RELATIONSHIP OF MARBLED MURRELETS WITH HABITAT CHARACTERISTICS IN REDWOOD FORESTS IN NORTHWESTERN CALIFORNIA

Sherri L. Miller *C. John Ralph*[1]

Abstract: We compared the relationships of Marbled Murrelet *(Brachyramphus marmoratus)* behavior with habitat and landscape characteristics in isolated old-growth and residual redwood forest stands from 2 to 400 ha in Redwood National and State parks. In isolated stands we found both higher murrelet detection levels a nd what we consider breeding behavior in stands with higher overall tree crown cover and higher proportion of coast redwood. Density of old-growth trees and tree species composition may be the strongest predictors of murrelet presence a nd occupancy in redwood forests. In the large park stands, we found that both detection levels and the number of stations with breeding behavior were highest in the major drainages and at lower elevations Major ridges tended to have lower levels of both variables.

Introduction

The Marbled Murrelet is a small. dove-sized seabird inhabiting coastal forests from Alaska to California. In recent years. much has been learned about its occurrence at inland forest sites. Throughout most of its range. the murrelet nests in old-growth forests within 50-75 miles of the coast (Ralph et al. 1995). In California, Paton and Ralph (1990) conducted general surveys to determine the distribution of murrelets and found- concentrations in regions containing large, contiguous. unharvested stands of old-growth coast redwood *(Sequoia sempervirons),* mostly within state and federal parks, with the highest detection numbers in stands >250 ha. in excess of 200 detections for single-survey mornings have been recorded at some survey stations in remaining unharvested stands within parks in California, including Redwood National Park and Prairie Creek State Park in Humboldt County; and Big Basin State Park in San Mateo County.

The Marbled Murrelet is currently classified as threatened or endangered in Washington, Oregon, California, and British Columbia by federal, state and provincial resource agencies. The recent listings have created a need for information about the role of habitat and landscape features for the bird.

We compared the relationships of murrelet behavior with habitat and landscape characteristics in old-growth and residual redwood forest stands from 2 to 400 ha in Redwood National and State parks and in isolated stands in fragmented landscapes of private landowners. In the large contiguous park stands of old-growth forest, we examined the number and type of murrelet detections by station elevation and topography. In the isolated stands. We examined the relationships of murrelet detection levels and murrelet behaviors to stand size, shape. distance from salt water. and vegetation characteristics.

Methods

Surveys methods followed the intensive survey protocol of Ralph et al. (1992). In the large park stands, surveys were positioned in a matrix of stations 400 m apart. We surveyed all sections of park stands with adequate accessibility. In the isolated stands. each individual forest stand was surveyed four times to determine with a 95% probability that murrelets were present (Miller and Ralph 1995). If below canopy behaviors were observed. we categorized the stand or station as "occupied" for analyses. We consider stands with occupied behavior to have breeding murrelets present.

For large park stands, elevation and position of each station on the landscape were estimated from topographic maps. Landscape position was described as one of five categories: (1) in the bottom of a major drainage: (2) in the bottom of tributary (or minor) drainage; (3) on top of a major ridge: (4) on top of a minor ridge: and (5) on a general slope, a station not on a ridge nor in a drainage.

Results

Isolated Stands

Potential study stands were characterized as residual or old-growth, with trees greater than 90 cm DBH. greater than 20 percent canopy cover of dominant and co-dominant trees, less than 40 km from the coast, elevation of less than 1.000 m, and dominated by coast redwood or Douglas-fir *(Pseudotsuga menzeisii).* We identified 286 potential study stands in Del Norte, Humboldt, Trinity, San Mateo, and Santa Cruz counties meeting the criteria in

[1] Wildlife Biologist and Research Wildlife Biologist. USDA Forest Service Redwood Sciences Laboratory, 1700 Bayview Drive. Arcata, California 95521

each of four size categories: 2 to 20 ha (n = 184); 21 to 40 ha (n = 39); 41 to 100 ha (n = 35); and > 100 ha (n = 28). Stands were randomly selected from the smallest size category. We located few stands > 21 ha; therefore, we surveyed all accessible stands in those categories. From these potential study stands, we selected and surveyed 152 stands as follows: 2 to 20 ha (n = 86); 21 to 40 ha (n = 22); 41 to 100 ha (n = 23): >100 ha (n = 21).

We used multiple regression analysis to examine the relationship between mean detection levels (standardized for seasonal variation) and the shape and vegetation characteristics of the stands. Density of the combined dominant and codominant tree cover and presence of redwood trees were significantly ($F_{0.05}$ = 2.428, df_{model} = 10, P = 0.0105, R^2 = 0.1625) related to mean murrelet detection levels in the model. Higher murrelet detection levels were found in stands with >50% coast redwood and higher dominant and codominant crown cover. Contrary to previous studies, we did not find that larger stands were more likely to have murrelets present.

For each stand we summarized the detections and behaviors for all surveys conducted during the study to determine the status of the stand. If no murrelets were detected during any of the surveys, then the status was "Undetected." Stands with murrelet detections were assigned a status of "Present"; or if occupied behaviors were observed. a status of "Occupied."

Using logistic regression with maximum likelihood analysis of variance. we examined the relationship between a selection of independent variables and status. The model included density of old-growth (both dominant and co-dominant species) tree cover, tree species, and stand size as variables explaining the differences between sites with no detections and those with murrelets present. Stands with higher density classifications. and with redwood as the dominant tree species. were more likely to have murrelets present. We also found a minor effect of smaller stands increasing the likelihood of murrelet presence. Using these variables accounts for virtually all of the variability in the model. We found. however, no significant effect of stand size on the status of murrelets (Undetected, Present, or Occupied) in the stands, when tested by Chi-square contingency table (df = 6, χ^2 = 3.294, P = 0.7721).

For stands with a status of Occupied (n = 37). compared with all Unoccupied stands (n = 115), old-growth tree density and tree species were significant variables (Table 1) for predicting observations of occupied behaviors. We also found that surveys were more likely to detect occupied behaviors at stands with higher crown cover and a greater proportion of redwoods.

Large Contiguous Stands

Northern California

We surveyed 352 stations in the 8 stands within northern California parks. We found that topography had a major influence on murrelet use (P < 0.0001). The mean detection levels were three times higher in major drainages (Table 2) than on the major ridges.

The proportion of Occupied stations was significantly higher at stations of less than 100-m elevation, than at stations >200 m (P < 0.0001). The proportion of stations with no detections was significantly higher in the >300 m category and significantly lower in the <100 m category.

Central California

Big Basin Redwoods State Park in Central California was surveyed in a matrix of 37 survey stations. The elevation ranged from 240 to 500 m, and we divided stations into four equal categories. We found the mean detection levels and the number of Occupied stations higher for stations in lower elevation categories. The proportion of Occupied stations was not significantly-different (P > 0.05) among topography categories. Occupied behaviors were observed in all topography categories, and the only station with a status of Undetected was on a major ridge.

Discussion

Stand Study

The most-important factor in indicating Occupied stands was density of the old-growth cover, that is, the percent of the area covered by the crowns of old-growth trees. Occupied stands had a higher percentage of old-growth cover than stands with murrelets only present, or in stands with no detections. These relationships are consistent with those found in Oregon (Grenier and Nelson 1995) and Washington (Hamer 1995).

We found the presence of redwood as the dominant tree species to be a factor for predicting higher mean detection levels and stand occupancy. Within the range of our study. stands dominated by Douglas-fir often were in drier areas with higher summer temperatures. Sites very close to the coast, within one mile, often are dominated by Sitka spruce (*Picea sitchensis*) and Douglas-fir and, for unknown reasons, also lack murrelets.

Contrary to previous studies. we did not find larger stands more likely to have murrelets present or to be

Table 1--Results of logistic regression analysis for stands in California (n = 152) with status of Occupied (n = 37) and stands with murrelets Present or Undetected (Unoccupied)(n = 115). Only variables with significant contribution to the model are presented

Variable	Regression coefficient	Chi-square	Chi-square probability
Tree Species[1]	1.9243	5.86	0.0155
Cover density[2]	1.0831	6.64	0.0100

[1] Coast redwood (*Sequoia sempervirens*) or Douglas-fir (*Psuedotsuga menziesii*) >50% of stand.
[2] Percent dominant and codominant tree cover.

Table 2--For northern California: Summary of detections[1] and status of Marbled Murrelet stations surveyed in old-growth forests within the state and national parks during the summer, 1933

Landscape var.	Mean Number of detections[2]	s.d.	Number of stations: Range	Occupied	Presence	Absence	Total
Topography							
Tributary drainage	22	33	0-134	18	19	54	91
Major drainage	30	28	0-140	67	25	17	109
General slope	14	17	0- 83	40	67	22	129
Minor ridge	16	19	0-107	19	29	18	66
Major ridge	10	13	0- 51	14	27	6	47
Elevation							
21-100 m	28	30	0-160	83	53	27	163
101-200 m	16	18	0- 83	46	66	36	148
201-300 m	12	13	0- 56	19	37	19	75
301-500 m	4	6	0- 22	10	11	18	39

[1] Includes only detections within 100 meters of observer

[2] Standardized detections

occupied. Other factors. such as stand history and juxtaposition to other old-growth stands may mask the effects. if any of stand size on murrelet presence and use.

Although we did not find a significant relationship between distance from the ocean and murrelet detections or behaviors, this possibly was related to the limited range of distances for stands surveyed for the study. We have examined all surveys conducted from 1988 through 1992 and found a strong pattern of declining murrelet presence with distance from the coast. The number of stations more than 40 km inland with murrelet detections was only about 2 percent. Current studies at inland stands in California have increased the sample of stations located in potential habitat over 25 km from the coast and results continue to indicate that few murrelets are nesting at these distances in California.

It is unlikely that one factor alone will best describe murrelet habitat. Density of old-growth cover and species composition are included as important factors in more than one analysis. These variables may be the strongest predictors of murrelet presence in California.

Large Contiguous Stands

Within the large stands of old-growth in the parks, most stations with observations of occupied behaviors occurred in the major drainages and, correspondingly at low elevations. Occupied behaviors were observed at 69 (73 percent) of the 95 stations in the major drainages. Trees in these drainages tend to be larger and experience less limb breakage from wind. Both of these factors could contribute to larger diameter branches and more potential nest platforms.

Literature Cited

Grenier. J.J., S.K. Nelson. 1995. Marbled Murrelet habitat associations in Oregon. pp 191-204, in Ralph. C.J., G.L. Hunt. Jr., M.G. Raphael. J.F. Piatt. Eds). Ecology and Conservation of the Marbled Murrelet. Gen. Tech: Rep. PSW-152. Albany, CA: Pacific Southwest Research Station. Forest Service. U. S. Department of Agriculture.

Hamer, T.E. 1995. Inland habitat associations of Marbled Murrelets in western Washington. pp 163-l75. *in* Ralph, C.J., G.L. Hunt, Jr., M.G. Raphael. J.F. Piatt. (Eds). Ecology and Conservation of the Marbled Murrelet. Gen. Tech. Rep. PSW-152. Albany, CA: Pacific Southwest Research Station. Forest Service, U.S. Department of Agriculture.

Miller, S.L., C.J. Ralph. 1995. Relationship of Marbled Murrelets with habitat characteristics at inland sites in California. pp. 205-218. in Ralph. C.J., G.L. Hunt, Jr., M.G. Raphael, J.F. Piatt. (Eds). Ecology and Conservation of the Marbled Murrelet. Gen. Tech. Rep. PSW-152. Albany, CA: Pacific Southwest Research Station, Forest Service. US. Department of Agriculture.

Ralph, C.J., G.L. Hunt, Jr., M.G. Raphael, J.F. Piatt. 1995. Ecology and conservation of the Marbled Murrelet in North America: An overview. pp. 3-22 in Ecologv and Conservation of the Marbled Murrelet. Gen. Tech. Rep. PSW-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Ralph. C.J., S.K. Nelson. 1992. Methods of surveying Marbled Murrelets at inland forested sites. Pacific Seabird Group, Bulletin #1. Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, Oregon.

Paton, P.W.C., C.J. Ralph: 1990. Distribution of the Marbled Murrelet at inland sites in California. Northwestern Naturalist 71: 72-84.