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To Whom It May Concern:

Enclosed, please find recent documents related to the Status Review of the Marbled Murrelet.

Thank you.

Sincerely,

Laird Henkel

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Summary of 2005
Corvid Monitoring Surveys
In The Santa Cruz Mountains

Prepared for

Command Oil Spill Trustee Council

Prepared by

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Final Report

INTRODUCTION

In 2002 David Suddjian (unpubl. data) conducted a pilot study in Big Basin Redwoods State Park, Portola Redwoods State Park, Butano State Park, and San Mateo County Memorial Park (Figure 1) to compare relative abundance of corvids in areas of high human use with those well removed from areas of high use. In 2003 the Command Oil Spill Trustee Council (COSTC) initiated a corvid monitoring program in the same four parks that was patterned closely the 2002 effort (Suddjian 2004). The COSTC study was to assist the Council in restoration planning for potential projects benefiting the Marbled Murrelet (*Brachyramphus marmoratus*), including corvid management. This report presents the results of corvid monitoring surveys conducted in 2005.

Corvids are among the most significant predators on eggs and chicks of marbled murrelets (Nelson 1997, Peery et al. 2004). Both Steller's Jay (*Cyanocitta stelleri*) and Common Raven (*Corvus corax*) have been documented to prey on murrelet eggs or chicks in the Santa Cruz Mountains (Singer et al. 1991, Suddjian 2003, 2003b, Perry et al. 2004), and Peery et al. (2004) demonstrated rates of nest predation as high as 61-87% in the region. The Steller's Jay has apparently always been a prominent member of the avian community in old growth forests in this region. In contrast, Common Ravens are relatively new in those forests, and have only become numerous in recent decades (Figure 2; Kelly et al. 2002). Both species are attracted to campgrounds and other areas of parks with high human use, where human food is often readily available. Consequently, previous studies and general observations in the Santa Cruz Mountains have typically found both Steller's Jay and Common Raven to be much more numerous at campgrounds than away from campgrounds. A third species of corvid, American Crow (*C. brachyrhynchos*), was recorded in the study area for the first time this year (one shot at Huckleberry Campground at Big Basin on April 6, P. Halbert pers. comm.). However, at present this is the only record from the interior part of Big Basin (they are rare non-breeding visitors coastward at the Rancho Del Oso unit), and crows do not yet occur at the other three parks.

This study compares corvid populations in murrelet nesting habitat within campgrounds (treatment areas) to corvid populations in such habitat in areas located >300 meters from campgrounds (control areas). It also provides a baseline from which to judge future changes in numbers related to corvid management projects. Such projects were initiated in 2005.

METHODS

STUDY DESIGN

The pilot study in 2002 sampled corvids in nine treatment areas and 19 control areas (D. Suddjian unpublished data). The monitoring program initiated by COSTC in 2003 established and surveyed one or more treatment and control areas in each park in 2003, except at Memorial, where no suitable control areas were identified (Table 1, and Figures 3-6). All of the treatment and control areas selected for the COSTC study overlapped entirely or partially with areas surveyed by Suddjian in 2002. Surveys in 2003 to 2005 sampled seven treatment areas and 12 control areas. All survey sites are in coast redwood (*Sequoia* sempervirens) forest known to support use by Marbled Murrelets, with nesting known or suspected to occur either in or immediately adjacent to the survey area. They range in size from 3.2 to 15.7 hectares (Table 1). In 2005 trees with potentially suitable nest platforms (Pacific Seabird Group 2003) were counted in each survey area to provide a measure of the habitat quality of each site for murrelets (Table 2).

Control areas are located a minimum of 300 meters from any campground, picnic area, or residential community, and are located along roads or trails to facilitate access. Treatment areas include standard campgrounds and their immediate surroundings. Group campgrounds were excluded because they were irregularly occupied, and they were often smaller than a minimum size criterion of 3.0 hectares (Suddjian 2004).

Surveys in 2005 were concurrent with initiation of several aspects of corvid management and park-user education in the three state parks (but not at Memorial County Park). These included direct removal of ravens, increased emphasis on proper food storage, increased education about Marbled Murrelets and about corvids as predators, and warnings and citations for campers feeding wildlife or improperly storing food or trash.

DESCRIPTION OF SURVEY AREAS

General Patterns Of Human Use

The campgrounds are used continuously throughout the survey period of June to August, although occupancy varies daily and throughout the season. Occupancy is typically at or near 100% on weekends, but often considerably less on weekdays, and is generally greater in July and August than in June. Campground occupancy during the surveys in 2005 ranged from 7% to 71% (Table 3). Average occupancy for each campground in 2005 was reduced from occupancy in 2004, except at Sequoia Flat in Memorial where it was very similar to that of 2004 (Table 3).

Human foods are continually available to corvids in varying degrees at occupied campgrounds. Food is occasionally (but regularly) offered directly to wildlife by campers, but is also widely available as discarded or fallen scraps or fragments, garbage left at camp sites, food fragments stuck on grills at fire rings, and at water spigots where dishes are rinsed. Food left unattended during the day or improperly stored at night is commonly plundered by wildlife. Additionally, in some parks food is readily available at trash receptacles that permit animal access, spillage by animals, are left open, or are too full to close properly.

Human activity in the control areas is mostly limited to hiking, with no established picnic sites. No people other than the surveyor were evident during any of the morning surveys in control areas in 2003 to 2005, with the exception of one park maintenance vehicle that drove through once at one site in 2005.

Big Basin Redwoods State Park

Treatment areas are Blooms Creek Campground (55 sites), Sempervirens Campground (31 sites), Huckleberry Campground (71 sites), and Wastahi Campground (27 sites) (Table 1, Figure 3). Two control areas are located along the upper reach of Opal Creek, and four are along Gazos Creek Escape Road west of Opal Creek (Table 1, Figure 3).

Campgrounds had trash dumpsters with plastic lids, and a small number of metal trashcans with hinged wooden lids. The margins of the plastic and wooden lids on the dumpsters were often chewed by squirrels, enabling them to enter and forage, occasionally dragging trash and food out of the dumpster. Rusted holes in some dumpsters permitted the same access to garbage. The lids on the dumpsters and trashcans were usually closed, but rarely were left open, and occasionally (following weekends) the lid of an overly full dumpster could not be closed, permitting birds and other animals to reach its contents.

Portola Redwoods State Park

The treatment area is the main campground, referred to here as Portola Campground (53 sites; Table 1, Figure 4). The control areas are along Peters Creek north of the campground, and in two areas along the Iverson Trail (Table 1, Figure 4).

The campgrounds and picnic areas at Portola have metal trash bins with animal proof lids. On one occasion in 2005 an overfull trash bin had a large amount of garbage spilled around it., but otherwise there was no spillage was observed around the garbage receptacles in Portola.

Butano State Park

The treatment area is the Ben Ries Campground (61 sites; Table 1, Figure 5). The control areas are along the Butano Service Road extending northeast from the campground, Goat Hill Trial, and Doe Ridge Trail (Table 1, Figure 5).

The campground at Butano had metal trashcans with hinged wooden lids, placed within a wooden receptacle. The lids were heavy enough to prevent animal entry, although the edges of some had been partially chewed. No animal access to the cans or spillage around the cans was observed in 2005.

San Mateo Memorial County Park

The treatment area is the Sequoia Flat Campground (104 sites) (Table 1, Figure 6). No control areas with suitable habitat and sufficient distance from areas of high human use were identified, so control areas for this park were located in Big Basin instead (four areas along Gazos Creek Escape Road, Figure 3).

Sequoia Flat campground had 35 open metal trash cans with no lids, and one small number of metal dumpsters with a plastic lid. Animal access was commonly observed. Trashcans were tipped over and spilled by raccoons and other mammals, and mammals entered the cans and carried garbage out of them onto the ground.

CORVID SURVEY METHODS

Each site was surveyed using the total area search method (Ralph et al. 1993). The search area at treatment areas included the entire area of campsites and extended outward 50 meters from the edge of the camp boundary. Control areas were established along roads and trails, and the search area extended outward for 50 meters from the center of the road or trail. Thus, the control areas were equivalent to 100-meter wide strip transects in which the total area searches were conducted. Fifty meters was selected as the outside distance to insure the best chance of visual detection of perched, silent birds. Vegetation obscured views too significantly beyond 50 meters. Movement off the road or trail was avoided in control areas to minimize noise made by the surveyor.

David Suddjian conducted all the surveys. Surveys were done by walking slowly through the survey site and pausing often for brief periods, listening for vocalizations and making visual scans to detect corvids. Although Luginbuhl et al. (2001) found that broadcasting taped calls enhanced detections of ravens, this method was not used in this study to avoid disturbance of campers and distraction to the surveyor when campers would inquire about the broadcast calls. Furthermore, the taped calls might attract ravens into the survey areas from outside the boundary during the survey.

Each jay and raven was recorded, indicating its age if known. Aging of ravens was straightforward though the season due to the status of molt of adults, feather wear, vocalizations, and the presence of a pale gape on the juveniles. Aging of jays was easy in June and most of July (using plumage pattern, begging behavior and vocalizations, and the pale gape of the juveniles), but it became more difficult in late July and August, when the juveniles more closely resembled adults and begging activity declined. Behavior of jays and ravens was recorded in notes, particularly as it related to foraging.

Other information recorded for each survey included date, start and end times, weather conditions, number of occupied campsites, number of opportunities to access human food (i.e., spilled trash, unattended food, campers feeding wildlife), and details of foods consumed by corvids.

Survey Frequency and Timing

Four surveys were conducted at each site, with one survey in June, two in July, and one in August. Survey dates in 2005 for each site are given on Table 4. Each site was surveyed only once per day, but often more than one site was surveyed on the same morning. Campgrounds were only surveyed on weekdays. An effort was made to sample each site on dates close to those when it was sampled in prior years.

Each survey occurred in a window beginning 35 minutes after sunrise and extending for up to four hours after sunrise. The rationale for selection of this window of time for the surveys was described in Suddjian (2004). The time required to cover each survey area varied with the size of the area, but the average rate of coverage was 3.1 minute per ha (± 0.6 minute). The time expended in each area was kept fairly consistent over each four replications, and each year.

ANALYSES

Analyses comparing treatment and control areas used only the maximum number of corvids detected on any of the four surveys of each area (Luginbuhl et al. 2001), although average counts are also presented in the tables. No effort was made to distinguish among ages of corvids for these analyses. Values of $p < 0.05$ were considered statistically significant, while values $0.1 > p > 0.5$ were considered marginally significant.

Some comparisons are made to the results of the preliminary study of 2002 (D. Suddjian unpubl. data) for all sites pooled together, as the sites were either the same as those of the COSTC-sponsored surveys, or overlapped with them broadly, and the surveys methods were the same.

RESULTS

STELLER'S JAY

Survey results and statistical comparisons for each park in 2005 are given on Tables 5 and 6. Raw counts for 2003 to 2005 are given in Appendix 1. Steller's Jays were recorded in all survey areas; they were detected on all 28 surveys in treatment areas, and on 58% of 48 surveys in control areas (Table 4). They were ubiquitous in treatment areas, where overall they were 8.8 times more numerous than in control areas, with the difference being highly significant (Table 5). The higher numbers in treatment areas compared to controls was significant for each park (Table 5).

Steller's Jay abundance in 2005 was similar to that of 2004 when all parks were pooled (Table 9, Figure 7). A slight negative trend for treatment areas from 2003 to 2005 (r^2 = 0.38) was not significant ($p = 0.19$). A negative trend for control areas ($r^2 = 0.94$) was marginally significant ($p = 0.08$), but the absolute change in numbers was very small, as jays were uncommon in those areas (Appendix 1). Over the three years, the ratio of jays in treatment and control areas has remained similar (ranging from 9.7 to 8.8), but has exhibited a marginally significant decrease ($p = 0.10$). Among parks, jay abundance in treatment areas in Big Basin showed a steady (but non-significant) decline from 2003 to 2005, but there was no consistent trend in the other parks (Figure 8, Appendix 1).

As in past years, jay density in 2005 was positively correlated with the number of occupied campsites in a campground ($r^2 = 0.51$, $p < 0.001$). Jays remained consistently most abundant at Memorial, where they are over twice as numerous as at the other parks, but abundance in the treatment areas in the three state parks was generally similar (Figure 9). The maximum raw count for any area in 2005 was 161 jays at Sequoia Flat Campground at Memorial on July 26. The exceptional abundance at Memorial is presumably due to ready access to garbage in a relatively large campground. Jay numbers increased over the season at all campgrounds ($r^2 = 0.12$, $p = 0.03$), but showed no consistent pattern over the season in control areas (Table 5).

The percentage of juvenile jays in the treatment areas was higher in 2005 than in the previous two years. However, because juveniles might disperse to campgrounds from outlying areas, and adult mortality may vary annually, it is uncertain how closely the percentage of juvenile jays on the surveys reflects actual productivity. Nonetheless, the campgrounds host a substantial numbers of young jays; e.g., there were at least 83 juvenile jays at Sequoia Flat in Memorial on August 25, 2005. The seasonal increase in juvenile jays in the campgrounds was statistically significant ($r^2 = 0.86$, $p < 0.0001$, but no significant increase was evident in the control areas, where very few juvenile jays were seen. The low number of juveniles recorded on surveys in the control areas could be an artifact of small samples of birds in those areas, or it might reflect dispersal of juveniles away from those areas to places with better foraging opportunities.

Jay behavior and interactions with people were similar to those observed in previous years (Suddjian 2004, 2005a). Jays were observed taking advantage of spilled garbage, stealing unattended food in camps, and being fed directly by campers. Jays were frequently seen inspecting occupied campsites for food, and were very quick to capitalize on an opportunity to steal unattended food, or to search for food in just-vacated sites. Jays typically began each morning with a highly active search of campsites for food scraps left from the previous night, and visited trash receptacles where nocturnal mammals had made food available. Two places where jays consistently sought and found scraps of food were at the grills of campsite fire rings, and at campground water spigots where campers rinse their dishes. Human foods taken by jays during the surveys were similar to those mentioned in Suddjian (2004).

COMMON RAVEN

Survey results and statistical comparisons for each park are given on Tables 7 and 8. Raw counts for 2003 to 2005 are given in Appendix 1. Common ravens were recorded in all seven of the treatment areas in 2005, where they were detected on 57% of the 28 surveys (Table 7). In contrast, they were detected at just two (16%) of the 12 control areas, and on only 4% of 48 surveys (Table 7). Raven numbers in treatment areas exceeded those in control areas by 28 times when the data from all sites was pooled together (Table 8), reflecting the very low abundance in control areas in 2005. Taken individually, the difference between the two areas was significant for each park, but only marginally so for Butano (Table 8).

Common Ravens decreased in overall abundance from 2004 to 2005 by 35% in treatment areas and by 83% in control areas (Table 9, Figure 10). This decrease was reflected in each individual park, except at Memorial, where abundance increased, and change at Big Basin was minimal (Figure 11). However, the changes in absolute numbers of individuals were small. Among the parks, Memorial was the only park to have a relatively large number of ravens every year, although the other parks had relatively large numbers in at least one prior year (Figure 12, Appendix 1).

Ravens were generally uncommon, and no large groups were observed in 2005. Most surveys recorded only one or two adults, rarely three adults. Observations over multiple dates could sometimes indicate if a certain individual or pair was in long term residence in a given area, but it was often not possible to determine an individual raven's status as local resident or "floater". Most of the change in numbers from 2004 to 2005 was attributable to a lesser number of juvenile ravens in 2005 (see the assessment of corvid management actions in the discussion section below). Unlike the jay, raven numbers did not increase consistently over the season among the sites (Table 7). Most treatment sites had one pair of adults that was regularly or irregularly present, and in some cases their offspring. Productivity in the parks in 2005 was low overall compared to 2004 and 2002, but was similar to that of 2003 (Suddjian 2004, 2005, and unpubl. data).

At Big Basin there were approximately eight pairs of ravens in the general region of the park containing the survey areas, plus additional single birds. However, only two family groups of fledglings were noted, and fledgling occurred later than normal. Two juveniles were near the south end of Opal Creek Picnic Area beginning July 17, and three juveniles were in the area of Huckleberry and Wastahi campgrounds by July 5. The other resident pairs were apparently unsuccessful or did not nest (see discussion). Raven presence and activity at Blooms Creek and Sempervirens campgrounds was much less consistent through the season than in previous years.

At Portola the pair which resided in the general region of the main campground apparently did not nest in 2005 or had a failed nesting attempt. Raven presence in the main campground area was much less consistent than in prior years. A family group of three juveniles seen north of park headquarters on July 29 was judged to have most likely come from a nest located away from the survey areas (Suddjian 2005b)

At Butano a pair nested in the central area of the park, in the general region of the survey areas. A family with two new fledglings was first evident along Little Butano Creek near the Service Road on July 22. The adults were inconsistently present at Ben Ries Campground, and the family group was not seen there.

At Memorial three pairs were resident in and near the park, but only two produced young. A pair nesting near the central part of Sequoia Flat had two fledglings by July 8, and another near the south end of the campground had two fledglings by July 26. Ravens were continually present at Sequoia Flat campground through the season.

Raven behavior and interactions with people were similar to those described previously (Suddjian 2004 and 2005a). However, compared to 2003 and 2004, ravens generally spent less time in the campgrounds in 2005. As in prior years, they remained wary and did not approach people or take handouts, as did jays. The concentration of naïve fledgling jays at campgrounds continued to attract attention from ravens, and at times seemed to be a principal attraction for them at campgrounds.

DISCUSSION AND RECOMMENDATIONS

POPULATION TRENDS

No significant trends in abundance of jays or ravens were evident over the years of this monitoring program. A detailed comparison of the results of this program with other contemporaneous data sources (i.e., the Christmas Bird Count, USGS Breeding Bird Survey, and the Santa Cruz County Forest Bird Monitoring Program) has not been performed, as such a comparison is beyond the present scope specified for this project. This could be changed in future years, or amended for the present year, pending direction from the COSTC and the contracting agency.

MANAGEMENT ACTIONS

The apparent effectiveness of the various management actions implemented in 2005 to affect corvid populations in the parks is discussed in a separate letter to the COSTC.

GARBAGE MANAGEMENT

Except for rare events, garbage receptacles and collection by park staff at Portola and Butano appeared to be adequate to eliminate any appreciable food resource for corvids. Two problems were noted at Big Basin: (1) many dumpsters had holes in the lids or bottoms that allowed squirrels to pull garbage out; and (2) it was not uncommon for an overfull dumpster to be left full for more than one day, permitting wildlife access to the contents. These issues could be alleviated by replacing or repairing damaged receptacles, and by emptying dumpsters on Sunday or Monday instead of Tuesday. Memorial Park continues to have the most substantial issues with garbage management, as nearly all receptacles in the park were simply open metal cans. These were emptied most mornings, but nocturnal animals could access the cans when they were the most full, and park staff did not empty all the cans when they made the rounds through the campground.

WEST NILE VIRUS

West Nile Virus (WNV) was active in bird populations in the Santa Cruz Mountains for the second year in 2005, but its impact on corvids in the study areas was unknown. A low incidence of bird deaths due to WNV from San Mateo and Santa Cruz Counties suggests it may not yet have had a significant effect. The California WNV information website (http://westnile.ca.gov/2005_casecounts.htm) cited just 10 bird deaths from those two counties, out of 2,534 reported for the state as of September 27, 2005.

TIMING OF MONITORING SURVEYS

Comments from the COSTC (C. Andrade via email dated August 16, 2005) raised a concern that the monitoring surveys, by not beginning until June, were not assessing corvid numbers during the period murrelet eggs were being depredated. The original plan put forward by COSTC in spring of 2003 was to include surveys in each month from May to August. Due to delays in contracting that year, the surveys did not begin until June, and the June to August schedule has been continued subsequently. Even without surveys in May, the current June to August schedule does overlap partly with the period of the egg or incubation phase of the murrelet's nesting cycle (Nelson 1997). Additionally, based on extensive prior observations (Suddjian pers. obs.), the results from June are expected to be largely comparable to numbers of corvids that would be recorded in May. The June surveys are mostly before the period in which juveniles have left the nest, and probably completely precede the period of post-breeding dispersal that might swell numbers of corvids in campgrounds. However, the schedule of monitoring surveys could be adjusted in future years at the direction of the COSTC.

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Table 1. Attributes of the corvid survey areas.

Survey Area	Type	Human Use	Access[1]	Area (ha)	Slope Position[2]	Approx. Elevation	*Canopy Composition*[3] RW	DF	TO	ILO	MA	Other
Big Basin Redwoods SP												
Blooms Creek	Treatment	Camp	1	15.7	B	900–1,120'	1	2	1	2	3	3
Sempervirens	Treatment	Camp	1	7.2	B	960-1,080'	1	2	1	2	3	--
Huckleberry	Treatment	Camp	1,2	13.4	B	980-1,160'	1	2	1	1	2	--
Wastahi	Treatment	Camp	1,3	7.2	B	1,020-1,250'	1	2	1	--	--	--
Opal Creek 2	Control	Hiking	1	10.2	B	1,050-1,180'	1	2	1	3	3	3
Opal Creek 3	Control	Hiking	3	6.6	B	1,075-1,225'	1	2	1	3	3	3
Gazos Creek Road 1	Control	Hiking	2	9.4	S	1,120-1,280'	1	2	1	2	2	--
Gazos Creek Road 2	Control	Hiking	2	6.7	S	1,240-1,350'	1	1	1	2	2	--
Gazos Creek Road 3	Control	Hiking	2	7.5	S	1,140-1,320'	1	2	1	2	2	--
Gazos Creek Road 4	Control	Hiking	2	7.5	S	960-1,180'	1	2	1	2	2	--
Portola Redwoods SP												
Portola	Treatment	Camp	1	8.4	B	350-560'	1	2	1	1	3	3
Peters Creek	Control	Hiking	1,3	7.7	B	400-600'	1	2	1	2	3	3
Iverson Trail 1	Control	Hiking	3	7.1	B	320-520'	1	2	1	2	2	3
Iverson Trail 2	Control	Hiking	2,3	6.9	B	350-520'	1	2	1	3	3	3

Continued on next page,

Table 1, continued

Survey Area	Type	Human Use	Access[1]	Area (ha)	Slope Position[2]	Approx. Elevation	*Canopy Composition*[3]					
							RW	DF	TO	ILO	MA	Other
Butano SP												
Ben Ries	Treatment	Camp	1,3	9.6	B	400-650'	1	2	1	3	3	--
Butano Service Road	Control	Hiking	2	8.1	B	500-670'	1	2	1	3	3	3
Goat Hill Trail	Control	Hiking	3	3.2	S	620-840'	1	2	1	2	3	--
Doe Ridge Trail	Control	Hiking	3	15.7	S	880-1,120'	1	1	1	2	3	--
Memorial CP												
Sequoia Flat	Treatment	Camp	1	12.6	B	180-280'	1	2	1	2	--	2

1. Access: 1 (paved road), 2 (unpaved road), 3 (trail).
2. Slope position: B (bottom of valley), S (mid-slope), R (ridgeline).
3. Approximate canopy cover by each tree species, classed as 1 (50-100%), 2 (11-49%), 3 (1-10%). Tree species: RW (coast redwood), DF (Douglas-fir), TO (tan oak), ILO (interior live oak), MA (madrone), other (includes California bay, red alder, white alder, and big leaf maple)

Table 2. Number of trees with platforms in each survey area[1].

Survey Area	Area (ha)	# RW[2]	# DF	# All	# RW / ha	# DF / ha	# All / ha
Big Basin							
Blooms	15.7	11	38	49	0.7	2.4	3.1
Sempervirens	7.2	7	16	23	1.0	2.2	3.2
Huckleberry	13.4	28	31	59	2.1	2.3	4.4
Wastahi	7.2	9	8	17	1.3	1.1	2.4
Opal 2	10.2	16	11	27	1.6	1.1	2.7
Opal 3	6.6	6	12	18	0.9	1.8	2.7
Gazos 1	9.4	11	13	24	1.2	1.4	2.6
Gazos 2	6.7	10	9	19	1.5	1.3	2.8
Gazos 3	7.5	13	3	16	1.7	0.4	2.1
Gazos 4	7.5	7	4	11	0.9	0.5	1.5
Portola							
Portola	8.4	21	33	54	2.5	3.9	6.4
Peters	7.7	4	22	26	0.5	2.9	3.4
Iverson 1	7.1	16	29	45	2.3	4.1	6.4
Iverson 2	6.9	11	18	29	1.6	2.6	4.2
Butano							
Ben Ries	9.6	17	44	61	1.8	4.6	6.4
Service	8.1	3	20	23	0.4	2.5	2.8
Goat Hill	3.2	2	8	10	0.6	2.5	3.1
Doe Ridge	15.7	9	25	34	0.6	1.6	2.2
Memorial							
Sequoia	12.6	39	45	84	3.1	3.8	6.7

1. "Platforms" were features in the live crown of a conifer that offered potentially suitable nest sites for Marbled Murrelets; "a relatively flat surface at least 10 cm (4 in) in diameter and 10 m (33 ft) high" Pacific Seabird Group (2003, p. 2).

2. "RW" (coast redwood), "DF" (Douglas-fir).

Table 3. Campground occupancy during the 2003 - 2005 corvid surveys.

Survey Area	# Sites	Run 1			Run 2			Run 3			Run 4			Avg		
		'03	'04	'05	'03	'04	'05	'03	'04	'05	'03	'04	'05	'03	'04	'05
<u>**Big Basin**</u>																
Blooms	55	73%	67%	44%	76%	75%	36%	80%	55%	71%	75%	71%	53%	75%	67%	53%
Sempervirens	31	61%	65%	52%	87%	87%	16%	94%	61%	65%	74%	74%	65%	79%	72%	49%
Huckleberry	71	54%	37%	48%	86%	80%	21%	55%	38%	39%	70%	52%	37%	66%	52%	36%
Wastahi	27	22%	11%	7%	67%	56%	26%	26%	26%	22%	56%	26%	15%	43%	30%	18%
<u>**Portola**</u>																
Portola	53	25%	17%	13%	83%	28%	23%	47%	25%	21%	23%	26%	25%	44%	24%	20%
<u>**Butano**</u>																
Ben Ries	61	23%	26%	36%	30%	43%	28%	62%	54%	44%	36%	46%	43%	38%	42%	38%
<u>**Memorial**</u>																
Sequoia	104	25%	36%	25%	42%	74%	59%	100%	28%	56%	46%	33%	37%	53%	43%	44%

Table 4. Dates of the 2005 corvid surveys.

	Survey Dates			
Survey Area	*Run 1*	*Run2*	*Run 3*	*Run 4*
Big Basin				
Blooms Creek	June 20	July 5	July 19	August 22
Sempervirens	June 20	July 5	July 19	August 22
Huckleberry	June 20	July 5	July 19	August 22
Wastahi	June 20	July 5	July 19	August 22
Opal Creek 2	June 21	July 6	July 21	August 24
Opal Creek 3	June 21	July 6	July 21	August 24
Gazos Creek Road 1	June 18	July 4	July 18	August 23
Gazos Creek Road 2	June 18	July 4	July 18	August 23
Gazos Creek Road 3	June 18	July 4	July 18	August 23
Gazos Creek Road 4	June 18	July 4	July 18	August 23
Portola				
Portola	June 28	July 13	July 29	August 26
Peters Creek	June 28	July 13	July 29	August 26
Iverson Trail 1	June 27	July 12	July 28	August 26
Iverson Trail 2	June 27	July 12	July 28	August 26
Butano				
Ben Ries	June 15	July 1	July 22	August 11
Butano Service Road	June 14	July 1	July 22	August 11
Goat Hill Trail	June 14	July 1	July 22	August 11
Doe Ridge Trail	June 14	July 1	July 22	August 11
Memorial				
Sequoia Flat	June 16	July 8	July 26	August 25

Table 5. Number of Steller's Jays per hectare on the 2005 surveys.

Survey Area	Run 1	Run 2	Run 3	Run 4	Max	Avg
Big Basin						
Blooms	1.40	3.06	2.74	3.38	3.38	2.64
Sempervirens	1.53	2.64	1.94	2.64	2.64	2.19
Huckleberry	2.01	1.94	2.91	2.76	2.91	2.41
Wastahi	0.28	0.69	0.56	0.83	0.83	0.59
Opal 2	0.10	0.10	0.00	0.20	0.20	0.10
Opal 3	0.00	0.30	0.00	0.00	0.30	0.08
Gazos 1	0.11	0.32	0.00	0.00	0.32	0.11
Gazos 2	0.45	0.00	0.00	0.00	0.45	0.11
Gazos 3	0.00	0.27	0.00	0.00	0.27	0.07
Gazos 4	0.00	0.13	0.00	0.13	0.13	0.07
Portola						
Portola	2.02	1.90	3.57	3.21	3.57	2.68
Peters	0.26	0.00	0.13	0.65	0.65	0.26
Iverson 1	0.00	0.56	0.00	1.13	1.13	0.42
Iverson 2	0.14	0.00	0.00	0.14	0.14	0.07
Butano						
Ben Ries	1.15	1.67	4.48	2.08	4.48	2.34
Service	0.25	0.25	0.49	0.00	0.49	0.25
Goat Hill	0.63	1.25	0.31	0.94	1.25	0.78
Doe Ridge	0.45	0.32	0.06	0.13	0.45	0.24
Memorial						
Sequoia	2.86	6.03	12.78	11.27	12.78	8.23

Table 6. Comparison of numbers of Steller's Jays in treatment and control areas in 2005.

Survey Area	Avg/ha[1]	S.E.	N	Statistical Significance
<u>All parks combined</u>				
Treatment	4.4	3.87	7	$t = 3.5$, $p^{(1\text{-tailed})} < 0.001$
Control	0.5	0.36	12	
<u>Big Basin</u>				
Treatment	2.4	1.11	4	$t = 4.9$, $p^{(1\text{-tailed})} = 0.0006$
Control	0.3	0.08	6	
<u>Portola</u>				
Treatment	3.6	0.00	1	$t = 5.1$, $p^{(1\text{-tailed})} = 0.018$
Control	0.6	0.49	3	
<u>Butano</u>				
Treatment	4.5	0.00	1	$t = 7.2$, $p^{(1\text{-tailed})} = 0.009$
Control	0.7	0.45	3	
<u>Memorial</u>				
Treatment	12.8	0.00	1	$t = 84.5$, $p^{(1\text{-tailed})} < 0.0001$
Control[2]	0.3	0.13	4	[2]see note

1. Average of maximum counts from each survey area.
2. Controls for Memorial CP were located in Big Basin Redwoods SP.

Table 7. Number of Common Ravens per hectare on the 2005 surveys.

Survey Area	Run 1	Run 2	Run 3	Run 4	Max	Avg
Big Basin						
Blooms	0.13	0.00	0.00	0.13	0.13	0.06
Sempervirens	0.14	0.00	0.00	0.00	0.14	0.03
Huckleberry	0.15	0.15	0.37	0.07	0.37	0.19
Wastahi	0.14	0.42	0.28	0.00	0.42	0.21
Opal 2	0.00	0.00	0.00	0.00	0.00	0.00
Opal 3	0.00	0.00	0.00	0.00	0.00	0.00
Gazos 1	0.00	0.11	0.00	0.00	0.11	0.03
Gazos 2	0.00	0.00	0.00	0.00	0.00	0.00
Gazos 3	0.00	0.00	0.00	0.00	0.00	0.00
Gazos 4	0.00	0.00	0.00	0.00	0.00	0.00
Portola						
Portola	0.12	0.00	0.00	0.00	0.12	0.03
Peters	0.00	0.00	0.00	0.00	0.00	0.00
Iverson 1	0.00	0.00	0.00	0.00	0.00	0.00
Iverson 2	0.00	0.00	0.00	0.00	0.00	0.00
Butano						
Ben Ries	0.10	0.00	0.00	0.00	0.10	0.03
Service	0.00	0.00	0.00	0.00	0.00	0.00
Goat Hill	0.00	0.00	0.00	0.00	0.00	0.00
Doe Ridge	0.00	0.06	0.00	0.00	0.06	0.02
Memorial						
Sequoia	0.40	0.40	0.71	0.16	0.71	0.42

Table 8. Comparison of numbers of Common Ravens in treatment and control areas in 2005.

Survey Area	Avg/ha[1]	S.E.	N	Statistical Significance
All parks combined				
Treatment	0.28	0.23	7	$t = 4.3$, $p^{(1\text{-tailed})} = 0.0002$
Control	0.01	0.04	12	
Big Basin				
Treatment	0.26	0.15	4	$t = 4.24$, $p^{(1\text{-tailed})} = 0.001$
Control	0.02	0.04	6	
Portola				
Treatment	0.12	0.00	1	$p^{(1\text{-tailed})} < 0.0001$
Control	0.00	0.00	3	
Butano				
Treatment	0.10	0.03	1	$t = 2.0$, $p^{(1\text{-tailed})} = 0.092$
Control	0.02	0.04	3	
Memorial				
Treatment	0.71	0.00	1	$t = 11.1$, $p^{(1\text{-tailed})} = 0.0008$
Control[2]	0.03	0.05	4	[2]see note

1. Average of maximum counts from each survey area.
2. Controls for Memorial CP were located in Big Basin Redwoods SP.

Table 9. Number of corvids per hectare in treatment and control areas in the four parks from 2002 to 2005.

Species	2002[1]	2003	2004	2005
Steller's Jay				
Treatment areas	5.39 ± 1.53	6.79 ± 3.65	4.46±2.90	4.37±3.87
Control areas	0.61 ± 0.29	0.66 ± 0.32	0.53±0.26	0.48±0.36
Common Raven				
Treatment areas	0.55 ± 0.25	0.22 ± 0.17	0.43±0.24	0.28±0.23
Control Areas	0.09 ± 0.07	0.09 ± 0.14	0.06±0.10	0.01±0.04

1. 2002 surveys (D. Suddjian unpublished data)

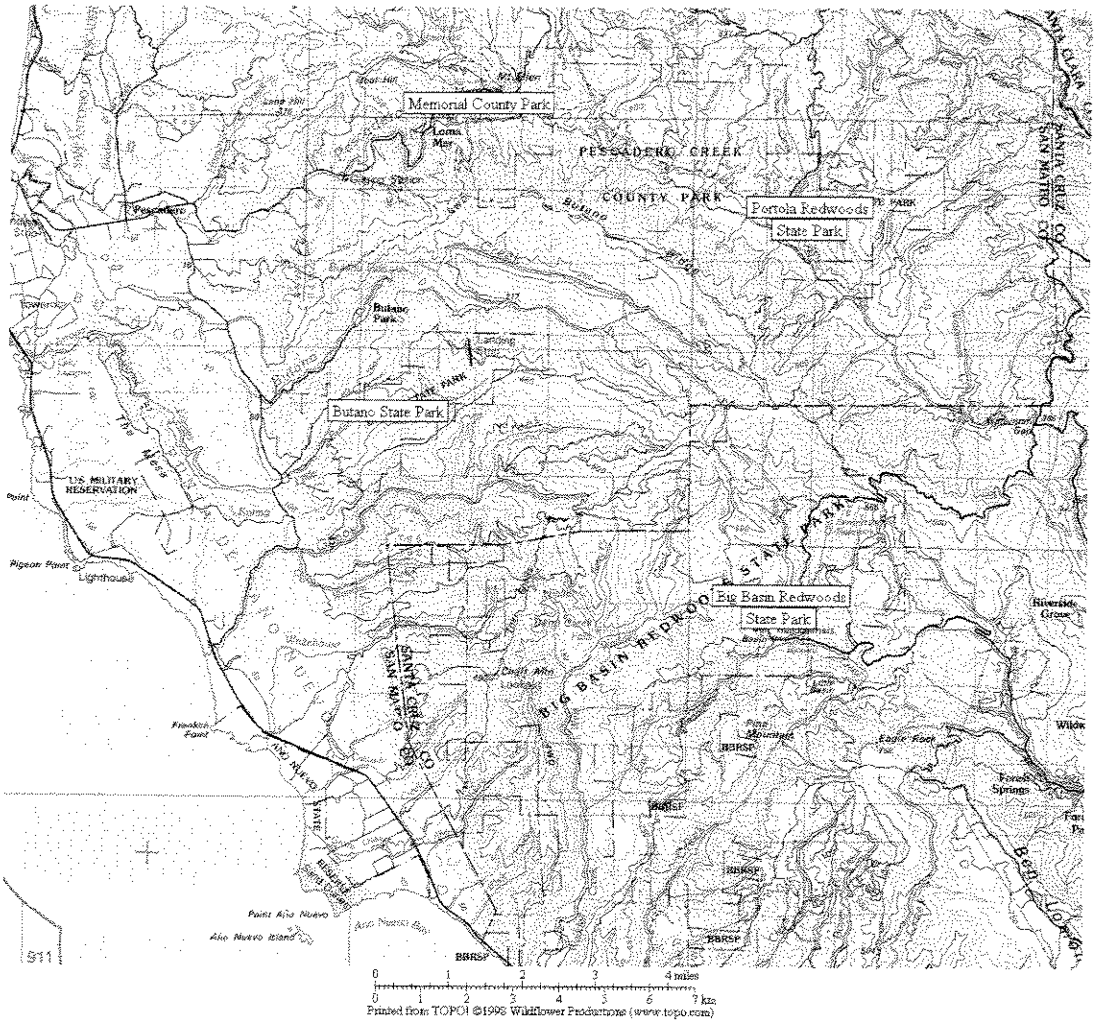


Figure 1. General location of survey areas.

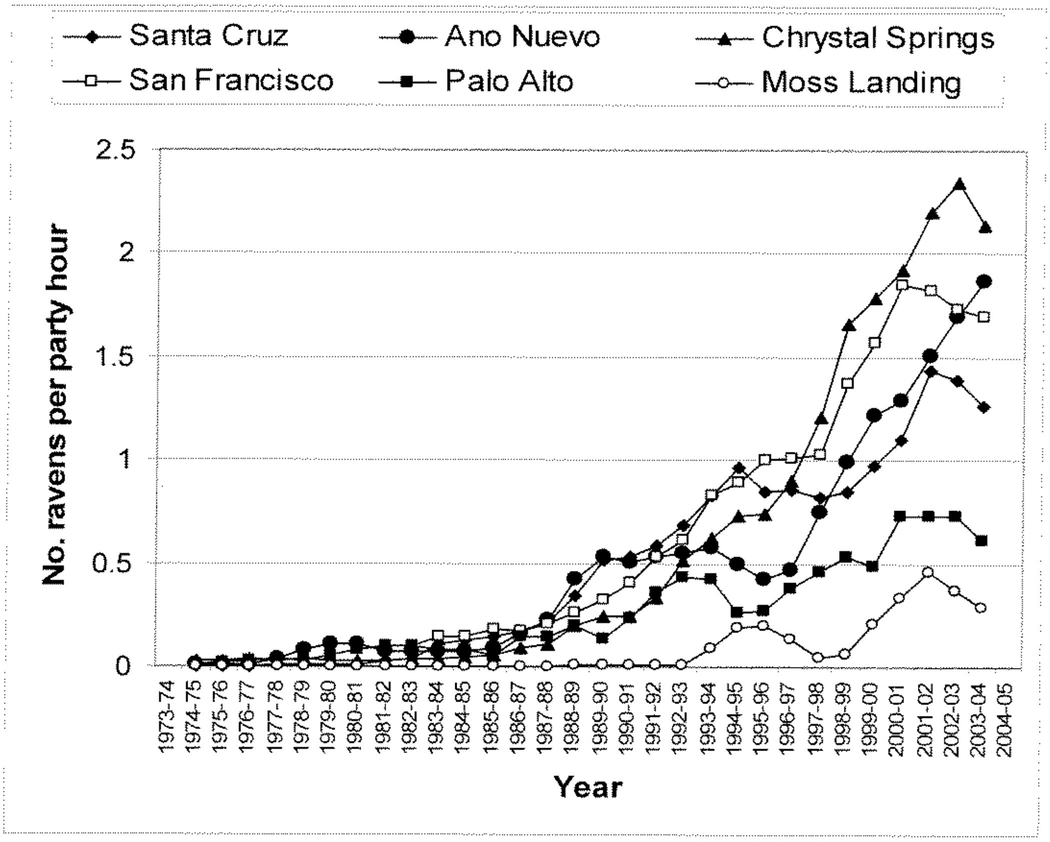


Figure 2. Common Ravens have increased dramatically in all six Christmas Bird Count circles in the Santa Cruz Mountains region. (Note: data presented as a 3-year running mean.)

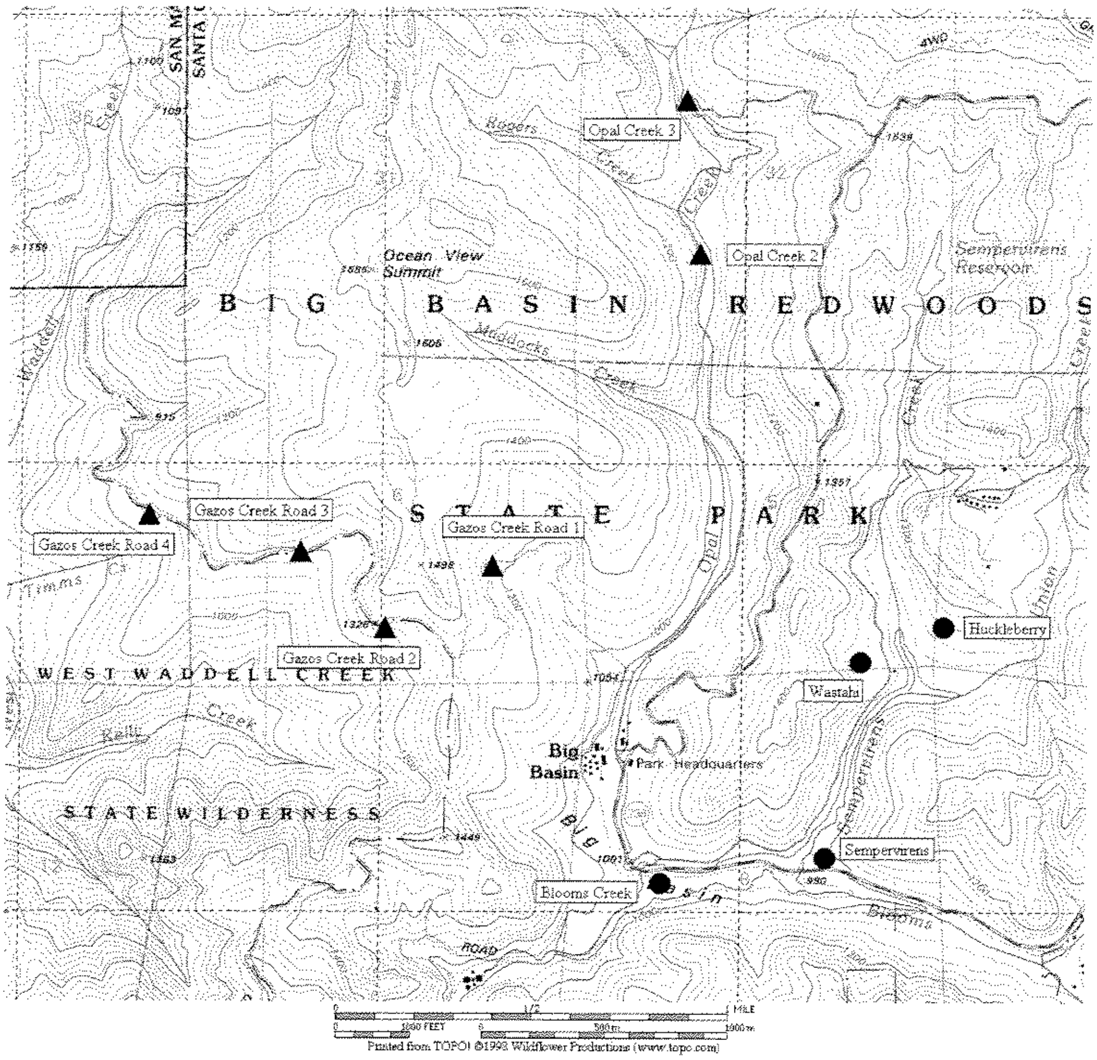


Figure 3. General location of corvid surveys area at Big Basin Redwoods State Park.

● treatment sites ▲ control sites

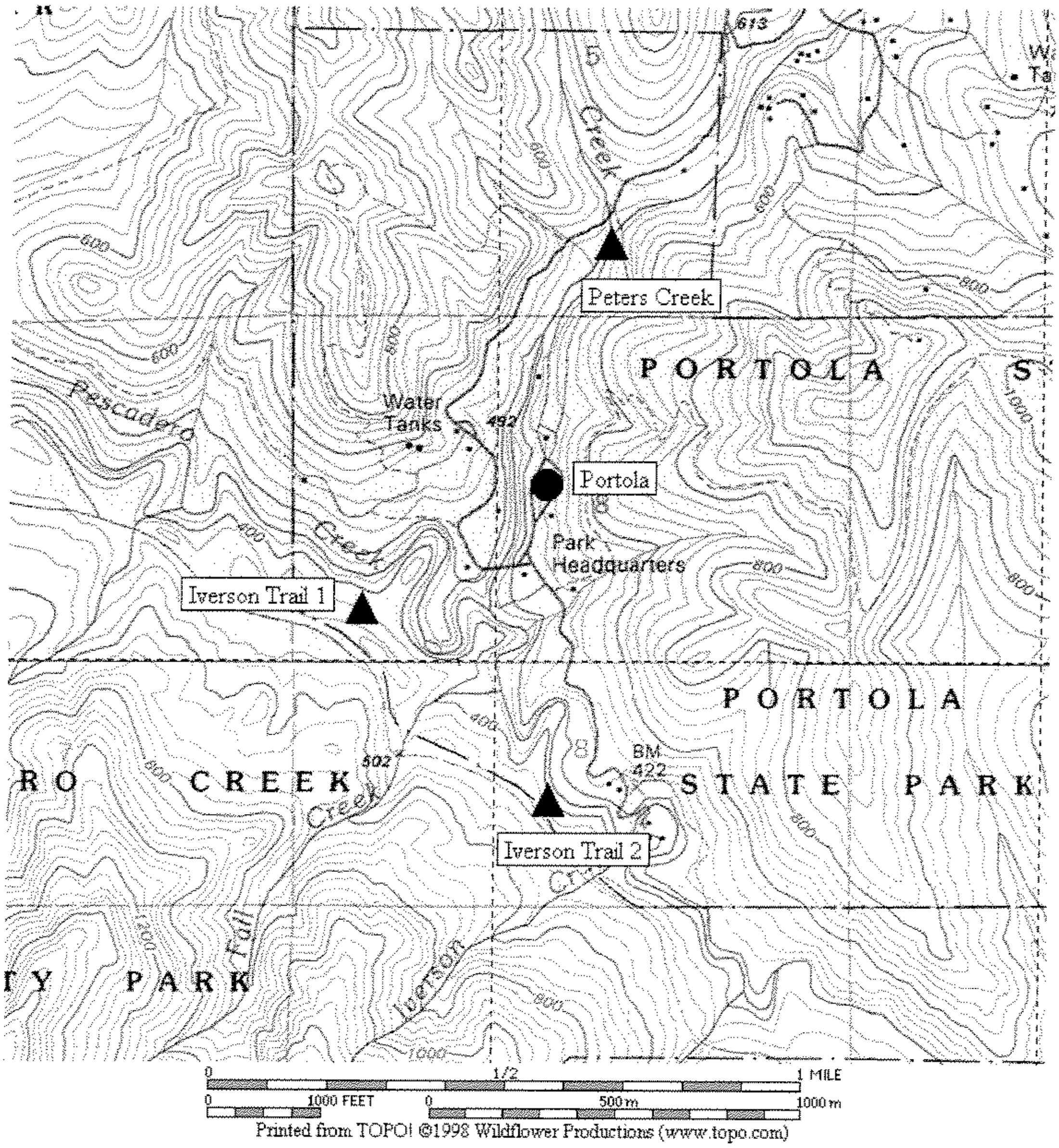


Figure 4. General location of corvid surveys area at Portola Redwoods State Park.

● treatment sites ▲ control sites

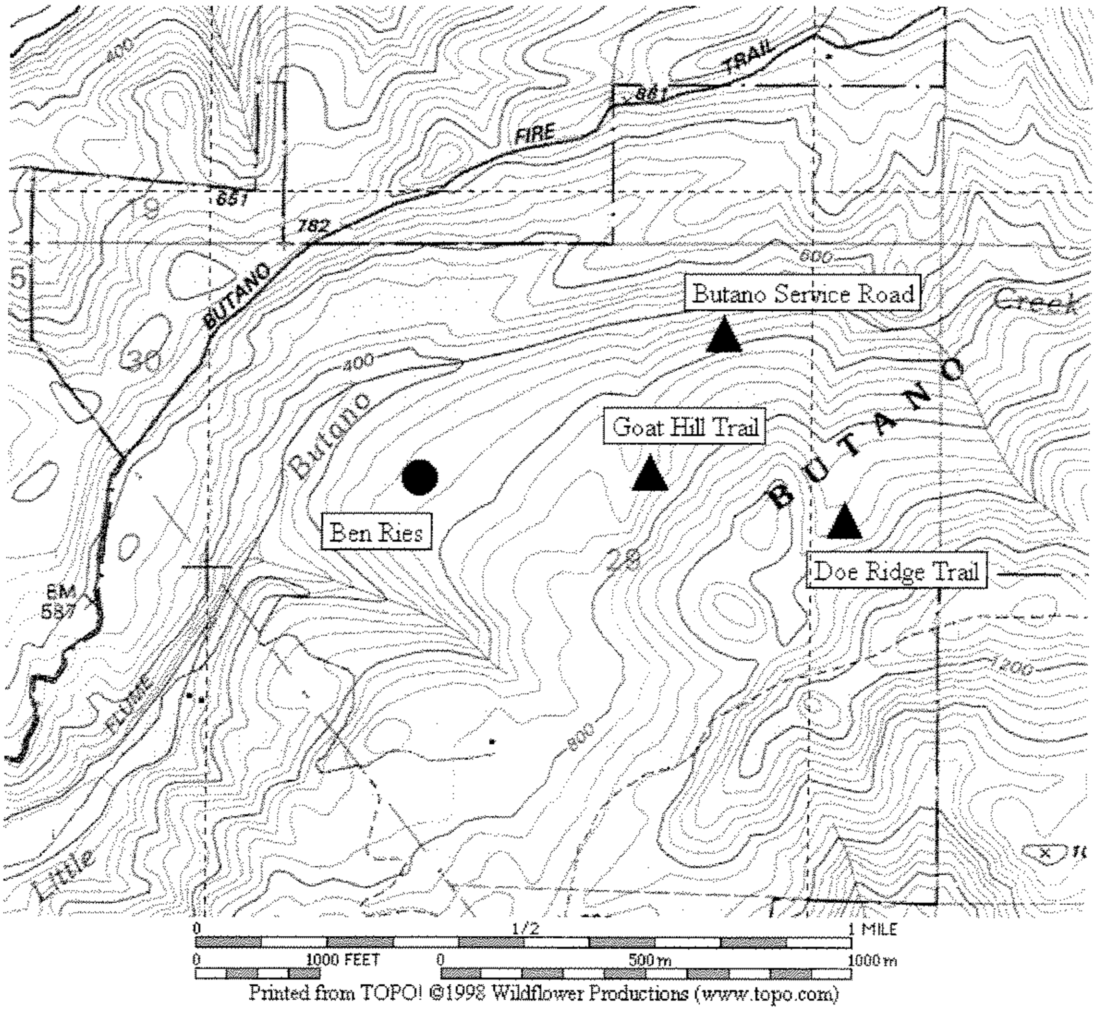


Figure 5. General location of corvid surveys area at Butano State Park.

● treatment sites ▲ control sites

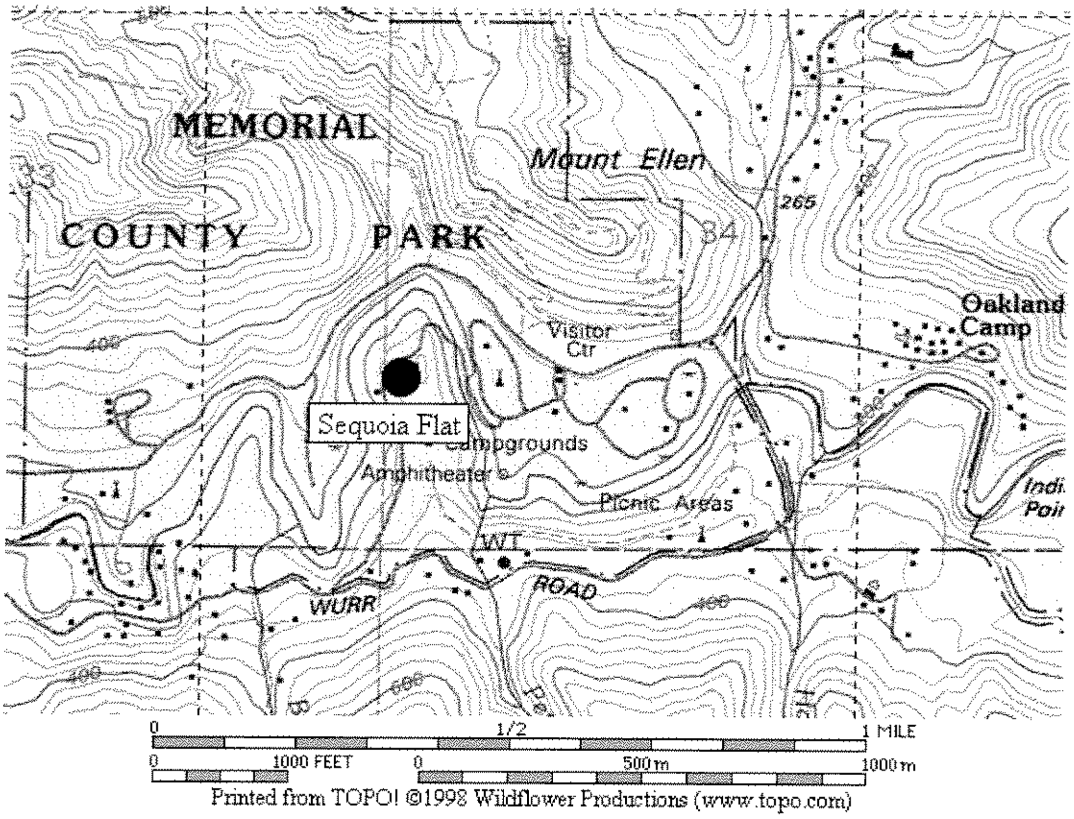


Figure 6. General location of corvid surveys area at San Mateo County Memorial Park.

● treatment sites

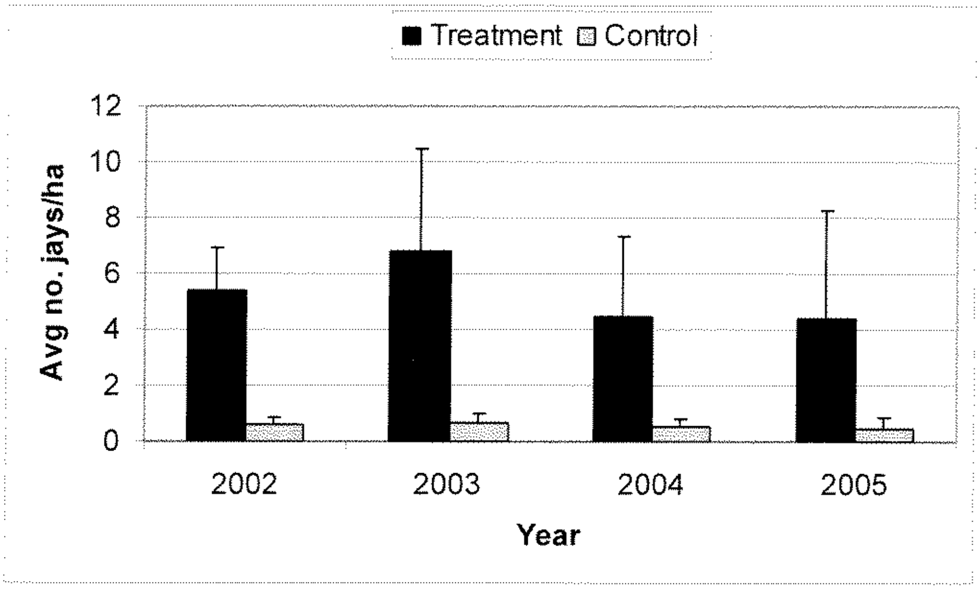
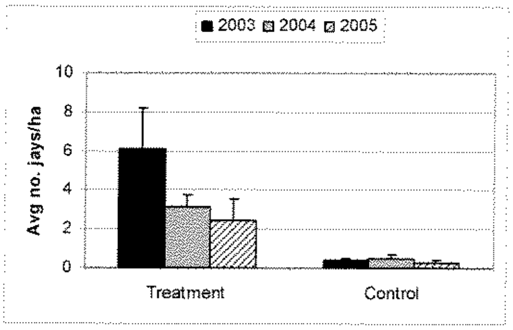
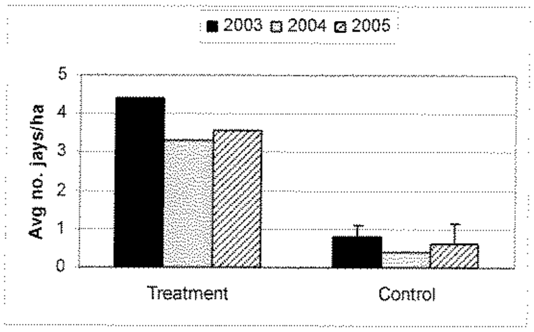


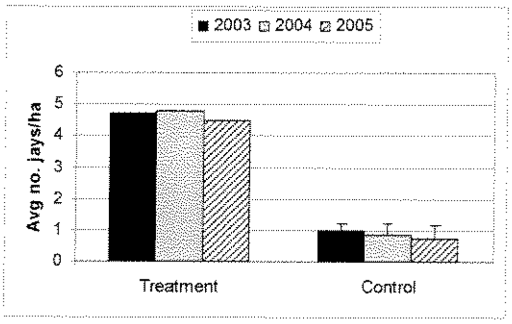
Figure 7. Abundance of Steller's Jay at all sites combined from 2002 to 2005.



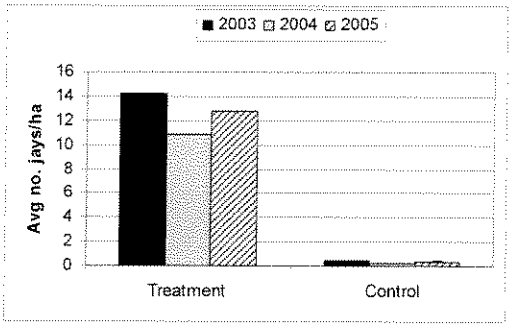
A. Big Basin



B. Portola



C. Butano



D. Memorial

Figure 8. Abundance of Steller's Jay in each park from 2003 to 2005.

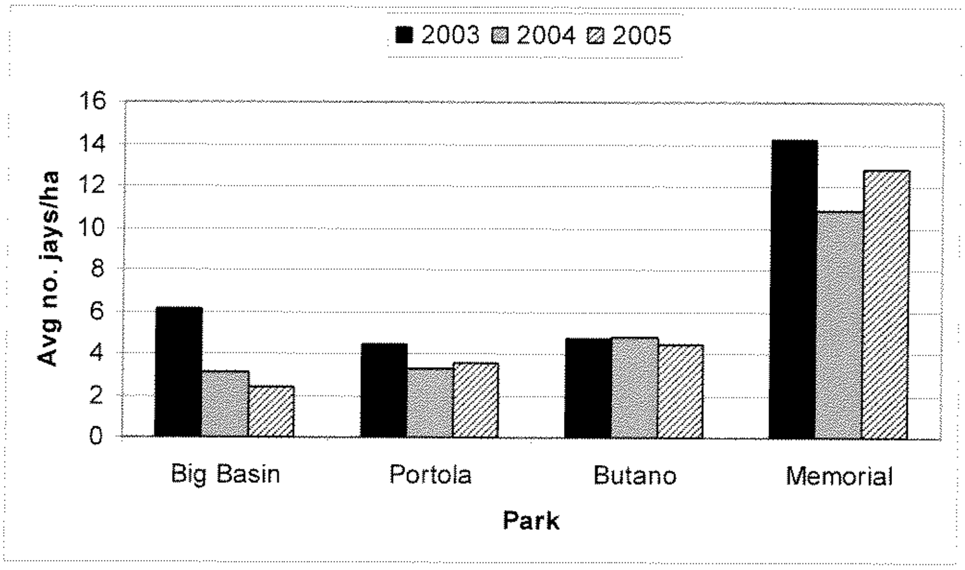


Figure 9. Relative abundance of Steller's Jays in treatment areas in each park from 2003-2005.

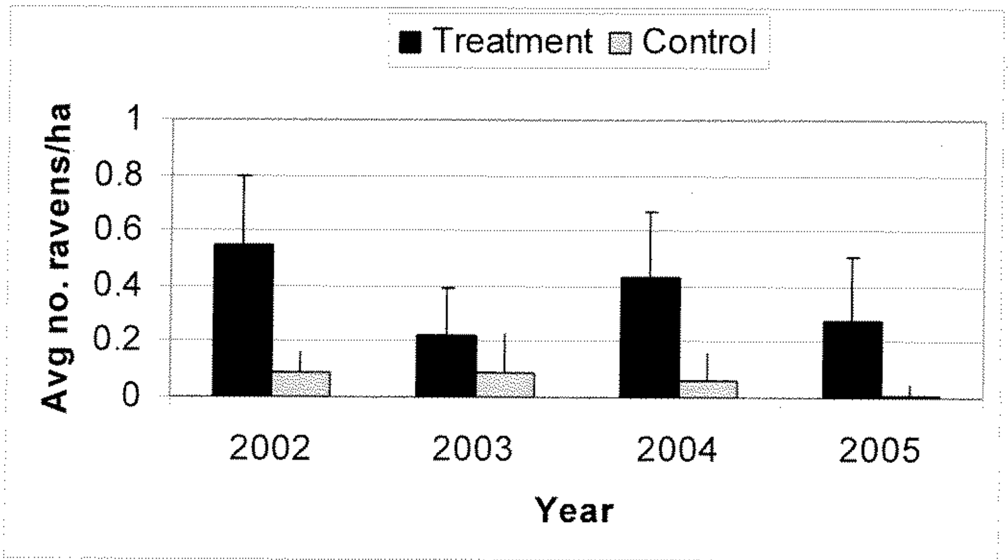
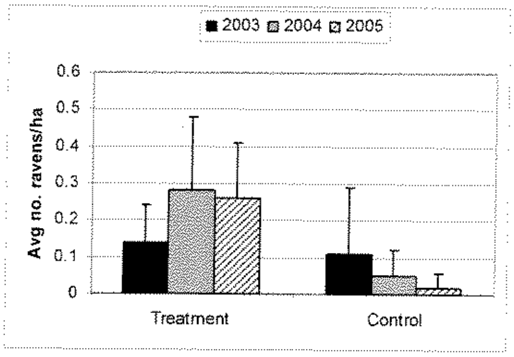
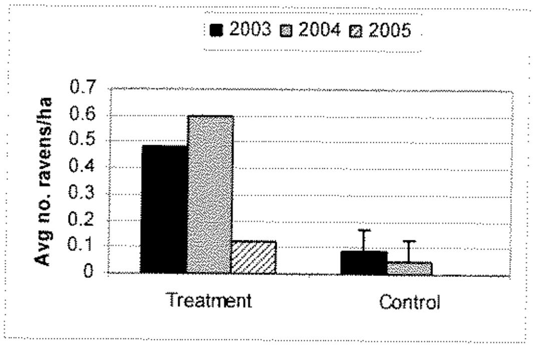


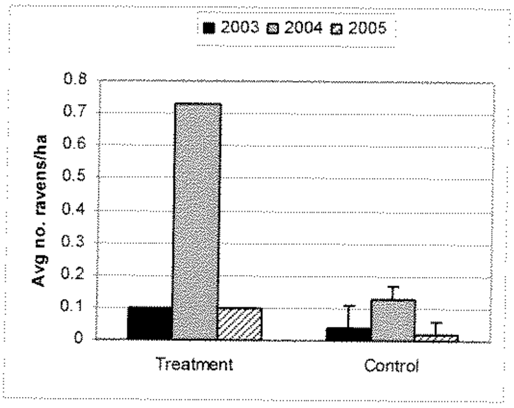
Figure 10. Abundance of Common Raven at all sites combined from 2002 to 2005.



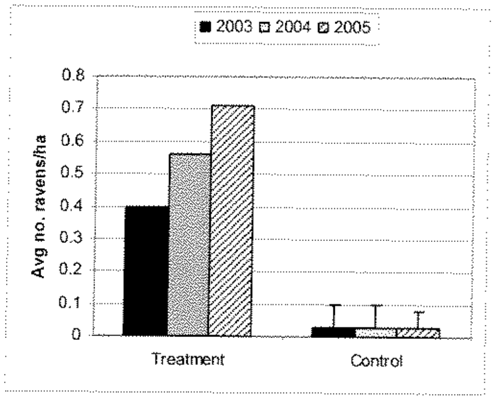
A. Big Basin



B. Portola



C. Butano



D. Memorial

Figure 11. Abundance of Common Raven in each park from 2003 to 2005.

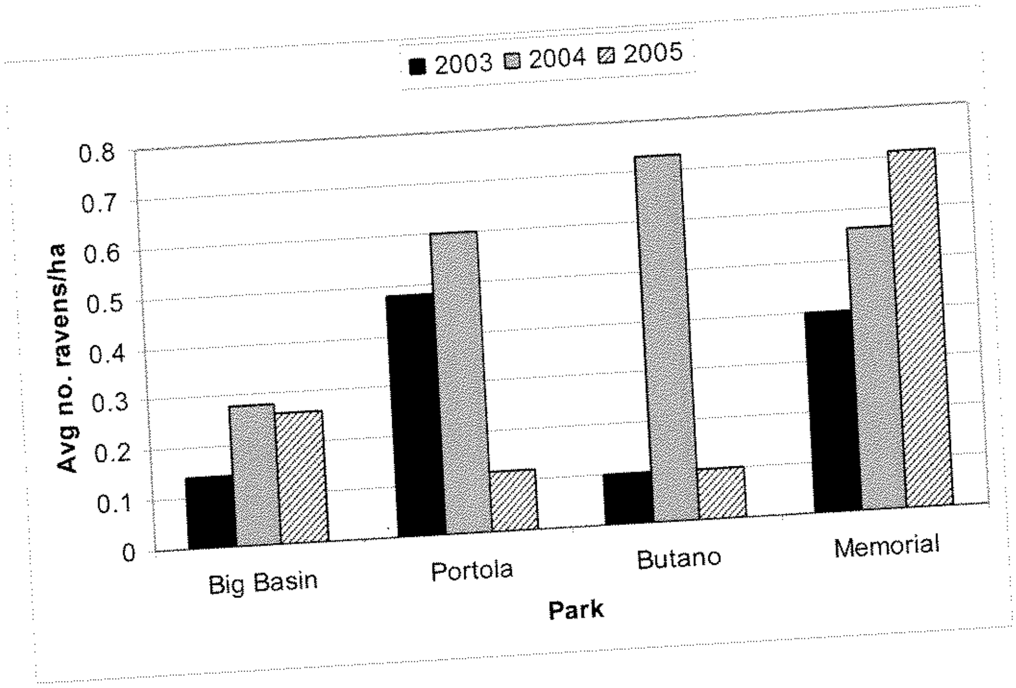


Figure 12. Relative abundance of Common Raven in treatment areas in each park from 2003-2005.

Appendix 1. Raw numbers of Steller's Jays and Common Ravens on each survey, 2003-2005.

STELLER'S JAY

Survey Area	2003 Run 1	2003 Run 2	2003 Run 3	2003 Run 4	2004 Run 1	2004 Run 2	2004 Run 3	2004 Run 4	2005 Run 1	2005 Run 2	2005 Run 3	2005 Run 4	Annual Maximum 2003	Annual Maximum 2004	Annual Maximum 2005
Big Basin															
Blooms	25	47	57	93	27	18	47	36	22	48	43	53	93	47	53
Sempervirens	11	25	33	54	17	19	18	25	11	19	14	19	54	25	19
Huckleberry	41	45	48	102	48	39	23	32	27	26	39	37	102	48	39
Wastahi	10	2	4	23	4	10	15	16	2	5	4	6	23	16	6
Opal 2	3	3	2	1	0	2	1	3	1	1	0	2	3	3	2
Opal 3	4	0	2	0	1	4	2	2	0	2	0	0	4	4	2
Gazos 1	4	4	3	1	2	2	1	1	1	3	0	0	4	2	3
Gazos 2	0	2	2	1	1	1	0	1	3	0	0	0	2	1	3
Gazos 3	1	4	3	0	2	0	2	2	0	2	0	0	4	2	2
Gazos 4	3	2	2	3	1	1	0	0	0	1	0	1	3	1	1
Portola															
Portola	7	24	24	37	28	19	20	23	17	16	30	27	37	28	30
Peters	3	4	3	3	1	2	0	3	2	0	1	5	4	3	5
Iverson 1	8	5	6	6	1	3	2	1	0	4	0	8	8	3	8
Iverson 2	3	2	5	2	0	2	3	2	1	0	0	1	5	3	1
Butano															
Ben Ries	22	32	35	45	18	34	40	46	11	16	43	20	45	46	43
Service	4	8	3	4	2	2	5	4	2	2	4	0	8	5	4
Goat Hill	4	3	2	3	4	2	2	2	2	4	1	3	4	4	4
Doe Ridge	6	12	5	5	11	7	7	4	7	5	1	2	12	11	7
Memorial															
Sequoia	46	71	107	179	46	79	136	133	36	76	161	142	179	136	161

Appendix 1, continued.

COMMON RAVEN

Survey Area	2003 Run 1	2003 Run 2	2003 Run 3	2003 Run 4	2004 Run 1	2004 Run 2	2004 Run 3	2004 Run 4	2005 Run 1	2005 Run 2	2005 Run 3	2005 Run 4	Annual Maximum 2003	Annual Maximum 2004	Annual Maximum 2005
Big Basin															
Blooms	3	3	0	0	2	2	2	2	2	0	0	2	3	2	2
Sempervirens	1	0	0	0	1	0	4	4	1	0	0	0	1	4	1
Huckleberry	3	3	3	3	2	3	2	4	2	2	5	1	3	4	5
Wastahi	0	0	0	0	1	1	1	1	1	3	2	0	0	1	3
Opal 2	0	0	1	0	1	0	1	1	0	0	0	0	1	1	0
Opal 3	0	3	0	0	0	0	0	0	0	0	0	0	3	0	0
Gazos 1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Gazos 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gazos 3	0	1	1	0	0	1	0	0	0	0	0	0	1	1	0
Gazos 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portola															
Portola	0	4	3	3	1	5	4	2	1	0	0	0	4	5	1
Peters	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Iverson 1	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0
Iverson 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Butano															
Ben Ries	1	0	0	1	2	1	6	7	1	0	0	0	1	7	1
Service	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Goat Hill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Doe Ridge	0	0	0	0	1	1	0	0	0	1	0	0	0	1	1
Memorial															
Sequoia	2	3	4	5	7	5	7	5	5	5	9	2	5	7	9

2006 BIANNUAL REPORT

GAZOS CREEK MARBLED MURRELET MONITORING PROGRAM

Submitted to:

APEX HOUSTON TRUSTEE COUNCIL
SACRAMENTO, CALIFORNIA

SEMPERVIRENS FUND
LOS ALTOS, CALIFORNIA

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DECEMBER 2006

INTRODUCTION

This is a report of the 2006 survey results obtained as part of the multi-year monitoring program of Marbled Murrelet (*Brachyramphus marmoratus*) use of Gazos Mountain Camp and the Gazos Creek Watershed in the central Santa Cruz Mountains. The approved project includes funding for radar surveys in alternate years, but the funding for ground observer surveys has been exhausted. However "pro bono" ground surveys are conducted whenever possible and six were conducted in 2006. This report contains the results of both radar surveys and ground observer surveys conducted in 2006.

Gazos Creek is located in the central, western Santa Cruz Mountains and discharges into the ocean at a point about midway between Santa Cruz and Half Moon Bay. Radar surveys were conducted at the Double Low Gazos site, about 2.0 kilometers upstream of the mouth of Gazos Creek (see map, page 10). Ground observer surveys were conducted in the meadow at Gazos Mountain Camp, which is located at the end of pavement of Gazos Creek Road, about 4.2 kilometers upstream from the mouth of Gazos Creek (see map, page 10). Survey stations are described in Singer and Hammer (2002, 2001, and 1999). A review of the 17 murrelet nest sites that have been documented in the Santa Cruz Mountains and habitat conditions required for nesting can be found in Baker, et al. (2006).

The monitoring program is funded by the Apex Houston Trustee Council and began in 1998 when the Council contributed money toward the purchase of Gazos Mountain Camp, a 110 acre parcel containing some areas suitable for nesting by Marbled Murrelets. The Gazos Mountain Camp property was then purchased by the Sempervirens Fund and later transferred to the State Parks Department. The property included a 10-acre old-growth stand, a second-growth stand with some residuals, a large area of young second-growth, and a 12-acre developed camp area that does not contain potentially suitable murrelet nest trees, but does have buildings and other facilities. It was understood that the old-growth area would be preserved as nesting habitat for the marbled murrelet and the developed portion of the property would be used for environmental education, scientific studies, or some other use that would be appropriate for the setting and compatible with both the purpose of the park and the intentions of the Sempervirens Fund donors, whose contributions allowed purchase of the property. To be sure that uses on the developed portion of the property did not harm any nesting marbled murrelets, a set of habitat management guidelines was prepared by the Sempervirens Fund and the Apex Houston Trustee Council in 1999 (Singer, 1999).

Gazos Mountain Camp was transferred from the Sempervirens Fund to the State Parks Department in 2001 and is now a part of Butano Redwoods State Park. The 12-acre developed portion of the Gazos Mountain Camp property was then leased to the Pescadero Conservation Alliance (PCA) who will be operating a scientific field station and environmental education program on the developed portion of the site. This is exactly the type of land use that the Apex Houston Trustee Council had in mind for the developed area when it contributed funds toward purchase of the property, but arriving at this point was not easy. PCA received a coastal development and use permit from the County in 2003, however, due to an appeal, it was not granted until after an additional hearing before the California Coastal Commission in 2006. During the appeal process it became apparent that some members of the local community did not have a clear understanding of the intentions and/or goals of the Apex Houston Trustee Council or the Sempervirens Fund for the property nor did they have a good understanding of the nesting ecology of the murrelet and the various threats to nesting murrelets. A large amount of misinformation was disseminated during this time by the appellants and their allies which had to be debunked by local murrelet experts. Ironically, the presence of so much misinformation during this debate served to emphasize the need for the kind of science-based environmental education programs and biological studies that PCA will be providing.

METHODS

Ground observer surveys were used to determine general murrelet detection levels and types of murrelet activities in the meadow across from the old-growth stand, while ornithological radar was used to develop a watershed-specific index of murrelet abundance that could be used to determine changes in murrelet use and total numbers over time (for example, see Cooper et al. 1999, Singer and Hamer 1999). The results will not be available until the end of the monitoring program.

Radar Surveys

Radar surveys were conducted using a modified marine radar system with the antenna mounted onto the camper roof of a 4x4 Ford pickup truck. Specifications for the radar have been given previously (see Singer and Hamer, 2001). Radar surveys started 75 minutes before sunrise and ended 75 minutes after sunrise, and followed recommended procedures for conducting radar surveys in the appendix to the Pacific Seabird Group's "Methods for Surveying Marbled Murrelets in Forests" (Cooper and Hamer 2000).

The experimental design that will allow us to determine changes in murrelet use of the Gazos Creek Watershed was developed using the MONITOR and TRENDS population modeling software programs. The goal is to detect a 5% annual change in population size at a power of 0.80. Seven radar surveys from the Double Low Gazos station are conducted during each survey year with the first survey year having been done in year 2000. Surveys were conducted annually through 2002, and will continue on a biannual basis through 2010.

Ground Observer Surveys

During 2006, six ground observer protocol surveys were conducted in July in the lower meadow area of Gazos Mountain Camp, formerly known as the ball field. This area was previously used as a ball field, but is now off-limits for all activities that would be disruptive to murrelets during the murrelet breeding season. All ground observer surveys were conducted according to the Pacific Seabird Group protocol that was in force when the project was initiated (PSG Marbled Murrelet Technical Committee, 1994).

RESULTS AND DISCUSSION

Radar Surveys

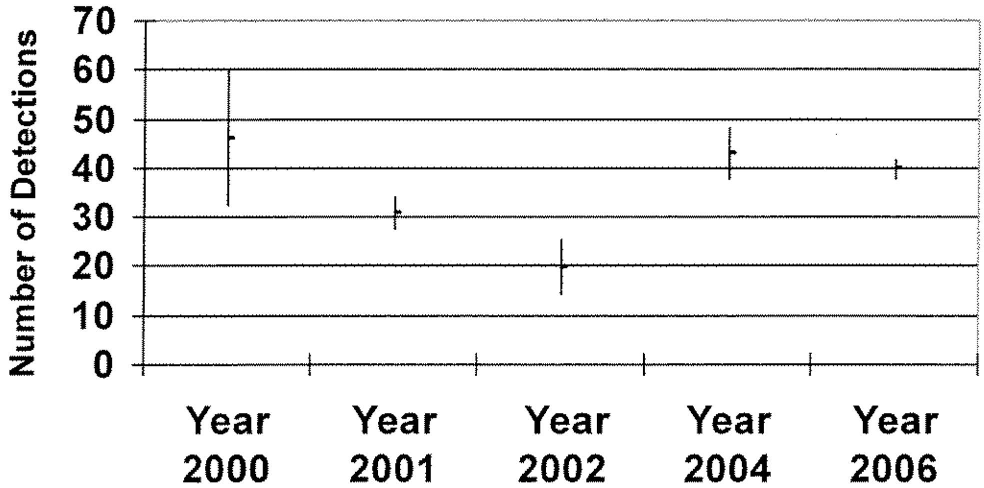
Seven radar surveys were conducted during July of 2006 at the Double Low Gazos site downstream of Gazos Mountain Camp. The total number of murrelets detected by radar in 2006 was close to the number detected in 2004, with a 7-day total of 279 detections in 2006 versus 300 detections in 2004. Results of the 2006 surveys are shown in Table 1 and compared with previous years in Table 2 and Figure 1. For a detection to be labeled as either "in-bound" or "out-bound", the bird's flight path had to be within 45 degrees of a line running along the long axis of the canyon. Detections labeled as "other" were of murrelets flying in other directions.

Table 1. Year 2006 results of radar surveys for murrelets at Double Low Gazos. Values for the mean (x), standard deviation (s.d.), and coefficient of variation (C.V.) are given in the bottom rows.

Date	% Overcast	Total Number of Detections	In-bound Detections	Out-bound Detections	Other Detections
7/02/06	100	39	10	18	11
7/03/06	100	40	10	25	5
7/04/06	100	38	15	15	8
7/05/06	100	38	18	16	4
7/06/06	100	40	21	16	3
7/07/06	0	40	14	17	9
7/08/06	0	44	14	28	2
Totals		279	102	135	42
Mean		x = 39.86	x = 14.57	x = 19.29	x = 6.00
s.d.		s.d. = 2.04	s.d. = 3.99	s.d. = 5.09	s.d. = 3.37
C.V.		C.V.= 0.051	C.V. = 0.274	C.V. = 0.264	C.V. = 0.561

The daily 2006 radar total detection values ranged from 38 to 44, which contrasts with ranges from 2001 (27 – 36), 2002 (11 – 27), and, 2000 (30 – 68); but is comparable with the range found in 2004 (35 – 52).

Figure 1. Mean Number of Total Radar Detections



(Note: Error bars represent one standard deviation)

Table 2. Comparison of the totals, means, standard deviations, and coefficients of variation among 2000, 2001, 2002, 2004, and 2006 radar surveys at Double Low Gazos.

Detection Type	Parameter	2000	2001	2002	2004	2006
All Detections	Total (all 7 days)	323	217	138	300	279
	Mean	46.14	31.00	19.71	42.86	39.86
	Standard Deviation	13.80	3.27	5.82	5.31	2.04
	Coefficient of Variation	0.299	0.105	0.295	0.124	0.051
In-bound Detections	Total (and % of All)	85 (26%)	52 (24%)	26 (19%)	106 (35%)	102 (37%)
	Mean	12.14	7.43	3.71	15.14	14.57
	Standard Deviation	4.30	2.64	1.89	3.72	3.99
	Coefficient of Variation	0.353	0.354	0.509	0.245	0.274
Out-bound Detections	Total (and % of All)	144 (45%)	68 (31%)	65 (47%)	127 (42%)	135 (48%)
	Mean	20.57	9.71	9.29	18.14	19.29
	Standard Deviation	10.24	5.25	4.86	4.38	5.09
	Coefficient of Variation	0.498	0.540	0.523	0.241	0.264
Other Detections	Total (and % of All)	94 (29%)	97 (45%)	47 (34%)	67 (22%)	42 (15%)
	Mean	13.43	13.86	6.71	9.57	6.00
	Standard Deviation	7.32	8.59	2.98	2.99	3.37
	Coefficient of Variation	0.545	0.619	0.444	0.313	0.561

It should be noted that the lowest coefficient of variation is associated with the "All Detections" parameter each year, and that is the parameter we will be using to construct a population index.

It is known that the number of individuals flying inland varies from year to year due to factors other than population change (McShane et al. 2005, Peery et. al. 2004a; Peery et al. 2004b). In a two-year study, Peery et. al. (2004a) placed radio-tags on 46 murrelets and found that, within their tagged sub-populations, non-breeders didn't fly inland as often as breeders, and that the proportion of non-breeders in the regional population varied from year to year. This natural variation will tend to mask changes in population size and explains why this study must collect data over a many year period.

Ground Observer Protocol Surveys

In 2006, five ground observer surveys were conducted at Gazos Mountain Camp in July and one in early August. All surveys were done in the lower meadow. Results are presented in Table 3. For comparison, the results from surveys done in 2004 are presented in Table 4.

Table 3. Year 2006 results of ground observer surveys for murrelets at Gazos Mountain Camp. Values for the mean (x), standard deviation (s.d.) and coefficient of variation (C.V.) are given in the bottom rows.

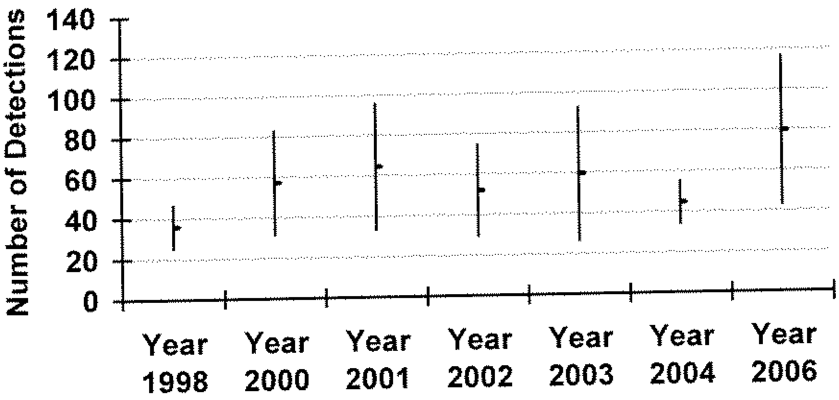
Date	%Overcast	Number of Detections (# visuals)	Number of Occupied Behaviors	Number of Single Silent Birds Below Canopy
7/6/06	80 – 100	98 (62)	41	11
7/8/06	0	71 (43)	17	3
7/12/06	60 – 100	107 (49)	21	0
7/19/06	0 – 35	52 (19)	16	1
7/28/06	75 – 100	125 (48)	23	2
8/4/06	80 – 100	25 (3)	1	0
Mean		x = 79.7	x = 19.8	x = 2.8
s.d.		s.d. = 37.33	s.d. = 12.94	s.d. = 4.16
C.V.		C.V.= 0.469	C.V.= 0.652	C.V. = 0.588

Table 4. Year 2004 results of ground observer surveys for murrelets at Gazos Mountain Camp. Values for the mean (x), standard deviation (s.d.), and coefficient of variation (C.V.) are given in the bottom rows.

Date	% Overcast	Number of Detections (# visuals)	Number of Occupied Behaviors	Number of Single Silent Birds Below Canopy
7/9/04	100	44 (18)	15	5
7/12/04	0	59 (21)	18	7
7/14/04	0	53 (16)	11	0
7/19/04	0 - 33	47 (24)	11	1
7/21/04	0	29 (2)	1	0
7/26/04	100	36 (2)	1	0
Mean		x = 44.7	x = 9.5	x = 2.17
s.d.		s.d. = 10.97	s.d. = 7.09	s.d. = 3.06
C.V.		C.V. = 0.246	C.V. = 0.747	C.V. = 1.41

Figure 2 plots the mean number of ground surveyor "total detections' for these years. Tables 5 and 6 provide data from 1998, 2000, and 2001 for a more detailed comparison with 2004 data.

Figure 2. Mean Number of Ground Survey Total Detections



(Note: Error bar represents one standard deviation)

Table 5. Comparison of the total detections and visual detections (in parentheses) of Marbled Murrelets by ground observers – 1998, 2000, 2001, 2002, 2003, 2004, and 2006 at Gazos Mountain Camp. Results ranked high to low by number of total detections. No surveys were done in 1999 and 2005. The mean number (x) of total detections is presented in the bottom row.

1998 Total Detections (# of Visuals)	2000 Total Detections (# of Visuals)	2001 Total Detections (# of Visuals)	2002 Total Detections (# of Visuals)	2003 Total Detections (# of Visuals)	2004 Total Detections (# of Visuals)	2006 Total Detections (# of Visuals)
49 (22)	100 (66)	105 (79)	75 (34)	127 (38)	59 (21)	125 (48)
42 (11)	67 (46)	85 (60)	72 (18)	56 (20)	53 (16)	107 (49)
41 (17)	59 (31)	85 (43)	71 (23)	46 (9)	47 (24)	98 (62)
38 (14)	57 (22)	53 (25)	38 (9)	45 (17)	44 (18)	71 (43)
28 (10)	36 (15)	34 (16)	31 (7)	45 (10)	36 (2)	52 (19)
18 (6)	25 (13)	26 (3)	25 (4)	39 (5)	29 (2)	25 (3)
x = 36.0	x = 57.3	x = 64.6	x = 52.0	x = 59.7	x = 44.7	x = 79.7

Table 6. Comparison of the number of occupied behaviors, designated as Occ. Beh., and single silent birds below canopy (SSBBC) detected by ground observers - 1998, 2000, 2001, 2002, 2003, 2004, and 2006 at Gazos Mountain Camp. Results were ranked from high to low by the number of occupied behaviors, which included birds circling above canopy. No surveys were conducted in 1999 or 2005.

1998 Detections Occ. Beh. & (SSBBC)	2000 Detections Occ. Beh. & (SSBBC)	2001 Detections- Occ. Beh. & (SSBBC)	2002 Detections Occ. Beh. & (SSBBC)	2003 Detections Occ. Beh. & (SSBBC)	2004 Detections Occ. Beh. & (SSBBC)	2006 Detections Occ. Beh. & (SSBBC)
16 (10)	31 (1)	43 (2)	18 (0)	15 (0)	18 (7)	41 (11)
13 (4)	21 (0)	29 (3)	14 (2)	15 (0)	15 (5)	23 (2)
13 (3)	15 (0)	19 (1)	8 (7)	10 (0)	11 (1)	21 (0)
10 (3)	10 (0)	7 (2)	7 (0)	9 (0)	11 (0)	17 (3)
7 (3)	7 (4)	6 (2)	5 (0)	5 (2)	1 (0)	16 (1)
5 (1)	6 (1)	3 (0)	3 (0)	4 (0)	1 (0)	1 (0)

Tables 5 and 6 show that there is a large amount of both day-to-day and year-to-year variation in both the number of total detections and the number of occupied behaviors from 1998 to 2004. This is in agreement with the work of Jodice (1998) who conducted ground surveys at 5 sites in the Oregon Coast Range on a near-daily basis throughout the season for three breeding seasons. He found there to be high variation in daily activity levels and concluded that the power of ground surveys to detect annual declines in detections of 25 percent and 50 percent were only "very low" and "moderate", respectively. Consequently, we are only using ground survey data to determine if nesting, or more correctly, behaviors associated with nesting are occurring, and not to ascertain trends in the number of murrelets using the canyon. Radar surveys are the only appropriate tool for that.

Much research has shown that the behavior most strongly indicative of nesting in the vicinity is single silent birds seen flying below canopy (SSBBC). When this behavior is observed on all or nearly all survey mornings, as was the case in 1998 and 2001, it may indicate that nesting is occurring in the nearby old-growth stand during the survey period, although the timing of these below-canopy flights would also need to be taken into considerations. Flights during the early part of the activity period are more likely to represent incubation exchanges.

CONCLUSIONS

A comparison of Figures 1 and 2 shows the value of radar surveys over ground surveys if trying to determine the number of murrelets using an area. Both year to year variation and day to day variation are significantly less when using radar (i.e., note the difference in the scale of the Y axis between the two tables). However ground observer surveys are useful for other reasons. They can provide evidence of nesting at Gazos Mountain Camp through the detection of occupied behaviors and the detection of single silent murrelets flying below the canopy. Radar surveys cannot detect birds flying below canopy in forests with small openings or meadows such as at Gazos Mountain Camp. What radar surveys can do is to provide an index of murrelet abundance in the Gazos Creek Watershed. Since non-breeding birds are not believed to consistently fly inland (Peery et al 2004) and since the number that nest will vary from year to year based on prey availability or other conditions (McShane et al., 2004, Peery et al. 2004b), there will be year-to-year variation in the number of murrelets flying inland. Consequently, to detect long-term trends, even radar studies need to be of a sufficient duration to overcome this source of variability. This study will provide two more years of radar data (2008 and 2010), and when it ends in 2010 should be able to answer the question, are the number of murrelets that use the Gazos Creek Watershed increasing, decreasing, or remaining stable?

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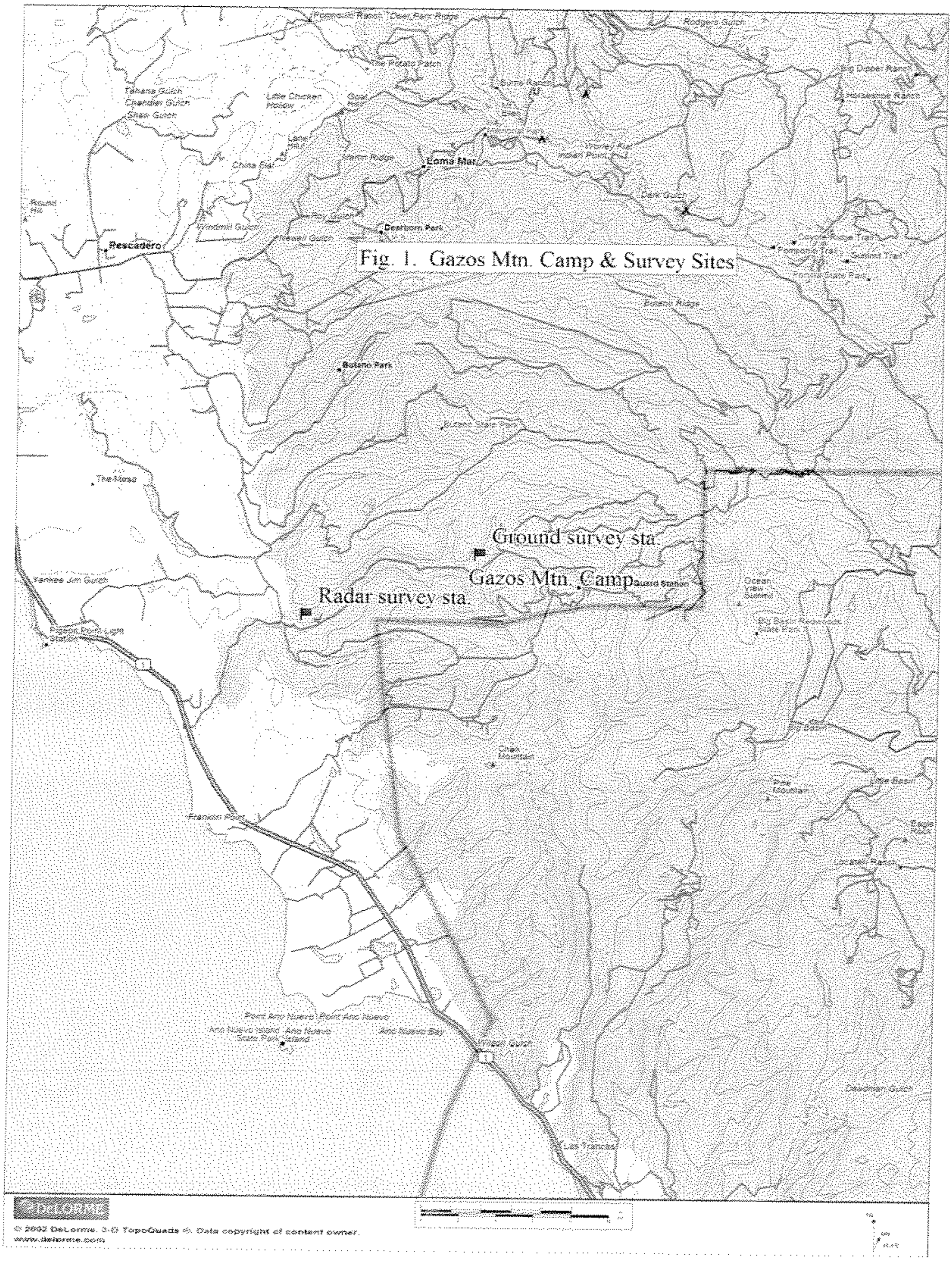


Fig. 1. Gazos Mtn. Camp & Survey Sites

2007 REPORT
GAZOS MOUNTAIN CAMP MURRELET MONITORING PROGRAM

by
Steven Singer
Certified Wildlife Biologist

Dec. 31, 2007

Introduction

In 2007, six ground surveys were conducted in the Meadow at Gazos Mountain Camp in Butano Redwoods State Park. These surveys are part of the larger Gazos Creek Marbled Murrelet Monitoring Program initiated by the Apex Houston Trustee Council and the Sempervirens Fund with the support of the California State Parks Department, and conducted under a Biological Investigations permit from the Parks Department. This program includes funding for murrelet radar surveys in alternate years, with the next scheduled radar surveys to occur in 2008.

Since the Apex Houston funds for ground surveys have been exhausted, these surveys were done on a pro bono basis. Three surveys were done by the author and three were done by Portia Halbert, State Park Ecologist.

Findings

The results of the six ground protocol surveys are shown in Table 1 below.

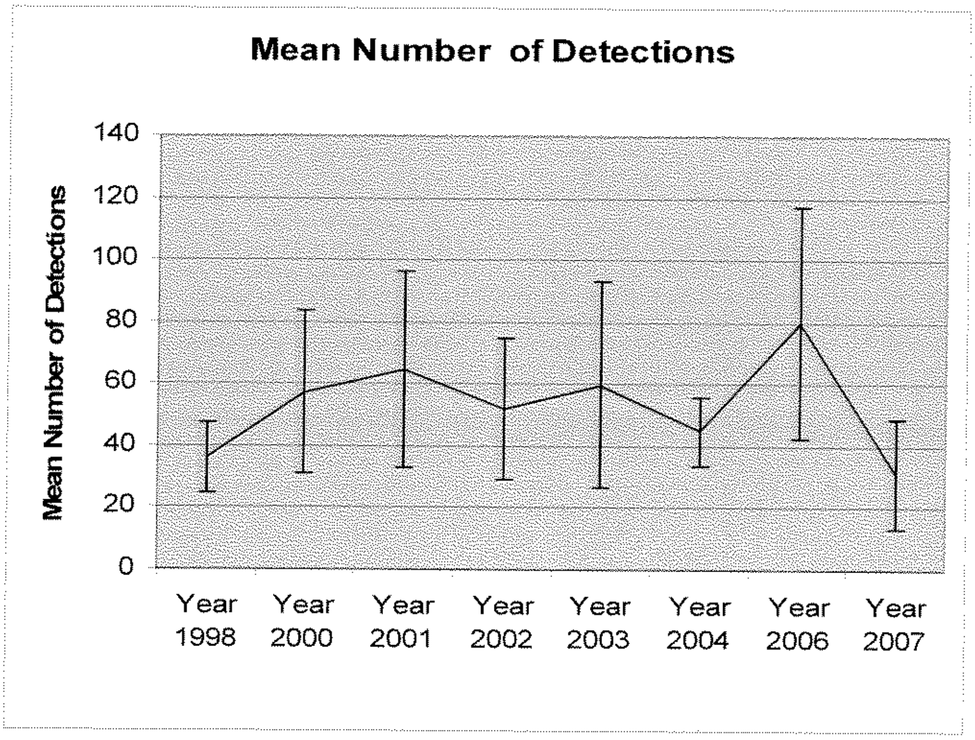
Table 1. Results of 2007 Marbled Murrelet Ground Surveys

Site	Date	Total Detects	# Occup. Behavior	# Visuals	# SSBBC	% Overcast	Ppt.	Fog (low ceiling)
Gazos Mtn Camp	6/29/2007	20	2	4	0	30 - 66	N	N
Gazos Mtn Camp	7/11/2007	40	8	12	5	100	N	N
Gazos Mtn Camp	7/14/2007	11	0	0	0	0	N	N
Gazos Mtn Camp	7/20/2007	38	5	7	1	10 - 50	N	N
Gazos Mtn Camp	7/29/2007	59	27	30	12	25 - 85	N	N
Gazos Mtn Camp	8/1/2007	19	13	14	2	66 - 100	N	N
MEAN		31.17	9.17	11.17	3.33			
STDV		17.77	9.87	10.55	4.63			
CV		0.57	1.08	0.95	1.39			
Notes: (1) #SSBBC = Number of single, silent birds below canopy								
(2) Occupied behaviors include circling above canopy								

Table 1 shows the high degree of variability associated with ground surveys. The number of daily total detections ranged from 11 to 59. Because of the high variability in daily detections, the purpose of the ground surveys is not to determine levels of annual use, but rather to provide evidence as to the type of use that is occurring. The fact that four of the six days had both occupied behavior and the occurrence of single silent birds below canopy suggests that the area and its environs are used as breeding habitat, although not necessarily in each year.

Graph 1 compares the mean total of daily detections in 2007 with the mean total of daily detections in previous years.

Graph 1. Mean Number of Ground Survey Murrelet Detections Since 1998



Graph 1 shows a drop in the mean number of detections in 2007, but that drop is not significant. The error bars associated with each point represent one standard deviation, and it is still possible to draw a straight line through them all. Thus these results do not show any trends in the annual number of murrelet detections, nor were they intended to. The broader program's radar surveys are more suited to determine any changes in the intensity of murrelet use over time.

Conclusion

Marbled Murrelets are still using Gazos Mountain Camp and are using it in a way that is compatible with breeding on the site or nearby.

Acknowledgements

Thanks to Portia Halbert for her field assistance. Thanks to the Pescadero Conservation Alliance for their support for this program as well as their on-going support for the protection and conservation of Marbled Murrelets in the Santa Cruz Mountains. Thanks also to the State Parks Department for granting a permit for this study.

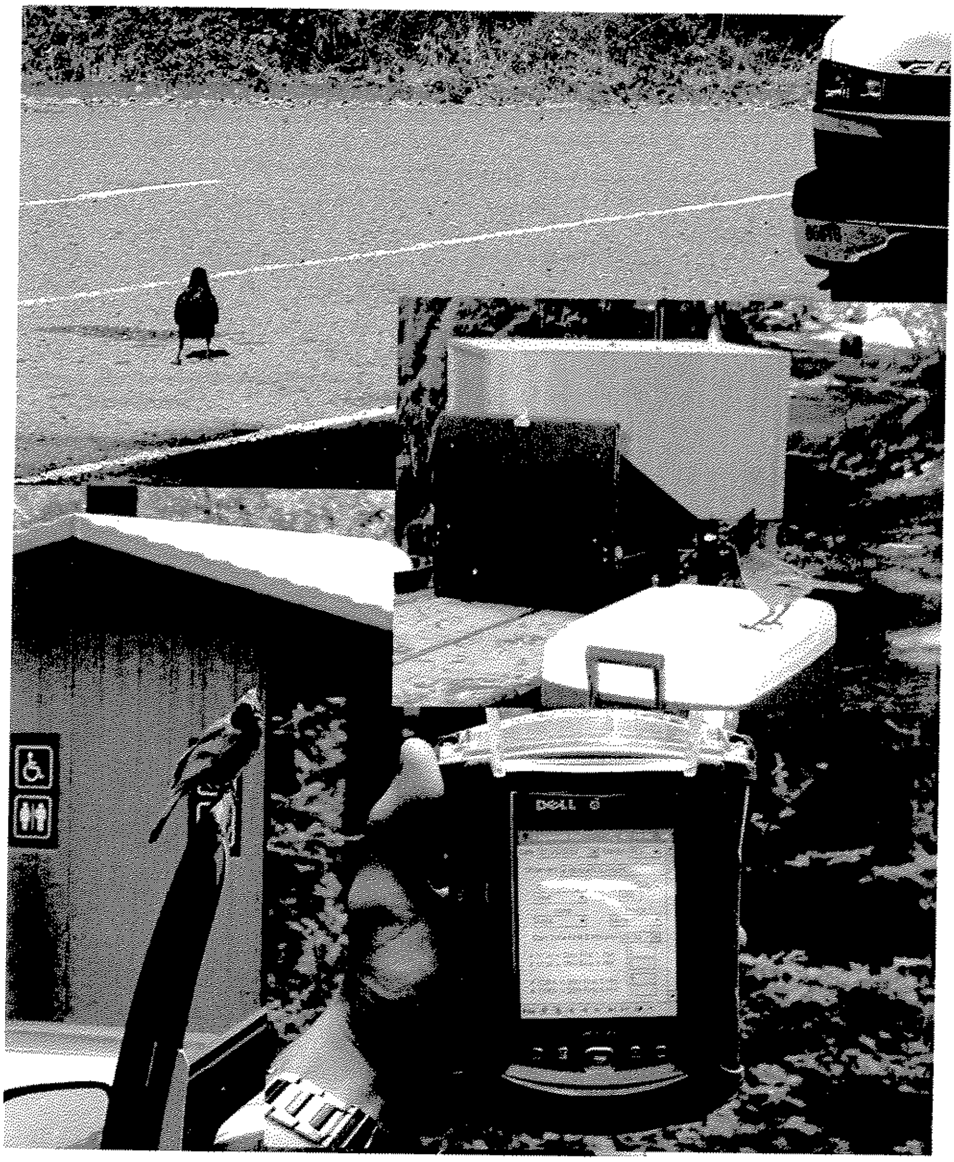
Redwood

National Park Service
US Department of the Interior

Department of Parks and Recreation
State of California

Corvid Monitoring
Corvid Management
Trail and Backcountry Management Plan Implementation

2007 Progress Report



Keith Bensen - Fish and Wildlife Biologist

Title page photographs, clockwise from upper left: common raven foraging at Big Tree parking lot, Steller's jay with human food scrap at Elk Prairie Campground, example of personal data assistant/data logger screen during *point count survey at trail control station #1 on Ten Tayapo Trail, Steller's jay on car door boldly begging for food from park visitors at Big Tree parking lot.*

INTRODUCTION

This report is divided into three interrelated sections concerning the management and monitoring of common ravens (*Corvus corax*) and Steller's jays (*Cyanocitta stelleri*) (collectively known as corvids) in Redwood National and State Parks (RNSP or parks). Section I covers corvid monitoring results for 2007. Section II describes corvid management activities that took place in RNSP in 2007. Section III reports on the progress of any new visitor use facilities constructed under the direction of the soon-to-be-completed RNSP Trail and Backcountry Management Plan. A comprehensive description of the purpose, policy, scientific background, management history, objectives and methods of corvid monitoring and management in RNSP and their relation to the RNSP Trail and Backcountry Management Plan is described in the park's Corvid Management Strategy (Draft). This report also satisfies the reporting requirements stipulated under the terms and conditions of the RNSP Trail and Backcountry Management Plan biological opinion (USFWS 2007).

The following paragraphs provide a brief overview of corvid predation of marbled murrelets (*Brachyramphus marmoratus*) and the parks' response:

The marbled murrelet was federally listed as threatened and California state listed as endangered in 1992. The Marbled Murrelet Recovery Plan (USFWS 1997) specifically identified RNSP as key to species conservation and recovery in California. Section 1.4 of the recovery plan states that nest predation by Steller's jays and common ravens is a threat to the species. Recovery action 3.1.2 in the recovery plan directs agencies to "decrease adult and juvenile mortality." This recovery action is given the highest priority rating. The most recent marbled murrelet five year conservation status review (McShane et al. 2004) revealed that nest predation is now the primary cause of current and future murrelet population decline, particularly in California. High rates of murrelet nest predation by corvids in RNSP have been conclusively recorded (Hebert and Golightly 2006). RNSP contains 62% of all the suitable murrelet nesting habitat in California and approximately 75% of the murrelets detected during at-sea surveys in California were off the coast of RNSP (McShane et al. 2004). Murrelets have been found to forage at sea primarily right off the coast of their inland nesting grounds (Raphael et al. 2004, Hebert and Golightly 2006). The California population represents roughly a third of the listed population. Current murrelet fledging success (percentage of chicks leaving the nest alive) within RNSP is estimated to be 0.3% - 2% (Hebert and Golightly 2006). To just maintain the current population size, RNSP fledging rates need to be between 18% and 28% (McShane et al. 2004). Thus, predation of murrelets by corvids in RNSP has the potential to have a significant negative impact on the listed murrelet population.

Numerous studies (e.g. Suddijan 2004, Leibzeit and George 2002, , Luginbuhl et al. 2001, George et al. 2001, Wallen et al. 1999) in and near national and state parks in Washington and California have tied increases in localized corvid densities and nest predation rates to supplemental food provided by park visitors. Almost all of RNSP's high-use visitor areas (i.e. campgrounds, visitor centers, picnic areas, trailheads) are located within high quality marbled murrelet nesting habitat. Recent studies in RNSP have revealed that Steller's jay densities in park campgrounds located in murrelet nesting habitat are two to six times greater than in murrelet nesting habitat away from campgrounds (George et al. 2001., Wallen et al. 1999). Conversely, murrelets have been found to have higher chick productivity in old growth forest areas located away from campgrounds that have lower corvid densities (Marzluff and Neitherlin, under review, Luginbuhl et al. 2001, Marzluff et al. 1996).

Due to the potential negative impact of visitor activities and their influence on corvid predation of marbled murrelets within RNSP, the park developed a Corvid Management Strategy (Draft). The aim of the strategy is to decrease the density of corvids surrounding visitor use developments in the parks. This report describes all corvid management and monitoring activities as well as visitor development construction minimization measures implemented by the parks in 2007.

SECTION I. CORVID MONITORING

A. Introduction

The RNSP Corvid Management Strategy (Draft) is adaptive. Effectiveness monitoring is central to the success of the strategy. Monitoring how and whether jay and raven populations are responding to management actions is central to determining whether the goal of reducing corvid densities near high use visitor areas is being met. As the monitoring information is collected, it is hoped that it will assist the park in directing corvid management activities to the most impacted areas and to using the most effective management techniques. At the least, the monitoring program is designed to determine whether the corvid management actions implemented by RNSP are successfully decreasing the density of corvids near park visitor use areas within suitable marbled murrelet habitat as compared to murrelet habitat areas located away from visitor developments. Again, for more detail on the monitoring system's design, rationale and corvid population targets, please refer to the RNSP Corvid Management Strategy (Draft).

B. Methods and Monitoring Station Locations

The point count survey protocol used for the RNSP corvid monitoring program is described in Appendix III of the RNSP Corvid Management Strategy (Draft). The 30 monitoring station locations are shown in Figure 1. The stations are grouped according to one of two types control areas or type of visitor use area they sample. Five control stations are located in marbled murrelet habitat areas at least 0.25 miles away from any visitor development (stations marked "FC" in Figure 1). Five control stations are located in marbled murrelet habitat areas along trails but at least 0.25 miles from any other visitor development (stations marked "TC" in Figure 1). Five stations are located within front country campgrounds in marbled murrelet habitat (stations marked "JS" and "PC" in Figure 1). Eight stations are located in picnic or major trailhead areas in or immediately adjacent to suitable marbled murrelet habitat (stations marked "PN" in Figure 1). Finally, seven stations are located along Redwood Creek downstream of the Bond Creek junction where dispersed backcounty camping is allowed (stations marked "RC" in Figure 1).

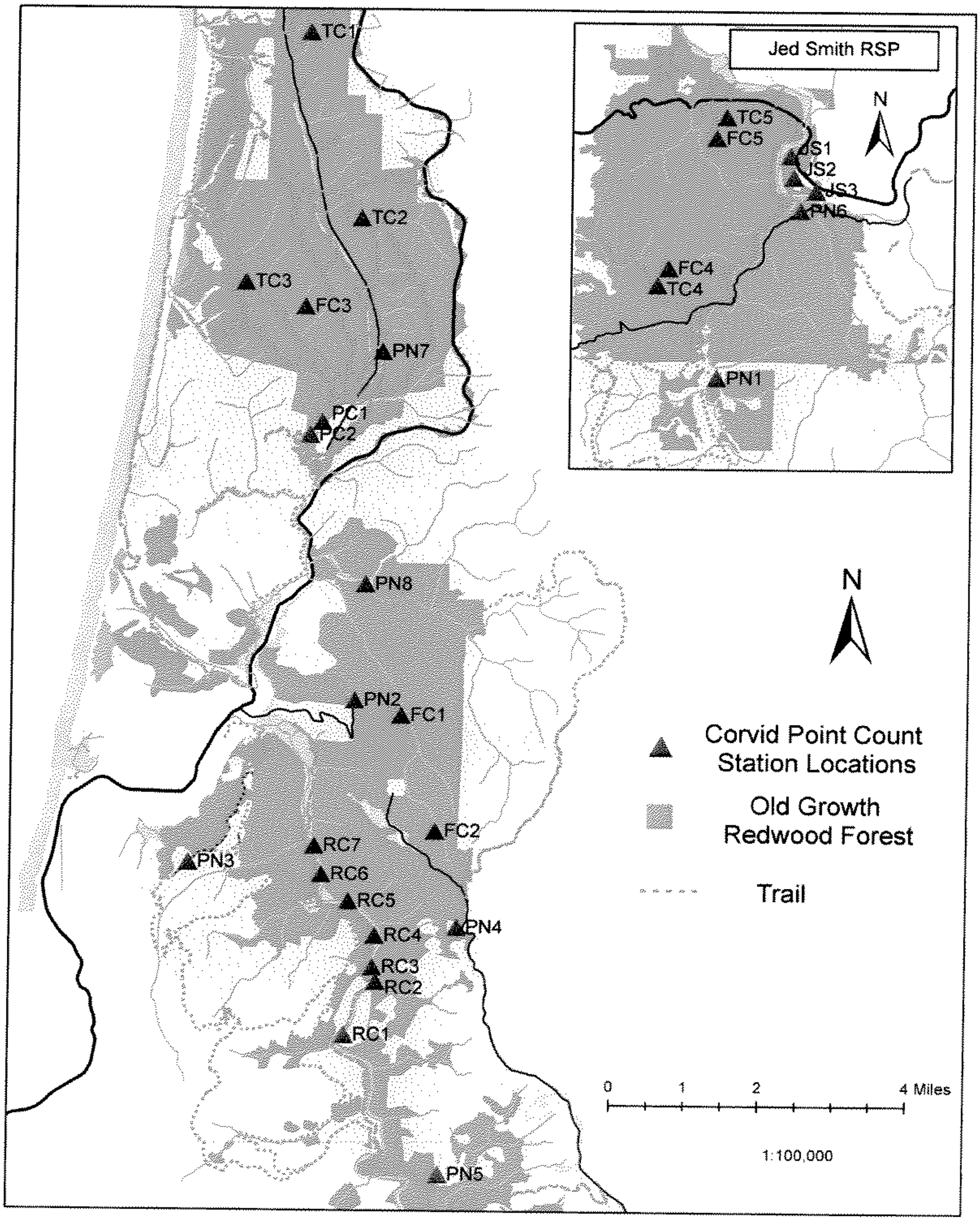


Figure 1. Location of point count survey stations within Redwood National and State Parks. FC = forest control station, TC = trail control station, JS = Jedediah Smith campground station, PC = Elk Prairie campground station, PN = picnic area station, RC = Redwood Creek dispersed camping area station.

C. Results

The 30 point count survey stations scattered throughout RNSP were visited twice a month from May through September of 2007 for a total of 300 surveys or ten visits to each station. Approximately 1,000 person hours were spent in the field completing the surveys.

The results for Steller's jays are shown in Table 1 and Figure 2. Only detections made within 50m of the survey station were analyzed because it is only within 50m that a high detection probability can be assumed according Luginbuhl et al. (2001) - the methodology that this monitoring program is based upon (Draft).

Table 1. Mean number of Steller's jays detected within 50m of point count stations in RNSP during May through September of 2007.

	Forest Control	Trail Control	Campgrounds	Picnic Areas	Redwood Creek
n	50	50	50	80	54[1]
mean	0.30	0.16	1.18	0.66	0.22
SD	0.81	0.51	1.40	1.02	0.58

[1]Stations along Redwood Creek could not be visited during the first few survey rounds in May because high water made surveys unsafe. In addition, a few station markers were destroyed by wildlife, effectively cancelling a few surveys until an accurate station location could be reestablished.

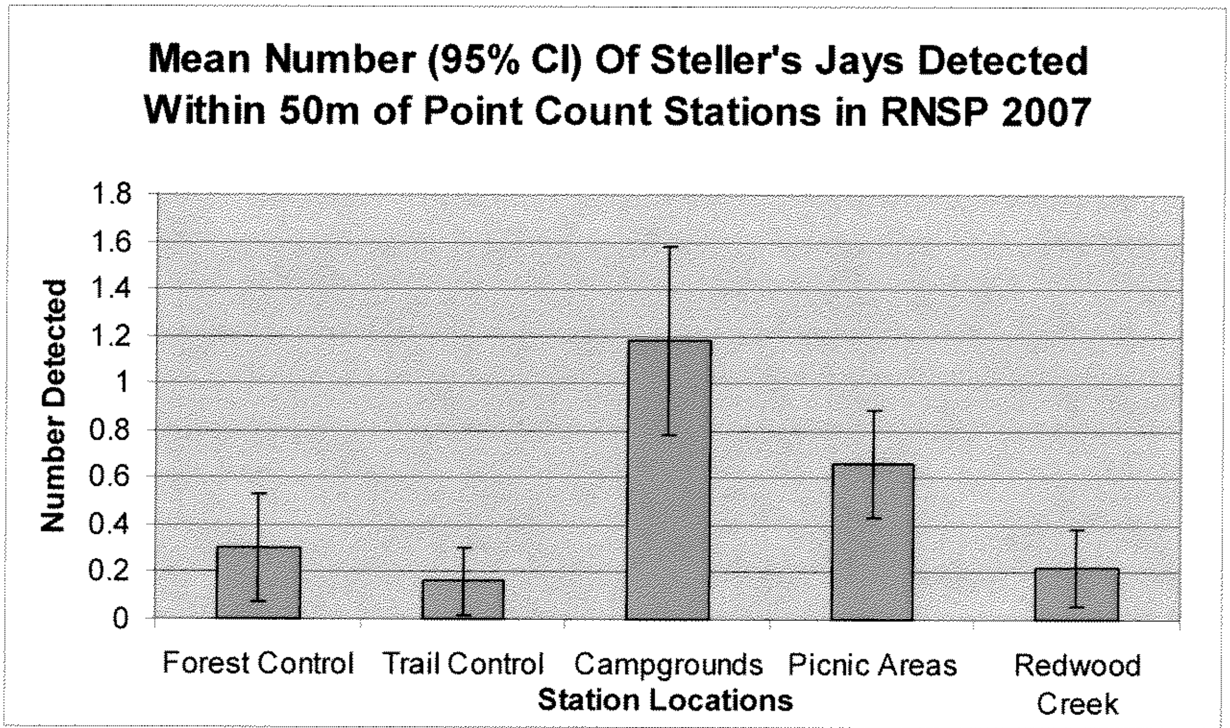


Figure 2. Mean number of Steller's jays detected within 50m of point count stations in RNSP in 2007. Error bars represent a 95% confidence interval.

The results for some of the visitor use area groupings may be misleading however, as demonstrated by the "within visitor use area" comparisons shown in Figure 3. Some survey stations *within* each type of visitor development contained considerably lower densities of Steller's jays than other stations of the same group type. Jedediah Smith campground station two was located within the middle of the campground, while Jedediah Smith campground station one was located within the picnic area of the campground which receives considerably less visitors per year (RNSP unpub. data, pers. obs.) than the campground. Stout Grove and Big Tree picnic areas receive considerably more visitors per year than do LBJ (Lady Bird Johnson Grove), Tall Trees and RC (Redwood Creek) Overlook picnic areas, while Mill Creek Trail and Orick Horse Trail picnic areas receive the least visitors per year (RNSP unpub. data, pers. obs.).

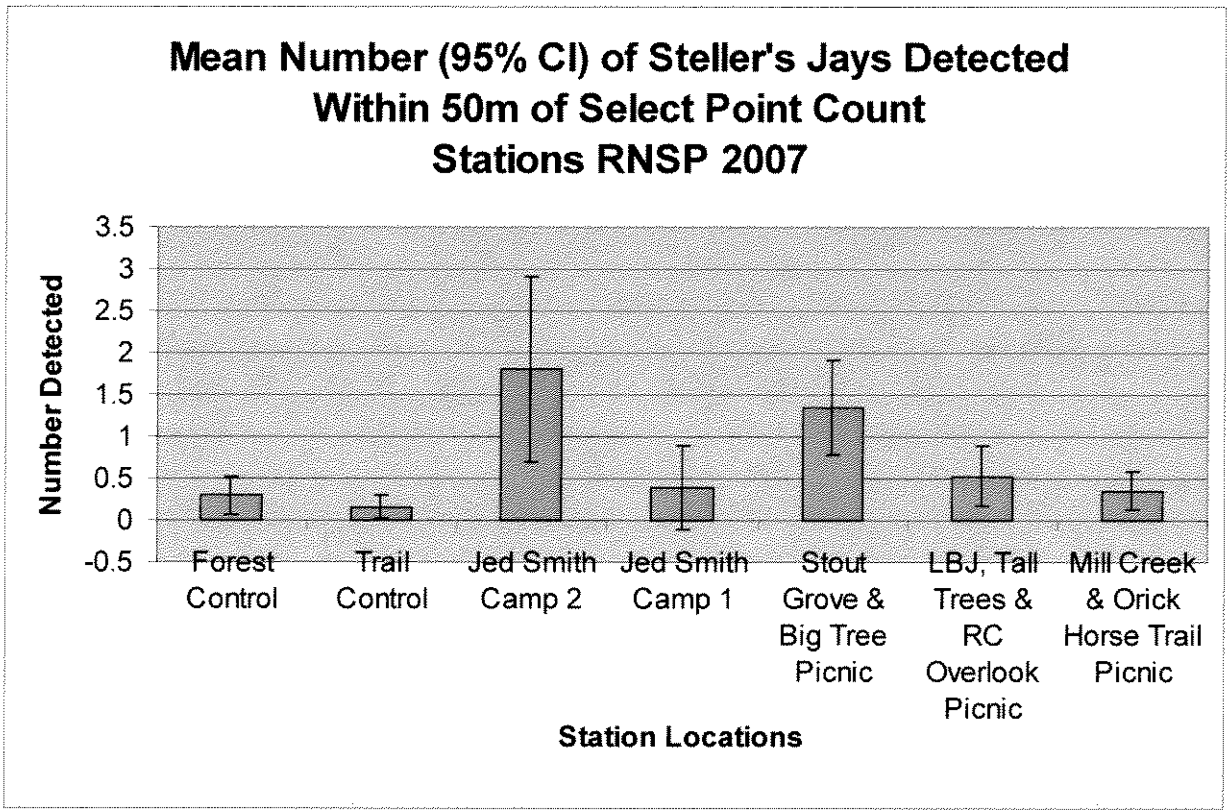


Figure 3. Comparison of some select survey stations within the same visitor use area category. Mean number of Steller's jays detected within 50m of point count stations in RNSP in 2007. Error bars represent 95% confidence interval.

The large home ranges and long distance daily movements of common ravens violate the assumptions of the point count sampling methodology used as part of this monitoring program. This problem was anticipated during the design of the monitoring program (J. Marzluff, J. Black, L. George pers. comm.) and is amply demonstrated by the results shown in Table 2 and Figure 4. None or virtually no ravens were detected within 50m of monitoring stations, except within the campgrounds.

Table 2. Mean number of common ravens detected within 50m of point count stations in RNSP during May through September of 2007.

	Forest Control	Trail Control	Campgrounds	Picnic Areas	Redwood Creek
n	50	50	50	80	54
mean	0	0	0.22	0.08	0.04
SD	0	0	0.51	0.35	0.19

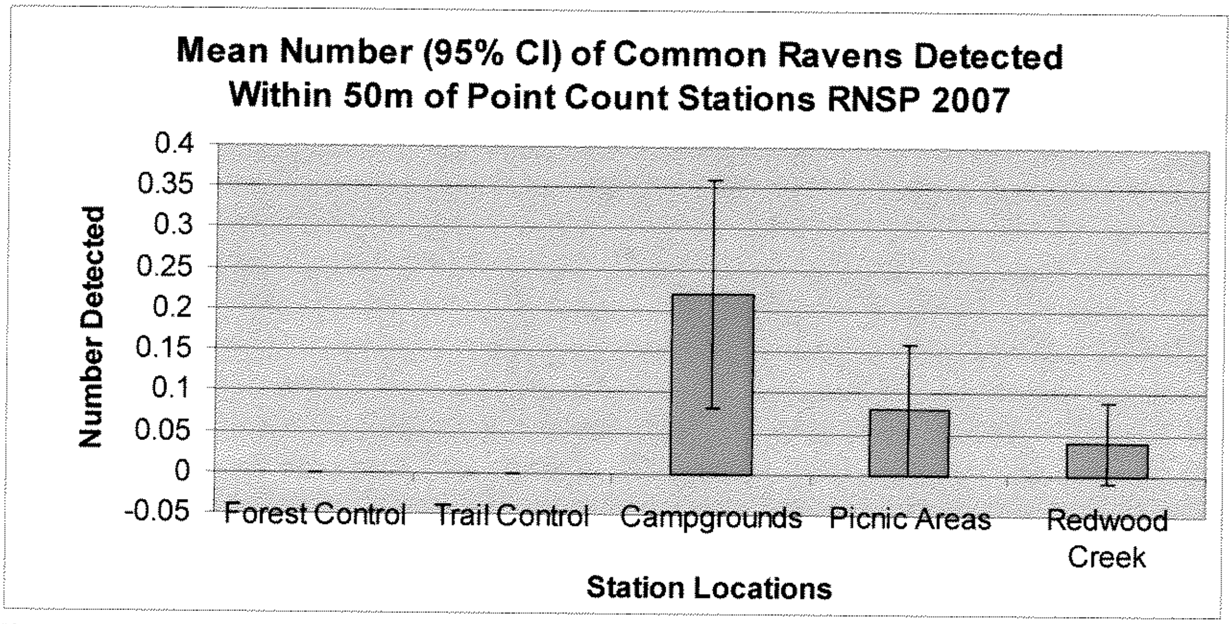


Figure 4. Mean number of common ravens detected within 50m of point count stations in RNSP in 2007. Error bars represent 95% confidence interval.

The relative abundance of common ravens can be roughly represented, however, by looking at the "no boundary" plot results, as shown in Table 3 and Figure 5. These results represent all detections at each station, regardless of how far away the individual ravens were from the station. Raven population numbers cannot be estimated with this method nor can a high probability of detection be established, making the results inconclusive.

Table 3. Mean number of common ravens detected at any distance of point count stations ("no boundary" plot method) in RNSP during May through September of 2007. Results indicate relative abundance only.

	Forest Control	Trail Control	Campgrounds	Picnic Areas	Redwood Creek
n	50	50	50	80	54
mean	0.20	0.18	0.72	0.24	0.54
SD	0.61	0.33	0.86	0.60	1.02

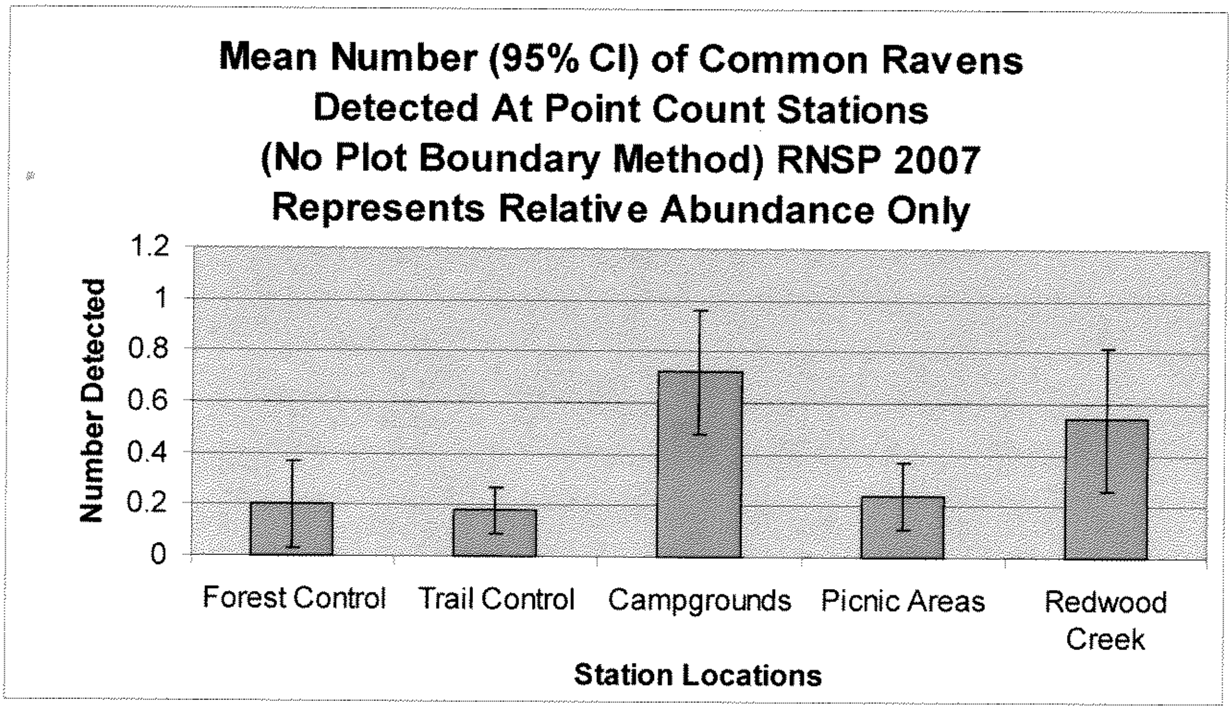


Figure 5. Mean number of common ravens detected at any distance of point count stations (infinite plot size) in RNSP in 2007. Error bars represent 95% confidence interval.

D. Discussion/Recommendations

The primary purpose of this past year's corvid survey effort was to provide a baseline upon which future survey years may compare as corvid management is implemented within RNSP. This objective proved logistically feasible and should be sustainable in future years if current biological technician staffing levels are maintained. A within year comparison between survey station categories showed, as expected, that the campground areas contained a significantly higher number of Steller's jays as compared to the two control category types in 2007; campgrounds averaged six times the number of jays. The picnic areas averaged approximately half as many jays as the campgrounds but were also significantly higher than the control areas. The high standard deviations and broad confidence intervals, however, confound the accuracy of these samples. Additional sampling in future years should bring these figures down and make conclusions more reliable. In addition, the "lumped" figures are misleading, however, as some of the more visited picnic areas had significantly higher jay detections than the least visited picnic areas. The least visited picnic areas actually had the same jay dectections as the control areas. This may indicate that humans are having very little effect on jay behavior and population size at low visitation developments in RNSP. This appears to be corroborated by the results from the dispersed camping area along Redwood Creek where the jay detections were identical to the two control category types. If these trends continue in future survey years, it may show that human effects on jays is only measurable at high visitation sites like front country campgrounds and high visitation front-country picnic sites and not detectable at low visitation backcountry picnic sites. Finally, the two control category types were nearly identical. If this trend continues for the next two years, it may be warranted to drop the hard-to-get-to and time consuming forest control stations and replace them with similar trail control stations, as recommended by J. Baldwin (pers. comm.).

Two previous Steller's jay point count surveys (Wallen et al. 1998 and George et al. 2001) have been conducted within the Jedediah Smith and Elk Prairie campgrounds and undeveloped marbled murrelet habitat areas of RNSP. Unfortunately, neither of those surveys used the same methodology used for this survey effort and so the results are not directly comparable. George et al. included birds up to 100m from point count stations, twice as far as the limit for this survey, and also included birds detected while walking in between survey stations. George et al. detected much higher numbers of jays at both campgrounds and at control sites; over 14 jays/station detected at the campgrounds and between two and five jays/station at control sites. Wallen et al. used a "no plot boundary" sampling method (J. Gordon, pers. comm.), again, unlike the 50m radius plot size used for this survey effort. Wallen et al. had somewhat similar results to those from this survey but unfortunately did not provide any confidence intervals. Interestingly, the factor of difference between the campgrounds and the control areas from both previous survey efforts roughly matches the results from this year's surveys, between two and six times greater, depending on the development type compared from this year (i.e. campground or picnic area).

The survey results for common ravens, also as expected (L. George and J. Black pers. comm.), were not conclusive. Raven territories and daily movement patterns are simply too large to be accurately sampled using standard point count methods. Hence the almost total lack of detection within the 50m plot size results. The "no plot boundary" results are also difficult to analyze because no detection reliability index can be established for birds located greater than 50m from point count stations, thus violating the assumption that all individuals are being observed. The variation in detectability is especially apparent when stations located deep in forests are compared to more open country survey stations like those along Redwood Creek. The longer sight lines of the Redwood Creek stations allow for greater visual detections and may skew results considerably (L. George pers. comm. and pers. obs.). L. George (pers. comm.) is currently researching statistical methods which may allow adjustments for such variables. Unfortunately, at this point in time, the raven results are not easily interpreted.

SECTION II. CORVID MANAGEMENT

A. Introduction

A comprehensive description of the purpose, policy, scientific background, management history, objectives and methods of corvid management in Redwood National and State Parks (RNSP or park) is described in the parks' Corvid Management Strategy (Draft). The following summary of actions implemented in 2007 is intended to match the organization of section V - Management Strategy, of the RNSP Corvid Management Strategy (Draft), for ease of tracking.

B. Corvid Management Actions Implemented

Section V. A. - Visitor Education, was partially implemented with the following tasks accomplished:

- The motto, "Don't Let a Good Bird Go Bad" joined the other motto of, "Feed a Jay, Kill a Murrelet" on printed materials given to visitors.

- A corvid-marbled murrelet education article was included in the 2007 issue of the RNSP visitor guide newsletter. 10,000's of these visitor guides were handed out across the parks.
- Approximately 1,200 corvid-murrelet education color posters were handed out to visitors, local educators and students.
- Approximately 10,000 "rack cards" about the corvid-marbled murrelet issue were handed out to visitors at front country campgrounds and visitor centers. Funding provided by a USFWS grant.
- A short presentation on the corvid-murrelet issue was included in all campfire programs from June through August.
- A corvid-murrelet educational video produced by Santa Cruz county CDPR parks was shown at two RNSP visitor centers on a daily basis.
- Wayside educational outdoor panels about the corvid-murrelet issue were installed at the Jedediah Smith, Elk Prairie, Mill Creek and Gold Bluffs Beach front county campgrounds. Panels were funded through an NPS grant.
- Corvid-murrelet educational signs were installed in all trailhead information kiosks.
- A corvid-murrelet dedicated web page was added to the publicly accessible Redwood National and State Parks website - http://www.nps.gov/redw/naturescience/marbled-murrelet.htm.

Section V. B. - Temporary Partial Dispersed Camping Prohibition and Removal of Select Picnic Tables, will be implemented in two years.

Section V. C. - Law Enforcement, was implemented as part of standard law enforcement practices within RNSP. No specific actions were reported to the Corvid Program Manager.

Section V. D. - Facility Management, was implemented as part of the standard maintenance procedures of RNSP. No specific actions were reported to the Corvid Program Manager.

Section V. E. - Program Coordination and Reporting, an RNSP staff member was assigned as the Corvid Program Manager to coordinate corvid management activities in RNSP. This report partially satisfies the data analysis and reporting component of this task.

Section VI. A. - Visitor Education Evaluation, was not implemented during 2007. Preliminary meetings with a Humboldt State University natural resource education researcher (Dr. Carolyn Ward) were held to plan for a potential corvid-murrelet visitor education evaluation program in the near future.

Section VI. B. - Corvid Monitoring and Reporting, was completed. The survey effort and data analysis described in this report documents this task for 2007.

Section VII. A. - Adaptive Management Process, will be implemented in two years.

Section VII. B. - Future Corvid Management Options, will be implemented, if necessary, in three to four years.

Section VIII. A. - Outside-the-parks Corvid Management, was not implemented in 2007 due to lack of additional funding and staff.

Section VIII. B. - Research, was implemented in 2007. Humboldt State University Wildlife Management graduate student, Ann Graham, under the direction of Dr. Luke George, conducted field work collecting data on common raven distribution in and around the Prairie Creek/Gold Bluffs Beach/Orick Valley area. Results should be available sometime in 2008 or 2009.

Section VII. C. – Additional Visitor Education, was not implemented in 2007 due to lack of additional funding and staff.

SECTION III. TRAIL AND BACKCOUNTRY MANAGEMENT PLAN ACTIONS AND AVOIDANCE AND MINIMIZATION MEASURES

A. Introduction

This report describes all visitor development construction minimization measures implemented by the parks in 2007 as stipulated in the terms and conditions of the soon-to-be-completed RNSP Trail and Backcountry biological opinion (USFWS 2007).

B. Trail Plan Actions and Avoidance and Minimization Measures Implemented

Since the RNSP Trail and Backcountry Management Plan was not fully completed in 2007, no new visitor use facilities were opened to the public and no new construction was completed. However, spotted owl presence surveys were conducted in preparation of the construction of two new trails. Spotted owl surveys were conducted around the rerouted James Irvine Trail in Prairie Creek Redwoods State Park and around the Elk Meadow to Lady Bird Johnson Grove Connector Trail. No spotted owls were detected during either survey.

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ABUNDANCE AND PRODUCTIVITY OF MARBLED MURRELETS OFF CENTRAL CALIFORNIA DURING THE 2007 BREEDING SEASON

Final Report
Submitted to

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Summary

We conducted five at-sea surveys for Marbled Murrelets (*Brachyramphus marmoratus*) off central California during the 2007 breeding season; four surveys offshore of breeding habitat between Half Moon Bay and Santa Cruz, and one survey in northern Monterey Bay. Using distance sampling, we estimated the central California population at 367 (95% CL = 240-562) individuals in 2007. This represents a 47% decline since the last surveys were conducted in 2003. The date-corrected ratio of juveniles to after-hatch-year birds in 2007 was 0.049 (SE = 0.0051), which was similar to estimates from 1996-2003. Based on this value, reproductive success is not sufficient to support a viable population. Looking at historic population estimates dating back to 1989, it appears that the central California population of Marbled Murrelets is continuing to experience a substantial long-term decline.

Introduction

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird that is federally-listed as Threatened and state-listed in California as Endangered. Potential threats to Marbled Murrelets in California include loss of old-growth forest nesting habitat, changes in prey (small fish) availability, increasing predator populations, gill-netting bycatch, and oil spills (Carter and Erickson 1988, Peery et al. 2004, Peery et al. 2006b). To work towards recovery of the species, various oil spill trustee councils have provided funding for restoration, including protection of nesting habitat and management of predatory corvids. In the last several years, the Command Trustee Council (for the 1998 T/V Command oil spill) has initiated efforts to control food sources for corvids in the Santa Cruz Mountains, initiated lethal control of some corvids, and acquired 80 acres of potential nesting habitat in the Santa Cruz Mountains, to be incorporated into Butano State Park.

Population monitoring of Marbled Murrelets typically is conducted using at-sea surveys. Other monitoring methods are used to monitor inland activity, including radar surveys and audio-visual surveys, but these methods do not provide information on actual population size. Population size has been monitored using mark-recapture studies and at-sea line transect surveys (Peery et al. 2006a). Regular (e.g., annual) population estimates are critical in determining the success of restoration efforts and the current status of the species range-wide. Under the Northwest Forest Plan, annual at-sea monitoring occurs in California within Conservation Zones 1-5, from the Oregon border south to San Francisco Bay. Conservation Zone 6, from San Francisco Bay south to Monterey Bay, is not included in the Northwest Forest Plan; thus population monitoring within Zone 6 has occurred in some years with a combination of state, federal, and private funding, but monitoring has not occurred since 2003. To aid in determining the success of restoration efforts in the Santa Cruz Mountains, the Command Trustee Council funded limited at-sea surveys in Zone 6 during the 2007 breeding season.

Methods

We conducted four at-sea surveys between Half Moon Bay and Santa Cruz (approximately 100 km), and one at-sea survey between Santa Cruz and Moss Landing (approximately 27 km). The surveys between Half Moon Bay and Santa Cruz followed zig-zag transect routes consistent with similar surveys conducted between 1999 and 2003 (Peery et al. 2006a). These surveys included between 70 and 87 km of transect in a "nearshore" stratum (200-1350 m from shore) and between 15 and 27 km of transect in an "offshore" stratum (1350-2500 m from shore); they were conducted between 20 June and 19 July 2007 (Table 1). The survey routes were created using random starting points (Peery et al. 2006a). In previous years an equal number of routes were drawn from starting points at the north and south ends of the survey area. In 2007, two transects were drawn from the south and two transects were drawn from the north.

The survey between Santa Cruz and Moss Landing was conducted on 20 August 2007 to assess whether a substantial number of murrelets had dispersed south out of the primary study area into northern Monterey Bay. This survey was conducted along transect parallel to shore, approximately 400 m offshore, consistent with the methods of Henkel (2004).

For all surveys, line transect methods were used (Becker et al. 1997, Peery et al. 2006a). Two observers, standing on either side of a 6-m open skiff, recorded angle off the track line and distance to all groups of Marbled Murrelets seen (prior to each survey, observers calibrated distance estimation using a laser rangefinder on buoys in the harbor). Birds in flight were counted if they crossed a line perpendicular to the track line, even with the observers. Counting flying birds (16% of sightings were of flying birds) may result in overestimation of abundance (Spear et al. 1992, Piatt et al. 2007), but this method was used for previous surveys in Central California, and was used in 2007 for consistency. Sightings data were analyzed using DISTANCE v.5.0 (see Peery 2006a for details on how density estimates are derived using DISTANCE). After discarding all sightings beyond 120 m (n = 3), we had 81 sightings. These data were not adequate to include any covariates in the DISTANCE models (e.g., observer or observation conditions); all data were included in global estimates of effective strip width. The model of declining detectability with distance (a half-normal curve with cosine adjustments) fit the observed data well (chi = 2.2, df = 4, $P = 0.70$). Effective strip width (ESW) was 64.1 m. To calculate abundance, we multiplied density estimates generated by DISTANCE by the total area of each stratum (104.65 km^2).

Estimating Juvenile Ratios

We used the ratio of juvenile (0 year old; hatch-year or HY) murrelets to after-hatch-year ($\geq$1 year old; AHY) murrelets observed during at-sea surveys as an estimate of productivity (i.e., reproductive success). Juveniles were distinguished from after-hatch-year murrelets using the characteristics reviewed by Strong (1998). Methodology used to estimate juvenile ratios followed Peery et al. (2007) and is described below.

We estimated juvenile ratios for Marbled Murrelets based on at-sea surveys conducted from Julian Date 192 (July 10) to 234 (Aug 23), when 34% to 75% of young were expected to have fledged. After 23 August, after-hatch-year murrelets have progressed far enough in their pre-basic molt that they are indistinguishable from juveniles. However, only a proportion of juveniles is expected to have fledged and is available to be counted by at-sea surveys during this period. Therefore, we date-corrected juvenile ratios for the number of juveniles that had not fledged at the time each survey was conducted. To this end, we estimated the proportion of young expected to have fledged as a function of date based on 47 known fledging events in California using linear regression analysis, with the cumulative proportion of young fledged as the dependent variable and Julian Date as the independent variable (Peery et al. 2007). The number of HY observed or captured ($H_{observed}$) during on a given at-sea survey was then corrected using following equation:

$$H_{corrected} = \frac{H_{observed}}{-1.5433 + 0.0098 \bullet DATE_i}$$

where the denominator represented the regression model for the cumulative proportion of juveniles fledged regressed against date, $H_{corrected}$ was the date-corrected number of juvenile individuals, and $DATE_i$ was the Julian Date for survey or capture session i.

Juvenile ratios can be upwardly biased because incubating after-hatch-year murrelets are not available to be counted during at-sea surveys. We used the equation below to correct the number of after-hatch-murrelets observed during a particular at-sea survey for the number of after-hatch-years that were expected to be incubating at the time of the survey.

$$A_{corrected} = \frac{A_{observed}}{1-\left(18.7145545 - 0.18445455 \bullet DATE_i + 0.00045455 \bullet DATE_i^2\right)}$$

where the right side of the denominator represented the regression model for the proportion incubation AHY regressed against date, $A_{corrected}$ was the date-corrected number of AHY individuals, and $DATE_i$ was the Julian Date for survey or capture session i. This regression model was estimated based on the proportion of radio-marked after-hatch-year murrelets that were incubating on a given date (Peery et al. 2007).

We estimated the (observed and date-corrected) juvenile ratio R in year t with the following equation:

$$\hat{R}_t = \frac{\sum_1^n H_i}{\sum_1^n A_i}$$

where H_i and A_i were the number of juvenile and after-hatch-year individuals for survey i, respectively, and n was the number of surveys conducted in year t. We estimated $\text{var}(\hat{R}_t)$ as:

$$\hat{\text{var}}(\hat{R}_t) = \frac{1}{n}\left(\frac{\hat{\text{var}}(\hat{H}_t)}{\hat{\hat{A}}_t^2} + \frac{\hat{\hat{H}}^2\,\hat{\text{var}}(\hat{A}_t)}{\hat{\hat{A}}_t^4} - \frac{2\hat{\hat{H}}_t\,\hat{\text{cov}}(\hat{H}_t, \hat{A}_t)}{\hat{\hat{A}}_t^3}\right)$$

where $\hat{\text{var}}(\hat{H}_t)$ was the variance in the number of juveniles observed in year t, $\hat{\text{var}}(\hat{A}_t)$ was the variance in the number of after-hatch-years observed in year t, $\hat{\text{cov}}(\hat{A}_t, \hat{H}_t)$ was the covariance between the number of juveniles and after-hatch-years observed in year t, and $\hat{\hat{H}}_t$ and $\hat{\hat{A}}_t$ were the mean number of juveniles and after-hatch-years observed in year t, respectively. We estimated the mean juvenile ratio for the entire study period ($\hat{\hat{R}}$) by averaging unweighted annual estimates and $\hat{\text{var}}(\hat{\hat{R}})$ was estimated as:

$$\hat{\text{var}}(\hat{\hat{R}}) = \frac{\sum_{1}^{n} \hat{\text{var}}(\hat{R}_t)}{n}$$

where n was the number of years in which surveys were conducted.

Results

The mean estimate of abundance from the four surveys conducted from Half Moon Bay to Santa Cruz was 367 (95% CL = 240-562). Individual survey estimates ranged from 187 to 492 (Table 1). No murrelets were detected in the offshore stratum in Half Moon Bay to Santa Cruz surveys, nor were any murrelets detected on the survey between Santa Cruz and Moss Landing.

Survey direction (zig-zag transects drawn from the north vs. drawn from the south) can affect abundance estimates because surveys drawn from the south are more likely to sample protected coves. We provide the 2007 data along with historic data collected between 1999 and 2003 in this context (Table 2). Using data from both directions, the estimated abundance in 2007 represents a 47% decline from 2003 (Fig. 1). Using data only from surveys drawn from the north, there was a 56% decline from 2003 to 2007; and from the south, there was a 38% decline.

Consistent methods were used for at-sea surveys in central California beginning in 1999. Population estimates between 1989 and 1995 based on at-sea surveys using slightly different survey methods ranged from 763 to 853 (Carter et al. 1992, Ralph and Miller 1995, Strong and Becker 1996). Although the variable methods used before 1999 mean that these historic data are not directly comparable with data from 1999 to the present, combining these data with current data show a fairly consistent (and statistically significant) decline in the local population (Fig. 2).

Only two juveniles were detected, both on the 10 July survey. Based on three surveys conducted between 10 July and 23 August we estimate that the uncorrected juvenile ratio was 0.017 (SE = 0.017) and the date-corrected juvenile ratio was 0.049 (SE = 0.051; Table 3). This value is similar to juvenile ratios estimated from 1996-2003.

Discussion

Our results suggest that the Marbled Murrelet population in central California is undergoing a significant decline. Peery et al. (2006a) determined that, based on low reproductive success, the central California population should show a consistent annual decline in the absence of immigration. However, abundance estimates based on at-sea surveys conducted between 1999 and 2003 showed no population decline; thus, Peery et al. (2006) suggested that immigration from northern California was supporting the central California population. The population decline observed between 2003 and 2007 suggests that during this time either: 1) immigration has declined or 2) Peery et al (2006) did not detect a decline that was in fact occurring. Although Peery et al. (2006a) used data collected in a consistent manner from 1999 on, data from other historic surveys indicate a larger population decline. Considering the larger, albeit inconsistently collected, dataset, the lack of decline between 1999 and 2003 could potentially represent sampling "noise" on a fine scale (e.g., from dispersal into and out of the survey area), in the context of a long-term population decline. We have no means of assessing whether immigration into central California has declined since 2003.

The low abundance estimate in 2007 could also be due in whole or in part to increased dispersal out of the study area compared with previous years. Marbled Murrelets sometimes disperse out of the central California study area during summer, although little is known regarding annual variation in how many birds disperse (Peery et al. in press). Marine climate in central California during spring and summer 2007 may have somewhat anomalous. Considerable numbers of Horned Puffins (*Fratercula corniculata*) were present in central California during this time (up to 8 were recorded on our surveys), which is very unusual. This influx of a typically high-latitude species may have been related to lower than normal air temperatures during spring. Similarly, high adult mortality of Snowy Plovers (*Charadrius alexandrinus*) during winter/spring 2007 is thought to be related to this cold snap of sub-freezing temperatures (K. Neuman, pers. comm.). Anomalous ocean conditions could have led to non-breeding Marbled Murrelets leaving the study area. Marbled Murrelets are normally very rare off the Monterey Peninsula (Roberson 2002), yet local birders recorded groups here several times throughout the summer (e.g., 7 on 21 June; B. Sullivan pers. comm.). Similarly, 22 were reported on 9 June off Sunset State Beach, in northern Monterey Bay (Santa Cruz Bird Club files), whereas Henkel (2004) never recorded more than a single Marbled Murrelet in this area during two years of summer surveys. However, we did not find any Marbled Murrelets in Northern Monterey Bay during the August survey, and aerial surveys conducted in nearshore waters of Monterey Bay and south to Big Sur in June and July failed to detect any Marbled Murrelets south of Santa Cruz (L. Henkel, unpubl. data). Additionally, we are not aware of any anomalously high numbers of Marbled Murrelets off San Luis Obispo County or areas further south in 2007.

The estimate of the juvenile ratio for 2007 (0.049), like estimates for all years between 1996 and 2003, was very low and too low support a viable population (Peery et al. 2006a). The estimate was reasonably similar to the mean observed across all years from 1996 to 2007 (0.034). However, we suspect that it was numerically greater than the mean largely because both juveniles observed in 2007 happened to be observed on the July 10 survey. This date represents the earliest date in which we conduct juvenile-ratio surveys and received a large "date correction factor". Had these two juveniles been observed later in the survey period, we believe that our estimate of the 2007 juvenile ratio would have been considerably lower. The juvenile ratio could also be artificially high if substantial numbers of AHY individuals had dispersed out of the study area, as discussed above.

Surveys conducted during 2007 provide important information on the status of the central California population of Marbled Murrelets. These data indicate that recent restoration projects implemented in the Santa Cruz Mountains may not be sufficient to increase reproductive success to a level that would sustain a viable population. However, to determine whether the observed population decline is real and sustained, regular (ideally annual) series of surveys are required. Recent research has shown that the central California population appears to be genetically distinct from populations to the north (Friesen et al. 2005, Piatt et al. 2007). Given the predicted and observed decline of this population, the genetic uniqueness of the population, and the susceptibility of this population for local extirpation (Peery et al. 2004), there is a clear need for immediate conservation action, and for annual monitoring of the success of these conservation efforts. For robust population estimates in future years, we recommend planning for eight surveys, four drawn from each direction.

Acknowledgments

The survey boat and driver (Jack Ames) were provided by DFG-OSPR; we thank Jack Ames and other OSPR staff for their long hours of logistical support. Moss Landing Marine Laboratories provided the survey vessel for the Monterey Bay survey. We thank Laurie Hall for critical field assistance. This project was funded by the Command Trustee Council, via the California Department of Parks and Recreation, through a contract with the San Jose State University Foundation.

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Table 1. Results of four surveys for Marbled Murrelets between Half Moon Bay and Santa Cruz in 2007.

Survey Date	Number of Groups	Mean Group Size	Number of Juveniles	Transect Length (km)[1]	Population Estimate[2]	Survey Direction[3]
20 June	13	1.5	0	87.1	187 (138-254)	North
10 July	18	1.8	2	76.8	351 (280-439)	North
12 July	25	1.7	0	69.6	492 (393-616)	South
19 July	25	1.7	0	70.8	483 (383-612)	South

[1]Nearshore stratum only; no murrelets were seen in the offshore stratum.
[2]95% CL in parentheses.
[3]Direction transect drawn from.

Table 2. Population estimates (95% CI in parentheses) of Marbled Murrelet in central California between 1999 and 2007. Historic data from Peery et al. (2006); n is number of surveys. No surveys were conducted from 2004 to 2006.

Year	From North Pop. Estimate	n	From South Pop. Estimate	n	Both Directions Pop. Estimate	n
1999	487 (333-713)	5		0		0
2000	496 (338-728)	8		0		0
2001	637 (441-920)	8		0		0
2002	628 (487-809)	9	733 (583-922)	7	661 (556-786)	15
2003	615 (463-815)	6	729 (494-1075)	6	683 (561-832)	15
2007	264 (142-489)	2	782 (570-1074)	6	699 (567-860)	12
			488 (408-585)	2	367 (240-562)	4

Table 3. Annual estimates of hatch-year to after-hatch-year ratios (*R*) and standard errors (SE) for Marbled Murrelets from at-sea surveys conducted in the breeding season in central California, 1996-2003 and 2007. Surveys and captures used to estimate ratios were conducted from 10 July to 23 August, 1996-2003, 2007. Corrected estimates were corrected for the proportion of hatch-year murrelets that had not fledged and the proportion of after-hatch-year murrelets still incubating at the time the survey was conducted (see Peery et al. 2007). n_{inds} = the number of individuals observed and $n_{surveys}$ = the number of surveys conducted.

	Uncorrected		Corrected			
Year	*R*	(SE)	*R*	(SE)	n_{inds}	$n_{surveys}$
1996	0.004	(0.003)	0.006	(0.004)	517	3
1997	0.010	(0.003)	0.022	(0.007)	701	5
1998	0.002	(0.003)	0.004	(0.004)	437	6
1999	0.015	(0.005)	0.030	(0.010)	693	10
2000	0.021	(0.010)	0.034	(0.016)	495	8
2001	0.031	(0.006)	0.063	(0.016)	400	8
2002	0.022	(0.005)	0.045	(0.011)	601	11
2003	0.024	(0.005)	0.049	(0.011)	424	8
2007	0.017	(0.017)	0.049	(0.051)	130	3
Total	**0.016**	**(0.003)**	**0.034**	**0.007**	**4398**	**62**

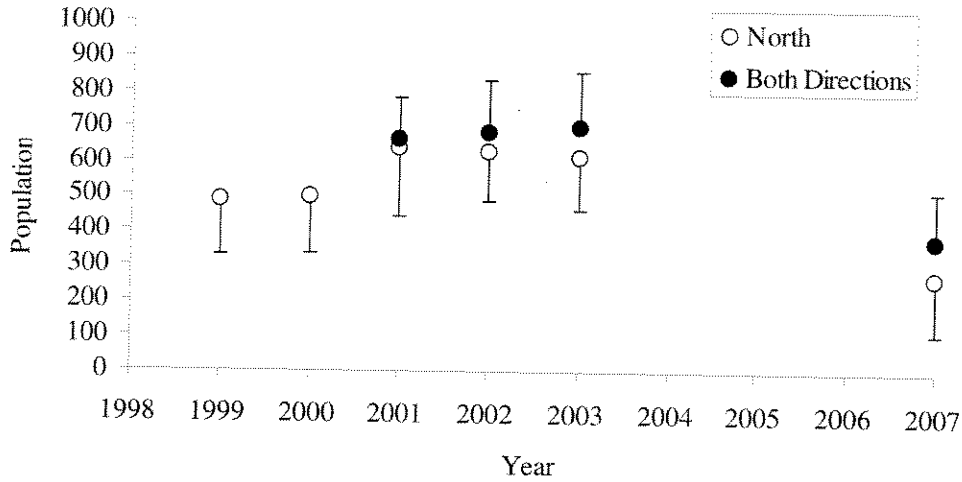

Figure 1. Abundance estimates for the central California population of Marbled Murrelets based on at-sea surveys, 1999-2007. Error bars are 95% confidence intervals. Because surveys before 2001 were conducted only on transects drawn from the north, these survey data are presented separately.

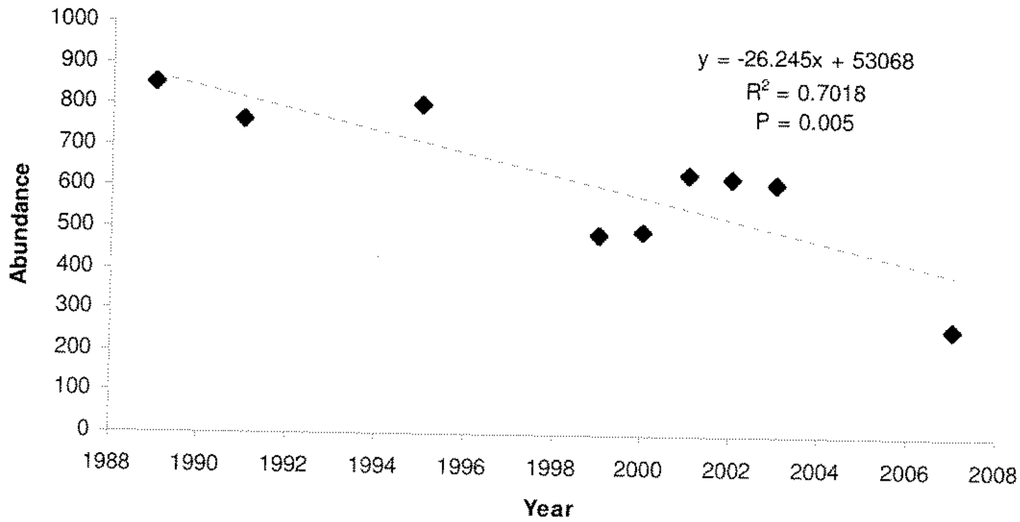

Figure 2. Abundance estimates for the central California population of Marbled Murrelets based on at-sea surveys, 1989-2007. Surveys before 1999 used slightly different methods; surveys drawn from the north were used from 1999-2003 and in 2007.

ABUNDANCE AND PRODUCTIVITY OF MARBLED MURRELETS OFF CENTRAL CALIFORNIA DURING THE 2008 BREEDING SEASON

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Summary

We conducted at-sea surveys for Marbled Murrelets (*Brachyramphus marmoratus*) in Conservation Zone 6 (central California) offshore of breeding habitat between Half Moon Bay and Santa Cruz in 2008. Using distance sampling estimation techniques, we estimated the central California population to be 122 (95% CL: 61-184) with surveys delineated from the north ($n = 3$), 225 (95% CL = 131-319) with surveys delineated from the south ($n = 3$), and 174 (95% CL: 91-256) with all surveys ($n = 6$). These estimates represent 54-55% declines since 2007 and 71-80% declines since 2003. No juveniles were detected and the date-corrected juvenile ratio, an estimate of productivity commonly used to index reproductive success in Marbled Murrelets, was therefore equal to zero for 2008. This was the first year since surveys for juvenile ratios started in 1996 that no juveniles were detected. Our results, in concert with previous and ongoing demographic and genetic work, indicate that Marbled Murrelets in central California will almost certainly become locally extirpated when the current cohort of adults dies.

Introduction

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird that is federally-listed as Threatened and state-listed in California as Endangered. Potential threats to Marbled Murrelets in California include loss of old-growth forest nesting habitat, changes in prey (small fish) availability, increasing predator populations, gill-netting bycatch, and oil spills (Carter and Erickson 1988, Peery et al. 2004). To work towards recovery of the species, various oil spill trustee councils have provided funding for restoration, including protection of nesting habitat and management of predatory corvids. In the last several years, the Command Trustee Council (for the 1998 T/V Command oil spill) has initiated efforts to control food sources for corvids in the Santa Cruz Mountains, initiated lethal control of some corvids, and acquired 80 acres of potential nesting habitat in the Santa Cruz Mountains, to be incorporated into Butano State Park.

Population monitoring of Marbled Murrelets typically is conducted using at-sea surveys. Other monitoring methods are used to monitor inland activity, including radar surveys and audio-visual surveys, but these methods do not provide estimates of population size. Regular (e.g., annual) at-sea surveys are critical in determining the success of restoration efforts and the current status of the species range-wide. Under the Northwest Forest Plan, annual at-sea monitoring occurs in California within Conservation Zones 4 and 5, from the Oregon border south to San Francisco Bay. Conservation Zone 6, from San Francisco Bay south to Monterey Bay, is not included in the Northwest Forest Plan, but population monitoring within Zone 6 was conducted from 1999 through 2003 with a combination of state, federal, and private funding. No decline was detected during this period, despite the fact that reproductive success was too low to compensate for adult mortality (Peery et al. 2006a). To aid in determining the success of restoration efforts in the Santa Cruz Mountains, the Command Trustee Council funded at-sea surveys in Zone 6 during the 2007 breeding season (Henkel and Peery 2008). These surveys suggested that the population had declined to 378 individuals in 2007 from 661-699 in the initial survey period (1999-2003). Here we report on similar surveys conducted in Zone 6 in 2008.

Methods

We conducted six approximately 100 km long at-sea surveys between Half Moon Bay and Santa Cruz in 2008 from 16 June to 15 September (Table 1) that followed zig-zag transect routes consistent with surveys conducted from 1999 through 2003, and in 2007 (Peery et al. 2006a). Surveys were always initiated immediately outside of the Half Moon Bay Harbor a random distance (200-2500 m) from shore. Surveys included between 69.4 and 78.0 km of transect in a "nearshore" stratum (200-1350 m from shore) and between 15.1 and 26.6 km of transect in an "offshore" stratum (1350-2500 m from shore). In previous years an equal number of routes were drawn from starting points at the north and south ends of the survey area, and transects drawn from the south tend to yield a higher densities that transect delineated from the north. Therefore, three of the six 2008 transects were drawn from the south and three transects were drawn from the north.

For all surveys, line transect methods were used (Becker et al. 1997, Peery et al. 2006a). Two observers, standing on either side of a 6-m open skiff, recorded angle off the transect line and distance to all groups of Marbled Murrelets seen (prior to each survey, observers calibrated distance estimation using a laser rangefinder on buoys in the harbor). Birds in flight were counted if they crossed a line perpendicular to the track line, even with the observers. Counting flying birds (2% of sightings were of flying birds) may result in overestimation of abundance (Spear et al. 1992, Piatt et al. 2007), but this method was used for previous surveys in central California, and was used in 2008 for consistency. Sightings data were analyzed using DISTANCE v.5.0 and density was estimated using

$$D = \frac{\hat{E}(n) \cdot \hat{E}(s)}{2L \cdot \widehat{ESW}}$$

where $E\hat{S}W$ was the estimated effective strip width, $\hat{E}(n)$ was the expected number of groups, $\hat{E}(s)$ was the expected number of birds per group, and L was the length of the line transect (km; Buckland et al. 2001).

Estimating *ESW* requires modeling the inevitable decline in detection probability as a function of distance from the sighting data. Due to the sharp decline in population size (see below), only 47 groups of Marbled Murrelets were detected during the six surveys conducted in 2008, a number that is insufficient to develop a robust detection function (Buckland et al. 2001). Therefore, we combined data from 2007 and 2008 (resulting in 131 detections) to estimate detection function parameters, but only estimated density and abundance for surveys conducted in 2008. All detections >120 m from the transect lines were discarded and the remaining detections were grouped into 7 20-m bins, similar to analyses conducted for previous years. A half-normal detection model with cosine adjustments (as used to model previous year's data) did not fit the pooled

2007-2008 data well, largely because of distance data collected during the 12 September 2008 survey. Eliminating this surveys resulted in reasonable model fit ($\chi2 = 4.1$, df = 4, $P = 0.39$) and an ESW of 61.4 m. To estimate abundance from density estimates, we multiplied survey-specific density estimates for the nearshore stratum generated by DISTANCE by the total area of the nearshore stratum (104.65 km^2; no bird were detected in the offshore stratum in either 2007 or 2008). Confidence intervals for the mean 2008 abundance estimate were calculated based on the variance across surveys-specific abundance estimates.

Results

As was the case in previous years, surveys conducted in 2008 that followed transects delineated from the south yielded greater estimates of population size (mean = 225; 95% CL: 131-319, $n = 3$) than transects delineated from the north (mean = 122; 95% CL: 61-184, $n = 3$; Table 1, Figs 1 and 2). The mean estimate of abundance from all 6 surveys was 174 (95% CL: 91-256; range: 49-316; Tables 1 and 2). Using data from both directions, the estimated abundance in 2008 represents a 71% decline from 2008. Using data only from surveys drawn from the north, there was a 80% decline from 2003 to 2008; and from the south, there was a 75% decline. From 2007 to 2008, there was a 54%, 55%, and 54% decline in abundance in surveys conducted from both directions, from the north, and from the south, respectively.

No juveniles were detected during any of the four surveys conducted within the window used to estimate juvenile ratios (10 July to 23 Aug). Thus, estimates of both uncorrected and date-corrected juvenile ratios were equal to zero in 2008; 2008 being the only year since 1996 that no juveniles were detected (Table 3).

Discussion

Our results suggest that the Marbled Murrelet population in central California underwent a significant and rapid decline between 2003 and 2008, recognizing that population estimates were not available from 2004-2006. Peery et al. (2006a) determined that, based on low levels of reproductive success, the central California population should show a consistent annual decline in the absence of immigration. However, abundance estimates based on at-sea surveys conducted between 1999 and 2003 showed no such decline; thus, Peery et al. (2006) suggested that immigration from northern California was supporting the central California population. Recent genetic analyses support the hypothesis that immigration without recruitment into the breeding population may have masked underlying deterministic declines in the population (M. Z. Peery L. A. Hall unpub data). Whether immigration stopped or declined after 2003, making the local population decline evident in 2007 and 2008, or whether the remaining individuals in central California are largely immigrants from other populations is uncertain without more recent genetic, mark-recapture, and radio-telemetry work. The low abundance estimates in 2008, and to a lesser extent 2007, could also be due in part to increased dispersal out of the study area compared with previous years, as Marbled Murrelets sometimes disperse out of the central California study area during summer (Peery et al.

2008). However, given the low productivity estimates in all 10 years that juvenile-ratio surveys were conducted from 1996 through 2008, the observed population decline, as well as future declines, is virtually inevitable. Indeed, our results indicate that current conservation projects in the Santa Cruz Mountains are insufficient to prevent the extirpation of Marbled Murrelets in central California when the current cohort of adults dies. Given the predicted and observed population decline, the genetic uniqueness of the population (Friesen et al. 2005, Piatt et al. 2007), and high probability of local extirpation, there is a clear need for immediate and stronger conservation actions in the region, and for annual monitoring of the success of these conservation efforts.

Acknowledgments

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Table 1. Results of six surveys for Marbled Murrelets between Half Moon Bay and Santa Cruz in 2008

Survey Date	Number of Groups	Mean Group Size	Number of Juveniles	Transect Length (km)[1]	Population Estimate[2]	Survey Direction[3]
16 July	13	1.4	0	78.0	207 (113-382)	South
22 July	11	2.2	0	68.2	316 (155-645)	South
6 Aug	3	1.3	0	74.0	49 (6-426)	North
12 Aug	7	1.7	0	70.8	152 (66-351)	South
12 Sep	9	2.1	NA	69.4	246[4]	North
15 Sep	3	2.0	NA	74.6	72 (25-211)	North

[1]Nearshore stratum only; no murrelets were seen in the offshore stratum.

[2]95% CL in parentheses.

[3]Direction transect drawn from.

[4]Estimated manually, not with DISTANCE; 95% CL not available.

Table 2. Population estimates (95% CI in parentheses) of Marbled Murrelet in central California between 1999 and 2008. Historic data from Peery et al. (2006a); n = number of surveys. No surveys were conducted from 2004 to 2006.

Year	From North Pop. Estimate	n	From South Pop. Estimate	n	Both Directions Pop. Estimate	n
1999	487 (333-713)	5		0		0
2000	496 (338-728)	8		0		0
2001	637 (441-920)	8	733 (583-922)	7	661 (556-786)	15
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2008	122 (61-184)	3	225 (131-319)	3	174 (91-256)	6

Table 3. Annual estimates of hatch-year to after-hatch-year ratios (*R*) and standard errors (SE) for Marbled Murrelets from at-sea surveys conducted in the breeding season in central California, 1996-2003 and 2007-2008. Surveys used to estimate ratios were limited to 10 July to 23 August, 1996-2003, 2007. Corrected estimates were corrected for the proportion of hatch-year murrelets that had not fledged and the proportion of after-hatch-year murrelets still incubating at the time the survey was conducted (see Peery et al. 2007). n_{inds} = the number of individuals observed and $n_{surveys}$ = the number of surveys conducted.

	Uncorrected		Corrected			
Year	*R*	(SE)	*R*	(SE)	n_{inds}	$n_{surveys}$
1996	0.004	(0.003)	0.006	(0.004)	517	3
1997	0.010	(0.003)	0.022	(0.007)	701	5
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2007	0.017	(0.017)	0.049	(0.051)	130	3
2008	0	(0)	0	(0)	47	4

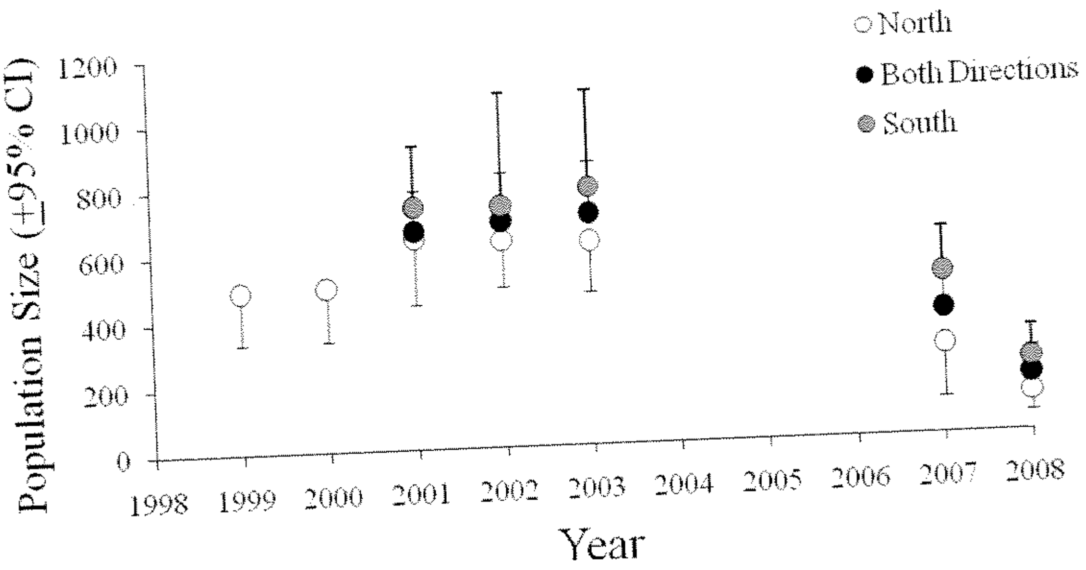

Figure 1. Abundance estimates for the central California population of Marbled Murrelets based on at-sea surveys, 1999-2008. Error bars are 95% confidence intervals. Because surveys before 2001 were conducted only on transects drawn from the north, these survey data are presented separately.