonstrate the value of using data from opportunistic nest and eggshell findings to investigate habitat selectivity.

These results have important implications for the conservation and management of marbled murrelet nesting habitat in the region. Relative to landowner regulation, murrelet habitat is categorized as nesting or non-nesting habitat based on the results of audio-visual surveys. Those stands classified as nesting, or "occupied" have essentially been given equal conservation value when, in reality, scattered residual old growth stands appear to actually have less nesting value. Results from this study support ranking old growth forest stands in terms of nesting suitability, thereby providing a scientific basis for development of a range of conservation strategies. For instance, an un-harvested old growth stand with a dense canopy near perennial streams may be more suitable for nesting than an open canopy residual old growth stand relatively far from a stream. The un-harvested stand may justify a high level of protection, while more permissive strategies may be appropriate for the scattered, open canopy stand. Interestingly, such a ranking is consistent with regulatory approaches for riparian management, and in some cases may reduce the complexity associated with selecting lands to set aside for murrelet conservation.

Although much is known about golden eagles in other regions or countries this is the first study to investigate habitat relationships in coastal northern California. We found that golden eagles need a large, predominant tree for a nest platform. Similar to our results, Menkens and Anderson (1987) found that tree nesting golden eagles selected one of the largest trees in the stand in both d.b.h. and height.

In terms of foraging habitat, we found that golden eagles select nesting sites that have ample foraging habitat within their nest territory to provide prey for eaglets *(table 2)*. Our results are similar to those in other golden eagle studies, where others have found that open ground for foraging can be a limiting factor, especially in managed forests. For example, McGrady and others (2002) and Madders and Walker (2002) found that eagles prefer areas that are open rather than timbered, and some of their research has shown a correlation between a decrease in breeding success with an increase in afforestation (Watson 1997, Whitfield and others 2001). McGrady and others (1997) noted that golden eagles generally avoid plantation forests because they were probably unable to hunt prey amongst the closely spaced trees. In fact, Bruce and others (1982) found that all 21 nests studied in western Washington were located within 500 m of a clearcut or open field.

In summary, we found: 1) several previously unknown nests of this species, 2) nesting on managed forestland, and 3) extensive foraging habitat surrounding the nests. Thus, considering our results, and the findings of others, we conclude that timber harvesting can be compatible with golden eagle habitat management, as long as seasonal disturbance minimization measures are used during the critical period for nesting golden eagles, and scattered predominant trees are retained for nest structures. Furthermore, given the importance of early seral patches to golden eagle foraging, a decreased timber harvest cycle, and/or an aggressive afforestation policy could actually decrease the overall suitability of habitat for golden eagles on managed lands.

In the coastal redwood region Cooper's hawks selected densely vegetated, even-aged, mid-seral stands that contained tall trees with shallow crowns and a relatively open understory. Most were located in areas where hardwood (for example, tanoak) was the dominant component or comprised a large portion of the stand. Similar nest site structural characteristics have been reported by others (for example, Bosakowski and others 1992, Garner 1999, Reynolds and others 1983). Interestingly, in the redwood-dominated nest stands that did not contain many hardwoods, the birds usually selected either grand or Douglas-fir, rarely selecting redwood as the actual nest tree (2 of 27 nests). Three nests (all in different territories) were located within timber harvesting plans. The CDFG recommends that a 61 m disturbance buffer be established around nest trees during the breeding season. However, after site-specific evaluations of two of the nesting territories it was decided to establish larger buffers around the nest trees to ensure that the core nesting territories were protected. Habitat buffers established included key elements such as the current and previous year's nest trees, roost trees and plucking areas. We also utilized riparian management zones and other species (for example, northern spotted owl) protection buffers to ensure that the nest area was not isolated from adjacent forested habitat.

As found in this and other studies (Jones 1979, Rosenfield and Bielefeldt 1996, Rosenfield and others 1995), Cooper's hawks exhibit strong nest stand reoccupancy. Our results indicate that the establishment of small, yet well-defined habitat buffers should enable the Cooper's hawk to return to their nesting territories in subsequent years, maintaining a balance between timber harvesting and protection for this non-listed species across the managed landscape.

Conclusions

This study is based on habitat associations, and not on cause and effect data. However it does demonstrate important considerations for management of marbled murrelets, golden eagles, and Cooper's hawks that could lead to further testing of habitat hypotheses. For example, based on direct evidence of nesting, murrelets appear to select old growth forest stands with high amounts of canopy closure. The conservation strategy of the PALCO HCP to include in set-asides virtually all occupied murrelet stands based on audio-visual surveys, whether old growth or residual old growth, may have been overly conservative. In addition, this strategy has resulted in hardship to the landowner in terms of restrictions on activities during the harvest season, and lost opportunities for harvest in stands of marginal or non-nesting habitat.

For golden eagles, our investigations into the habitat needs of the species led to a modification of survey area and strategy. The development of the modified strategy has resulted in a more reasonable approach for the landowner in terms of resources involved in surveys, and a reduction in areas seasonally restricted for harvesting activities. Lacking good data, the original conservative survey area was too broad-based, and overly restrictive. Data from this study are useful in refining management guidelines for this species, including information for maintenance of suitable nesting habitat.

For the Cooper's hawk, our results indicate that a conservation strategy for this species can be compatible with timber management. Based on our observations, site-specific protection can be developed by including key elements of nest territories in habitat buffers that incorporate riparian management zones and possibly other species buffers. In addition, retention of habitat components such as large hardwood trees appears important to maintaining Cooper's hawks on the managed landscape.

Finally, the results of this study also have implications for further research and monitoring for these and other species. For example, predictive modeling of habitat using GIS and forest growth models may be based on the habitat information provided in this study so that land managers can evaluate future harvest planning for the potential to impact species, and to develop methods to conserve important habitat areas.

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