DISTRIBUTION OF THE MARBLED MURRELET AT INLAND SITES IN CALIFORNIA

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ABSTRACT-We conducted transect surveys from the Oregon border to Monterey County in 1988 and 1989 to determine the distribution of marbled murrelets (*Brachyramphus marmoratus*) at inland sites in California. This seabird uses the coastal redwood (*Sequoia sempervirens)* forests of the northern half of California, but little is known of its distribution away from the ocean. We identified potential inland habitat from remote sensing data and then conducted systematic surveys of forest stands based on this inventory.

Murrelets were detected on 74 of 170 (44%) transects, with a patchy distribution concentrated in three regions in Del Norte, Humboldt, San Mateo, and Santa Cruz Counties: (1) east of Crescent City to Redwood Creek in Redwood National Park; (2) lands east of Humboldt Bay to Humboldt Redwoods State Park on the Eel River; and (3) state parks in southern San Mateo and northern Santa Cruz Counties. The primary habitat type where birds were detected was old-growth dominated forest, with 1.05 detections/station, compared to 0.02 detections/station on second-growth transects. Transects with high activity levels tended to be in or west of old-growth stands ≥ 250 ha. The farthest inland we observed murrelets was 39 km from the coast.

The marbled murrelet (*Brachyramphus marmoratus*) is unique among the alcids, as it is the only species which nests in trees. As of January, 1990, seven tree nests have been found, four in North America (Binford et al. 1975; Quinlan and Hughes 1990; Singer et al., 1990) and three in Asia (Kuzyakin 1963; Nechaev 1986; Labzyuk 1987). Research prior to 1984 focused primarily on their distribution and abundance at sea (Sowls et al. 1980; Sealy and Carter 1984; Carter 1984), breeding biology (Sealy 1974, 1975a; Simons 1980; Day et al. 1983; Hirsch et al. 1981), and feeding ecology (Sealy 1975b). At inland sites, murrelets are detected as they fly over and into forested stands. Censuses conducted in 1984-1986 by the U.S. Forest Service found murrelets at several inland localities in Oregon (K. Nelson, pers. comm.) and California (Paton et al., in press). Stationary counts in 1987 in northern California quantified their daily and seasonal activity patterns at several forested sites (H. Carter and T. Sander, pers. comm.).

In California, murrelets spend most of their time offshore, but occur inland throughout the year. Observations at inland forested areas peak from May to August, during the breeding season (Carter and Erickson 1988; Paton and Ralph 1988). Reasons for their use of inland sites during winter are not known; roosting or investigating nest sites are possibilities. Detection rates are highest near sunrise, with most observations between 30 min before and 30 min after sunrise (Paton and Ralph 1988). Both the male and female incubate, taking 24 hr shifts on the nest and switching in the morning (Naslund et al., 1990). Flock size of flying birds at inland sites is generally small, with single birds and pairs accounting for 85% of the observations (Paton and Ralph 1988). Marbled murrelets have a distinctive call that can be heard up to 300 m away. Birds tend to be vocal, with 30% of calling birds giving one to three notes, while 30% give >9 notes in succession. Birds flying silently are common, accounting for 40% of the detections at one of the most active stands in California (Paton and Ralph 1988). The flight characteristics and silhouette of silent birds are diagnostic if the observer has a clear view of the bird. The activity and behavioral patterns of this species make surveys possible to determine distributional patterns.

In California, the evidence points to this species nesting primarily in old-growth redwood (*Sequoia sempervirens*) dominated forests (Sowls et al. 1980; Carter and Sealy 1987; Carter and Erickson 1988; Paton and Ralph 1988). Less than 10% of the original 770,000 ha of old-growth redwood remain, a result of harvesting since the early 1800's (Fox 1989). The status and continued health of the California population may depend on these remnant forests (Marshall 1988). Despite the apparent loss of most of the potential murrelet nesting habitat in the state, only a few surveys had been conducted at inland sites prior to this study.

Our primary objectives were to: (1) determine the inland distribution of marbled murrelets in California, and (2) describe the habitat characteristics of the areas surveyed. This field work was designed to determine activity centers for further research to find nests.

STUDY AREA AND METHODS

The study area included state, federal, and private forested lands from the Oregon border south to Monterey County (Figs. la-c). We surveyed up to 40 km from the ocean, although murrelets are known to visit locations as far inland as 75 km in British Columbia (Carter and Sealy 1986). Our study area is varied topographically, but is primarily mountainous with scattered rivers, streams, and lagoons. The forests are dominated by redwoods, although Douglas-fir (*Pseudotsuga menziesii)* is the dominant species in certain locations.

In order to identify potential stands to survey, we collaborated with Dr. Lawrence Fox of Humboldt State University, who had mapped the distribution of the redwood forests in California using remote sensing techniques (Fox 1989). Maps were based on 2 April 1986 aerial photos taken from U2 flights at 19,800 m. Habitat types delineated included stands dominated by: (1) old-growth redwood; (2) old-growth redwood/Douglas-fir; (3) second-growth redwood; and (4) young/clearcut redwoods. We defined old-growth following Franklin et al. (1986) as stands having at least 20 trees/ha in excess of 80 cm diameter-at-breast-height (DBH) and containing a multi-layered canopy.

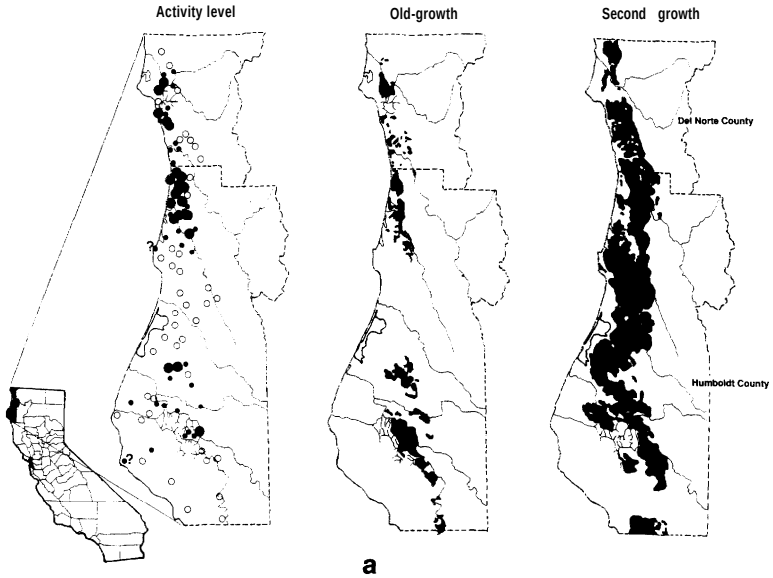
We surveyed 127 transects in 1988 and 43 other transects in 1989, attempting to census both old-growth and second-growth forests throughout the study area. The census period corresponded to the peak of murrelet activity at inland sites, 15 May to 15 August, and followed the protocol of Paton et al. (1990). We established 8 to 12 fixed stations along each transect. Depending upon conditions, spacing between stations was 250 m along trails, 500 m along rough roads, and 1 km on paved roads. Counts were conducted from 45 min before to 1.5 hr after official sunrise (Supplement to the American Ephemeris 1944). Each transect was visited at least twice, with the order of stations reversed. Stations were surveyed for 10 min on each visit, with observers standing silently in place, scanning the sky while listening for birds. No tape recordings were used to elicit calls from birds. We tried not to census transects at less than 2 wk intervals to minimize the effects of weather and monthly differences in detection rates. Observers were trained by taking them to inland sites with high murrelet activity to familiarize them with murrelet calls and flight characteristics. All observers were provided with a tape recording of various murrelet vocalizations.

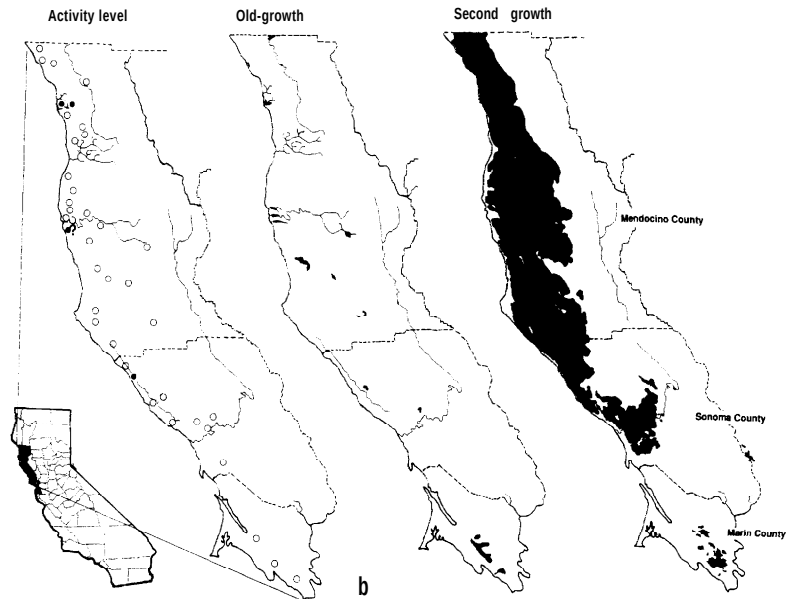
The basis of the survey was the rate of "detection." A detection was defined as seeing or hearing a single bird or a group birds flying together in the same direction (Paton et al., 1990). We do not know the relationship between the number of detections and the number of birds using a stand. However, we feel that detections can be used as an index of murrelet activity levels to compare among stands at the same time of year.

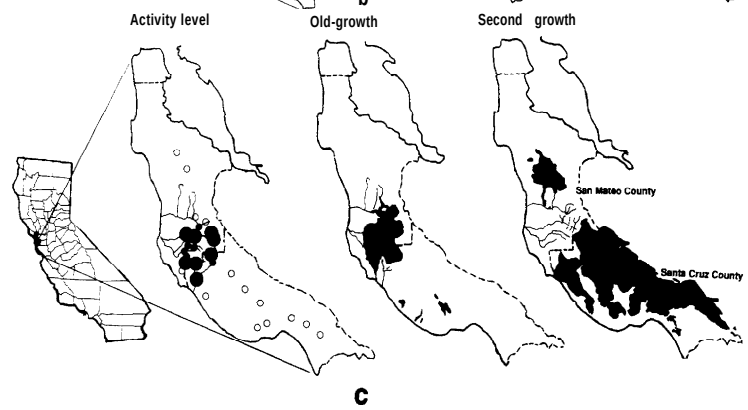
Analyses

We divided the data into three categories to compare murrelet detection rates among transects: no, moderate, and high activity. Categories were based on the mean number of detections per station. We assumed transects with no detections had either no murrelets or very low murrelet activity levels, transects with a mean of <1 detection/station indicated moderate activity levels, and transects with a mean of ≥ 1 detection/station had relatively high activity levels.

To quantify the vegetation near stations, we used the Fox (1989) forest stand map. A 500 m radius circle was centered on each transect station. We then determined the amount of old-growth and second-growth in the east half of the circle. Each half-circle was assigned a habitat designation based on which age class accounted for $>50\%$ of the area. We assumed that murrelets observed at


Activity level
Old-growth
Second growth
Del Norte County
Humboldt County
a


Activity level
Old-growth
Second growth
Mendocino County
Sonoma County
Marin County
b


Activity level
Old-growth
Second growth
San Mateo County
Santa Cruz County
c

a census station were headed to, or from, a nest or roost site farther east. We then classified transects into one of three classes: (1) old-growth with ≥70% of the stations dominated by old-growth forests; (2) mixed age with >10% to <70% of the stations dominated by old-growth forests (these transects were generally on fragmented timber company lands); and (3) second-growth with <10% of the stations dominated by old-growth forests. Analysis of variance (ANOVA) was used to test the null hypothesis of no difference in detection rates between the three classes of transects.

We also measured the DBH (±10 cm) of the closest 10 canopy trees <50 m from the station. The trees we measured represented samples from the dominant basal area size class of the stand. We used ANOVA to test for differences between the size of trees near transects of low, moderate, and high use.

RESULTS

Surveys were conducted on 377 mornings on 170 transects, with a total of 3697 10-min counts at 1735 stations (Appendix). Birds were detected on 74 (43.5%) of the transects, with a mean detection rate of 0.56/station (2070 detections at 3497 stations). Three transects had single detections where the observer was not positive the bird heard (or seen) was a murrelet: Patrick's Point and Mill Creek in Humboldt County, and Russian Gulch State Park in Mendocino County.

Inland Murrelet Distribution

The inland distribution of murrelets in northern and central California was patchy (Figs. 1a-c), with three areas of concentration: (1) east of Crescent City south to Redwood Creek in Redwood National Park; (2) east of Humboldt Bay to Humboldt Redwoods State Park on the Eel River; and (3) state parks in southern San Mateo and northern Santa Cruz Counties. San Mateo County had the highest percentage of transects with detections, 10 of 15 (67%). We found progressively lower rates in Del Norte, 15 of 25 (60%); Humboldt, 40 of 78 (51%); Santa Cruz, 4 of 13 (31%); Sonoma, 1 of 9 (11%); Mendocino, 3 of 27 (11%); and Marin, 0 of 3 (0%), Counties.

Ownership of areas where murrelets were found included both public and private lands. The majority of stands used by murrelets occurred in California state parks and Redwood National Park. State parks had a mean detection rate of 0.99/station (1110 at 1121 stations), National Parks had 1.00/station (520 at 518 stations), U.S. Forest Service lands had 1.13/station (216 at 192 stations), private commercial timberlands had 0.22/station (144 at 646 stations), and lands of mixed private ownership had the lowest detection rate of 0.07/station (80 at 1220 stations).

Areas with high activity levels included: in Del Norte County-Jedediah Smith Redwoods State Park and Del Norte Redwoods State Park; in Humboldt County-Prairie Creek Redwoods State Park, Redwood National Park, Grizzly Creek Redwoods State Park, Pacific Lumber Company lands, and Humboldt Redwoods State Park; in San Mateo County-Butano State Park, Portola State Park, and San Mateo Memorial County Park; and in Santa Cruz County- Big Basin Redwoods State Park.

The only private commercial timberlands with high detection rates were stands owned by The Pacific Lumber Company southeast of Humboldt Bay. Moderate activity levels

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FIGURE 1a. Activity levels of marbled murrelets in Del Norte and Humboldt Counties. Open circles represent transects with no detections, small solid circles had moderate numbers of detections (<1 detection per 10 min census station), and large solid circles had high numbers of detections (≥1 detection per station). The distribution of old-growth and second-growth redwood dominated forests is also shown (Fox 1989).

FIGURE 1b. Activity levels of marbled murrelets and the distribution of old-growth and second-growth redwood dominated forests in Mendocino, Sonoma, and Marin Counties.

FIGURE 1c. Activity levels of marbled murrelets and the distribution of old-growth and second-growth redwood dominated forests in San Mateo and Santa Cruz Counties.

TABLE 1. Land area (ha) by forest classification summarized for three regions in northern California (Fox 1989). The Northern region includes Del Norte and Humboldt Counties, the Middle region includes Mendocino and Sonoma Counties, and the Southern region includes Marin, Napa, Alameda, San Mateo, Santa Cruz, Santa Clara, and Monterey Counties.

Region class	Forest classification			Total	Overall % by region
	Old-growth	Second-growth	Other habitat		
Northern					
Area (% by type)	58,078 (17)	262,744 (78)	16,360 (5)	337,181	38
% by region	69	36	30		
Middle					
Area (% by type)	7419 (2)	364,266 (92)	24,743 (6)	396,429	45
% by region	9	49	45		
Southern					
Area (% by type)	18,743 (13)	112,553 (78)	13,709 (9)	145,005	17
% by region	22	15	25		
Total area	84,240	739,564	54,811	878,615	100
Overall.					
% by type	10	84	6		

occurred on Simpson Timber Company lands north of the Klamath River in Del Norte County, especially along the Wilson Creek drainage. The other large tract of private timberland we surveyed was owned by Louisiana-Pacific. This area east of Trinidad had a few detections at stations west of old-growth stands in Redwood National Park.

We found no birds over extensive areas of Mendocino, Sonoma, and Marin Counties on 43 transects, with four exceptions (Stewart's Point, Usal Road, Hales Grove, and Russian Gulch State Park). The Hales Grove and Usal Road observations were near Westport State Park where three murrelets in breeding plumage were observed offshore on 22 July 1989 (D. Tobkin, pers. comm.). Murrelets have been seen inland near Russian Gulch State Park (Carter and Erickson 1988; Paton and Ralph 1988).

Habitat Relationships

The mean detection rate was greatest in forested areas dominated by old-growth, with 1.05/station (SE = 0.074, N = 1669 stations on 71 transects). Mixed age transects had 0.18/station (SE = 0.039, N = 693, 34 transects), while second-growth transects had the lowest detection rate of 0.02/station (SE = 0.006, N = 1335, 65 transects). There was a significant difference when comparing the detection rates among the three types of transects ($F = 103.56$, $p < 0.0001$).

The remaining old-growth redwood forest in California corresponds to where we found the highest concentrations of murrelets (Figs. 1a-c; Table 1; Fox 1989). Del Norte and Humboldt Counties had the largest stands of old-growth redwood in California, 58,078 ha or 69% of the state's 84,240 ha (Table 1; Fox 1989). The rest of the old-growth redwood exists primarily in San Mateo and Santa Cruz Counties (22%). Only 2% remains of the original old-growth in Mendocino, Sonoma, and Marin Counties, where the largest grove, Montgomery Woods State Park, is only 160 ha. In contrast, Del Norte and Humboldt Counties have four large parks: Jedediah Smith Redwoods (3543 ha); Prairie Creek Redwoods (4250 ha); Redwood National Park (8100 ha); and Humboldt Redwoods (8400 ha), all with high murrelet detection rates. Santa Cruz and San Mateo Counties also have relatively large parks with high activity levels: Butano (600 ha), Portola (570 ha) and Big Basin Redwoods (810 ha).

Transects with high activity levels tended to be in, or to the west of, stands of old-growth ≥ 250 ha (Fig. 2). Fifty-one percent of transects in or near stands ≥ 250 ha had

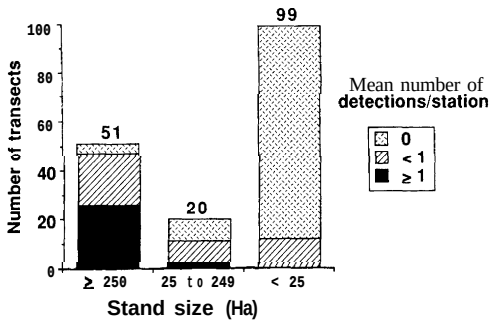

FIGURE 2. A comparison of the marbled murrelet detection rates in northern and central California to the size of the largest stand of old-growth ≤2 km east of the transect.

detection rates ≥ 1/station (N = 51). None of the transects near stands <25 ha had high activity levels, with most (87%, N = 99) having no detections. Over half of the transects near old-growth stands 25-249 ha in size (55%, N = 20) had detections, with 10% having high activity levels. However, murrelets were not recorded near all large stands of old-growth we surveyed. Stations near some stands at Humboldt Redwoods, the Northern California Coast Range Preserve (NCCRP, owned by the Nature Conservancy), and Whitehouse Creek west of Big Basin Redwoods State Park had no birds. Humboldt Redwoods is over 30 km from the ocean and murrelets appear to be concentrated at the north end of the park. The NCCRP is primarily Douglas-fir and located in Mendocino County where the birds may be extirpated. Murrelets were recorded in Whitehouse Creek in the past (G. Strachan, pers. comm.), but our lack of detections suggests this drainage is not a major flight corridor for birds travelling to Big Basin Redwoods.

We found a significant relationship between the size of canopy trees within 50 m of the survey station and the detection rate (F = 56.3, p < 0.001)(Table 2). Areas with high activity levels had a mean DBH of 86 cm, while areas with no activity averaged 48 cm DBH (Table 2).

The habitat type we surveyed most often had a redwood dominated canopy, with scattered Sitka spruce *(Picea sitchensis),* western hemlock *(Tsuga heterophylla),* and Douglas-fir. We detected murrelets in other habitat types, with birds heard along Myrtle Creek in the Six Rivers National Forest. The vegetation in this drainage was predominantly old-growth Douglas-fir and Port Orford cedar *(Chamaecyparis lawsoniana).* We also heard birds in Monument Creek on Pacific Lumber Company lands, where grand fir *(Abies grands)* and Douglas-fir were the dominant trees. We surveyed five Douglas-fir dominated

TABLE 2. Distance to the ocean and DBH of canopy trees of 170 marbled murrelet transects in northern and central California surveyed in 1988 and 1989, compared to three detection rates.

No. detections /station	$\bar{x}$	SD	Maximum	N
0				
Distance to ocean[1]	11.3	7.8	34	98
DBH of canopy trees[2]	44.7	34.1	190	
<1				
Distance to ocean	11.3	10.0	39	44
DBH of canopy trees	76.7	46.4	310	
≥1				
Distance to ocean	9.2	9.1	36	28
DBH of canopy trees	86.0	42.5	177	

[1] Shortest distance (km) from middle of transect to ocean.
[2] Mean DBH of canopy trees within a 50 m radius of the census point.

transects in the Kings Range in southern coastal Humboldt County and the North Coast Preserve, Mendocino County. We found no murrelets on these transects, even though the stands had old-growth characteristics similar in structure to stands having many detections, and were near the ocean.

Topographic Features

We found no significant effect of distance to ocean on number of detections. The mean distance from the ocean to the center of the transect was 9.2 km in high activity transects and 11.3 km in transects with moderate or low activity. This difference was not, however, significant ($F = 0.7$, $p > 0.05$) (Table 2). The ten most active transects were a mean distance of 6.5 km inland (SE = 1.4, max = 18 km). The farthest inland that birds were observed was 39 km, at Grizzly Creek Redwoods State Park.

Drainages with large tracts of old-growth near the ocean and in an east-west orientation tended to have high detection rates. The two most active areas were good examples: Godwood Creek in Prairie Creek State Park (8.7 detections / station) and along Redwood Creek in Redwood National Park (6.6 detections / station). It appeared that murrelets used drainages for flight corridors if they provided a relatively short route to the ocean and minimized the elevational gradient from the sea to the inland site. On the other hand, some murrelets used a low point in a ridge to minimize flight distances, rather than follow a meandering river. We observed this near Wheeler Creek on the Siskiyou National Forest in Oregon (Paton and Ralph 1988) and in the Kings Range over Panther Gap, an elevational gain of 840 m and a 35 km flight, rather than along the Eel River to the ocean, a 30 m elevation gain, but a 50 km flight.

DISCUSSION

In all probability, we did not find murrelets in some areas where they occurred, especially in areas with only one or two pairs. Little is known about the vocalizations of this species when comparing an isolated pair with a large concentration. Murrelets are best detected at an inland site by their calls. If isolated pairs tend to be quieter than larger groups, then finding solitary pairs would be more difficult.

The inland distribution pattern we found correlated well with that observed in the offshore surveys of Sowls et al. (1980) and H. Carter (pers. comm.), who found concentrations from the Oregon border to Eureka and from Half Moon Bay to Santa Cruz. Our records also corresponded with historical information compiled by Carter and Erickson (1988).

We documented use of several areas in California where murrelets had not been recorded previously. There were no records in the Myrtle Creek drainage, in Del Norte County, before our work on Six Rivers National Forest, and records from Simpson Timber Company lands along Wilson Creek were also new. However, birds had been recorded in an area adjacent to the Simpson lands, near Terwer Valley (Carter and Erickson 1988).

Probably the most significant discovery was finding the large concentration on Pacific Lumber Company lands, the largest tract of old-growth redwood owned by a private timber company. Prior to our study, there were only early historical records for this part of Humboldt County: Joseph Grinnell had observed murrelets in Carlotta in 1923 and 1929 (Grinnell and Miller 1944), 5-15 km southwest of Pacific Lumber Company lands.

There are no known historical records for Mendocino, Sonoma, or Marin Counties at inland localities, with the exception of one near Fort Bragg (Carter and Erickson 1988). In addition, a 1989 survey of offshore waters found no murrelets off Mendocino County (H. Carter, pers. comm.). However, we believe the redwood forests of these three counties provided suitable nesting habitat historically and that birds probably bred there. Redwood logging mills were operating in Monterey, Santa Cruz, Santa Clara, San Mateo, Alameda, Sonoma, and Marin Counties by the 1840's, with the eastern side of the Santa

Cruz mountains and the Oakland hills all logged by 1870 (Green 1985). Since much of the old-growth forest was gone by 1900, early ornithologists had no chance to describe their original avifauna. If one assumes that murrelets inhabited all old-growth redwood forests that once existed in California, and that only 10% of the old-growth is still standing (Green 1985; Fox 1989), then they have very likely experienced a dramatic population decline.

Areas with murrelet observations from the 1920's and 1930's that were subsequently logged now have few or no birds. The area east of Trinidad had many murrelets in 1916 (Dawson 1923) and was a collecting site for ornithologists in the 1920's (Anon. 1928). Yet we observed no birds near Trinidad in 1988, with one possible exception, a possible sighting at a station within 0.1 km of the coast at Patrick's Point State Park.

Areas with high activity levels were primarily old-growth forests in state and national parks protected from logging. Most of the high volume old-growth redwood in the state (36,200 ha) is found in parks, accounting for 63% of the state's standing old-growth redwood volume in 1983 (Green 1985).

Commercial timberlands tend to be located in drier, higher elevation sites than the parks, and the size of canopy trees tends to be smaller. Very few large contiguous tracts of old-growth redwood occur on private timberlands. However, at least one large concentration of birds occurs on private commercial timberlands, an area scheduled to be harvested in the next 20 years. The largest old growth stand, 1200 ha, is in the Salmon Creek drainage, where we found relatively high numbers of detections (3.4/station). The majority of private timberlands we surveyed had very fragmented landscapes, with most stands of old-growth less than 25 ha in size and with moderate detection rates at best.

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APPENDIX. Marbled murrelet transects surveyed in 1988 and 1989. The location refers to the center station on the transect. The total number of stations surveyed, total number of murrelet detections, shortest distance from the ocean to the center station, and the dominant age of the forest near the transect are given.

Study site	County[1]	Owner[2]	Legal description T	R	S	No. of stations	No. of detections	Distance inland (km)	Stand age[3]
Alder Camp	DeNo	NPS	13N	1E	8	22	10	1	OG
Boy Scout Trail	DeNo	SP	16N	1W	13	22	55	6	OG
Camp Klamath	DeNo	Misc	13N	1E	10	22	2	2	MG
Damnation Trail	DeNo	NPS	15N	1E	30	22	12	1	OG
H500/P500 Haul Rd.	DeNo	TimC	14N	2E	5	19	0	13	MG
Hiouchi	DeNo	Misc	17N	1E	3	22	7	16	OG
K-One Haul Road	DeNo	TimC	14N	2E	18	20	0	13	MG
Kermit Miller Exch.	DeNo	USFS	17N	1E	8	41	0	10	MG
Klamath	DeNo	NPS	13N	1E	33	22	5	1	MG
Klamath Mill area	DeNo	TimC	13N	1E	2	18	1	5	MG
Mill Cr. Campground	DeNo	SP	15N	2E	16	18	2	3	MG
Myrtle Creek	DeNo	USFS	16N	1E	4	30	11	14	MG
N. Redwood Ex. For.	DeNo	USFS	14N	1E	21	55	134	2	OG
Red Mountain	DeNo	USFS	13N	2E	14	22	0	16	SG
Requa	DeNo	NPS	14N	1E	29	22	3	0	OG
Rowdy Creek	DeNo	Misc	18N	1E	36	20	0	9	SG
S. of Crescent City	DeNo	Misc	15N	1W	12	20	5	1	SG
S. Redwood Ex. For.	DeNo	USFS	14N	1E	27	44	71	3	OG
S. Fork Smith River	DeNo	Misc	16N	1E	13	20	0	13	MG
Snavely Road	DeNo	Misc	18N	1E	16	20	0	12	SG
U-Ten Haul Road	DeNo	TimC	14N	2E	28	18	0	14	MG
Upper Corners	DeNo	TimC	14N	2E	30	20	0	11	MG
W-Ten Haul Road	DeNo	TimC	15N	1E	32	20	11	5	MG
Walker Road	DeNo	SP	17N	1W	31	20	29	9	OG
Wilson Creek	DeNo	TimC	14N	1E	17	16	14	3	MG
A-9 Road	Humb	NPS	10N	1E	35	27	14	5	OG
A-Line Haul Road	Humb	TimC	8N	1E	8	22	0	2	MG
Arcata City Forest	Humb	Misc	6N	1E	27	22	0	8	SG
B-900 Haul Road	Humb	TimC	12N	3E	17	22	0	18	MG
Bair Road	Humb	Misc	7N	3E	23	20	0	27	SG
Bald Hills Road	Humb	NPS	10N	1E	1	22	28	6	OG
Bear River Ridge	Humb	Misc	1N	1W	17	20	0	18	SG
Bear River Valley	Humb	TimC	1S	1W	11	22	0	19	SG
Big Tree	Humb	SP	1S	1E	25	18	5	26	OG
Bull Creek	Humb	SP	2S	1E	11	22	0	23	OG
Cal-Barrel Rd.	Humb	SP	11N	1E	1	17	39	4	OG

APPENDIX. Continued.

Study site	County[1]	Owner[2]	Legal description T	R	S	No. of stations	No. of detections	Distance in land (km)	Stand age[3]
Camp Snow Road	Humb	Misc	6N	3E	17	22	0	23	SG
Capetown	Humb	Misc	1N	3W	23	20	0	2	SG
Devil's Creek	Humb	NPS	9N	2E	16	22	1.2	17	OG
East C-line Road	Humb	NPS	10N	2E	31	33	8	10	OG
Elk River	Humb	Misc	4N	1W	22	20	2	10	SG
Elk's Head Spring	Humb	TimC	3N	1E	14	20	20	20	OG
Ferndale	Humb	Misc	2N	2W	22	20	1	8	SG
Fieldbrook	Humb	Misc	6N	1E	1	20	3	10	SG
Freshwater-Kneeland	Humb	TimC	4N	1E	1	29	0	19	SG
Geneva Road	Humb	NPS	11N	2E	19	22	5	9	MG
Gold Bluffs Beach	Humb	SP	12N	1E	33	20	34	0	OG
Greenlaw Creek	Humb	TimC	1N	1E	36	22	1	29	OG
Grizzly Creek	Humb	SP	1N	2E	10	75	61	36	OG
Hidden Spring	Humb	SP	2S	3E	7	11	0	28	OG
Honeydew	Humb	Misc	2S	1E	28	20	12	21	SG
Horse Trail	Humb	NPS	10N	1E	3	22	23	3	OG
Hwy 101-Prairie Cr.	Humb	SP	12N	1E	26	20	109	3	OG
Jacoby Creek	Humb	Misc	5N	1E	11	19	0	13	SG
James Irvine Trail	Humb	SP	11N	1E	2	17	148	4	OG
Kings Peak	Humb	Misc	4S	1E	9	22	0	4	SG
Lawrence Creek	Humb	TimC	3N	2E	8	9	5	23	MG
LB Johnson Grove	Humb	NPS	11N	1E	26	27	16	4	OG
Liscomb Hill Road	Humb	Misc	6N	2E	17	20	0	14	SG
Little River	Humb	TimC	7N	1E	7	20	0	4	SG
Long Ridge	Humb	TimC	1S	1W	16	18	0	14	SG
Look Prairie	Humb	SF	1S	2E	20	22	15	30	OG
Lost Man Creek	Humb	NPS	11N	1E	24	20	69	5	OG
Lower Freshwater Cr.	Humb	TimC	4N	1E	26	22	0	18	SG
Lower Mitchell Road	Humb	Misc	5N	1E	31	20	0	8	SG
Lower Redwood Cr.	Humb	NPS	11N	1E	2	33	218	4	OG
M-line, Redwood NP	Humb	NPS	9N	2E	8	22	0	14	OG
M-Line Haul Road	Humb	TimC	8N	2E	6	22	5	10	SG
Maple Creek	Humb	Misc	5N	2E	2	20	0	21	SG
Maple Creek-LP	Humb	TimC	8N	1E	12	21	0	9	SG
McCready Gulch	Humb	TimC	5N	1E	34	22	0	14	SG
Mill Creek	Humb	TimC	2S	2W	17	16	14	5	MG
Miranda	Humb	SP	2S	3E	34	22	0	27	MG
Miranda-Myers Flat	Humb	Misc	2S	3E	28	22	0	27	MG
Monument Creek	Humb	TimC	1N	1E	19	16	2	21	SG
Monument Ridge	Humb	Misc	1N	1W	24	20	0	20	SG
North 101 Bypass	Humb	NPS	12N	1E	13	22	0	5	SG
NW Ridge Trail	Humb	SP	12N	1E	10	20	43	2	OG
Owl Creek	Humb	TimC	2N	2E	15	22	7	32	OG
Patrick's Point SP	Humb	SP	9N	1W	26	18	14	0	SG
Pepperwood	Humb	Misc	1N	1E	32	22	4	31	OG
Piercy	Humb	SP	5S	3E	35	18	0	19	OG
R-Line Haul Road	Humb	TimC	8N	1E	25	22	0	8	MG
Redcrest	Humb	TimC	1S	2E	8	22	0	32	SC
Redcrest-Federation	Humb	SP	1S	2E	23	54	58	35	OG
Redway	Humb	SP	4S	3E	11	22	0	21	OG
Redwood Valley	Humb	Misc	7N	3E	17	22	0	23	SG
S. of Orick	Humb	NPS	10N	1E	4	33	11	2	OG
S. of Petrolia	Humb	Misc	2S	1W	33	20	0	9	SG
Salmon Creek	Humb	TimC	3N	1E	20	20	68	10	OG
Shaw Creek	Humb	TimC	3N	2E	20	22	0	28	OG
Skunk Cabbage Cr.	Humb	NPS	11N	1E	28	22	44	2	OG

APPENDIX. Continued.

Study site	County[1]	Owner[2]	Legal description T	R	S	No. of stations	No. of detections	Distance inland (km)	Stand age[3]
South 101 Bypass	Humb	NPS	12N	2E	31	20	0	6	SG
Big Tree/S. Fork	Humb	SP	1S	2E	29	20	7	32	OG
Stone Lagoon	Humb	Misc	10N	1E	29	22	0	1	MG
Stone-Big Lagoon	Humb	SP	IO N	1E	16	23	1	1	MG
T-Line Haul Road	Humb	TimC	8N	1E	16	22	0	6	MG
Tall Trees Grove	Humb	NPS	9N	1E	I	21	41	8	OG
Ten Tappo Trail	Humb	SP	12N	1E	11	20	80	3	OG
West Ridge Trail	Humb	SP	11N	1E	2	19	67	5	OG
Westside Haul Rd.	Humb	NPS	10N	1E	8	33	1	2	OG
Wilder Ridge	Humb	Misc	3S	1E	20	20	0	10	SG
Yeager Creek	Humb	TimC	2N	1E	11	22	9	26	OG
Adm. Standley Grove	Mend	SP	21N	16W	26	22	0	17	OG
Bear Harbor	Mend	BLM	24N	19W	25	11	0	0	SG
Branscomb	Mend	Misc	21N	17w	26	20	0	4	SG
Caspar Creek	Mend	TimC	18N	17W	9	22	0	6	SG
Eureka Road	Mend	Misc	12N	16W	13	20	0	8	SG
Fish Rock	Mend	Misc	11N	15W	3	20	0	6	SG
Fort Bragg Sher. Rd.	Mend	Misc	18N	17W	2	20	0	8	SG
Four Corners	Mend	Misc	24N	19W	11	22	0	2	SG
Hales Grove	Mend	Misc	23N	17W	17	22	1	6	SG
Hendy Grove	Mend	SP	14N	15W		22	0	19	OG
Hwy 20-Middle	Mend	Misc	17N	15W	8	22	0	22	SG
Hwy 20-West	Mend	Misc	8N	16W	31	22	0	10	SG
Jackson SF	Mend	SF	18N	17W	2	22	0	5	SG
Maillard Redwoods	Mend	SP	12N	13W	8	22	0	21	OG
Mendocino Woodlands	Mend	SP	17N	17W	24	20	0	8	OG
Montgomery Woods	Mend	SP	16N	14W	23	20	0	34	OG
Mountain View	Mend	Misc	13N	16W	25	22	0	12	SG
Navarro River	Mend	Misc	15N	16W	16	22	0	6	SG
No. Coast Preserve	Mend	Misc	22N	16W	28	22	0	15	OG
Philo-Greenwood	Mend	SP	14N	14W	19	11	0	11	OG
Rockport	Mend	Misc	22N	18W	23	22	0	1	MG
Russian G/Van Damme	Mend	SP	16N	17W	4	30	24	4	OG
Sanctuary Forest	Mend	TimC	5S	2E	34	22	0	5	MG
Standish Hickey	Mend	SP	23N	17W	3	22	0	11	OG
Ten Mile Road	Mend	Misc	19N	17W	4	20	0	2	SG
Ukiah-Mendocino Rd.	Mend	Misc	16N	16W	4	20	0	12	SG
Usal Road	Mend	Misc	23N	18W	27	22	1	1	SG
Annopolis Road	Son0	Misc	10N	14W	15	22	0	3	SG
Armstrong Redwoods	Son0	SP	8N	10W	7	20	0	14	OG
Cazedero Hwy	Son0	Misc	8N	11W	18	22	0	5	SC
Fort Ross	Son0	TimC	8N	12W		16	0	1	SG
Joy Road	Son0	Misc	6N	10W	1	20	0	10	SG
Kruse Rhododendron	Son0	SP	9N	13W	28	22	0	1	OG
Russian River	Son0	Misc	7N	10W	6	22	0	11	SG
Stewart's Point	Son0	Misc	9N	13W	6	22	1	3	SG
Tin Barn Road	Son0	Misc	9N	13W	15	22	0	6	SG
Kent Lake	Mari	SP	IN	8W		20	0	6	MC
Muir Woods NP	Mari	NPS	1N	7W		18	0	3	OG
SP Taylor	Mari	SP	2N	8W		20	0	8	MG
Alpine Road	SaMa	Misc	7S	2W	30	20	0	15	MG
Butano Creek	SaMa	Misc	8S	4W	17	10	8	8	OG
Butano SP	SaMa	SP	8S	4W	29	8	1	5	OG
Filoli	SaMa	Misc	5S	4W	31	20	0	10	SG
Gazos Creek	SaMa	SP	8S	4W	28	18	27	6	OG
Goat Hill	SaMa	SP	8S	4W	27	26	16	5	OG

APPENDIX. Continued.

Study site	County[1]	Owner[2]	Legal description T	R	S	No. of stations	No. of detections	Distance in-land (km)	Stand age[3]
Heritage-Alpine	SaMa	Misc	8S	4W	1	16	6	13	MG
Iverson Trail	SaMa	SP	8S	3W	8	36	107	18	OG
Memorial Park	SaMa	SP	7S	4W	34	12	7	10	OG
Pescadero-Haul Rd.	SaMa	Misc	8S	4W	1	19	28	14	MG
Pilarcitos Lake	SaMa	Misc	4S	5W	32	14	0	15	SG
Portola SP	SaMa	SP	8S	3W	8	20	27	18	OG
Ridge Trail	SaMa	SP	8S	1W	22	16	5	10	OG
San Gregoria-Hwy 84	SaMa	Misc	7S	4W	14	20	0	11	MG
Whitehouse Creek	SaMa	SP	8S	5W		12	0	4	OG
Aptos-Nisene Marks	SaCr	SP	10S	1E		36	0	7	MG
Bear Creek Road	SaCr	Misc	9S	2W	16	22	0	19	SG
Big Basin Hdqtrs.	SaCr	SP	8S	3W	33	36	64	12	OG
Brown's Vallev Road	SaCr	Misc	10S	1E	31	20	0	9	SG
Hecker Pass	SaCr	Misc	11S	3E		22	0	14	SG
Henry Cowell	SaCr	SP	10S	2W	26	30	0	8	OG
Hwy 9	SaCr	Misc	10S	2W	29	20	0	8	OG
Lodge Road	SaCr	SP	9S	3W	4	48	28	11	OG
San Lorenzo River	SaCr	Misc	9S	3W	1	22	0	14	SG
Sunset Trail	SaCr	SP	9S	4W	2	10	12	8	OG
Swanton Road	SaCr	Misc	10S	3W	2	12	0	1	OG
Waddell Creek	SaCr	SP	9S	4W	23	22	61	4	MG
Zayante Creek	SaCr	Misc	9S	1W	30	22	0	9	SG

[1] Counties: DeNo = Del Norte, Humb = Humboldt, Mend = Mendocino, Sono = Sonoma, Mari = Marin, SaMa = San Mateo, SaCr = Santa Cruz.

[2] Owners: BLM = Bureau of Land Management, Misc = miscellaneous private owners, NPS = National Park Service, SF = California State Forest, SP = California State Park, TimC = Timber Company, USFS = US Forest Service.

[3] Stand age (dominant age of forest near the transect): MG = Mixed ages, fragmented landscape of patches of old-growth, second-growth, and clearcuts; SG = Second growth, the dominant trees are less than 200 years old; OG = the dominant trees in the overstory are over 200 years old.

[4] Observer was not positive of identification.