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Landbird diversity and abundance in native Monterey pine forests

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LANDBIRD DIVERSITY AND ABUNDANCE IN NATIVE MONTEREY PINE FORESTS

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ABSTRACT

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By Nellie Thorngate

Native Monterey pine (*Pinus radiata*) forests support a unique assemblage of plants and animals, but little quantitative data exist describing avian communities in this ecosystem. The purpose of this study was to establish baseline data on avian communities in native Monterey pine forests, and to assess bird-habitat relationships at sites with varying habitat structures and land use intensities. Avian diversity was lower in spring than in any other season ($P < 0.001$), but did not differ between sites in any season. Avian diversity was positively correlated with shrub diversity in fall ($r = 0.640$) and summer ($r = 0.779$), and tree diversity in winter ($r = 0.644$). Bird diversity was negatively correlated with forb diversity ($r = -0.640$) in summer. Total avian abundance differed significantly between sites during winter surveys ($P < 0.001$), and abundances of selected avian focal species differed significantly between sites in fall, winter and summer.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Habitat loss and alteration resulting from resource extraction (Rich et al. 2004, Brooks et al. 1997), urbanization, and recreational use of intact habitats (Fernandez-Juricic 2000, Gutzwiller and Anderson 1999, Miller et al. 1998) is an important cause of decline exhibited by many bird populations in recent years (DeSante and George 1994). The majority of research concerning anthropogenic effects on bird populations has centered on timber harvest practices, while the effects of urbanization and the indirect effects of human disturbance, including encroachment of invasive species and recreational land use, have been less closely monitored (Marzluff and Sallabanks 1998). Landbirds worldwide continue to face varied and escalating threats from habitat loss, and effective conservation of remaining habitats is becoming increasingly urgent (Rich et al. 2004, Melles et al. 2003, McKinney 2002, Pickett et al. 2001).

Neotropical migrant songbirds have been the major focus of avian conservation biology for the past two decades, because long-distance migrants are thought to be more vulnerable to environmental perturbations than temperate migrants or sedentary species (James 1998). Relatively little attention has been paid to temperate migrants and sedentary species, particularly in coniferous forest habitats, where avian conservation efforts have focused on neotropical migrants or species that are under immediate threat of extinction or endangerment.

Coniferous forest ecosystems support a variety of bird species, and these habitats and their avian communities are being severely impacted worldwide by anthropogenic

alteration. Tracking long term trends in avian diversity and abundance can provide critical information about ecosystem health, help conservation and resource professionals to monitor responses of forest ecosystems to anthropogenic changes, and support effective conservation and adaptive management decisions for birds and their habitats (Hansen et al. 2001, CalPIF 2002).

Conservation biologists and resource professionals have found it helpful to conserve and manage habitats based on suites of focal species that represent the full spectrum of niches available in a particular habitat. California Partners in Flight (CalPIF), together with the Point Reyes Bird Observatory and other wildlife management and conservation organizations, have developed habitat conservation plans for eight different California habitat types, including Coniferous Forest Habitat. Each plan centers on a suite of bird species selected as focal species. Avian species are selected as focal species based on their conservation status and/or their degree of association with important features of the habitat (CalPIF 2002). Although the plans are based on avian conservation, they provide effective management guidelines for entire systems because birds are sensitive indicators of habitat health and respond quickly to changes in the environment (Hutto 1998). The avian focal species selected for each conservation plan require a wide range of habitat features that are also important to other species, thus acting as an umbrella for the protection of entire ecosystems.

Conserving important bird habitats provides protection for a variety of animal and plant species, and helps to insure ecosystem function (Marzluff and Sallabanks 1998). Monitoring trends in songbird abundance and diversity allows conservation

biologists to keep track of and respond to declines in bird populations before they become critical. It also provides an index to the health of the natural community in which the birds live, helping land managers to practice effective adaptive management techniques to create and maintain the health of the lands under their jurisdiction.

The Monterey Pine (*Pinus radiata*) forests of central coastal California are highly localized habitats that are gravely threatened by urbanization. This ecosystem supports a number of endemic plant and animal species, and yet it has received little scientific attention (Mathews and Nedeff 1993). The remaining stands of native Monterey pine forests, which include Año Nuevo State Park in Santa Cruz Co., CA, the Monterey Peninsula in Monterey County, CA, and Cambria, in San Louis Obispo county, CA, are largely privately owned and under the constant threat of development, while the Monterey pine habitats that are held in public trust are islands surrounded by development or agriculturally altered habitats (Mathews and Nedeff 1993, Deghi et al. 1993). There are currently no quantitative baseline data regarding the composition of landbird communities in Monterey pine habitats. Understanding basic patterns of avian diversity and abundance in native Monterey pine forests will help biologists to evaluate the health of the remaining pine forest stands in Monterey county, and can provide a starting point for developing avian conservation plans and adaptive management strategies for native Monterey pine forests in central California.

The purpose of this study was to establish baseline estimates of avian diversity and abundance in Monterey pine forests and to determine if avian diversity and abundance of individual species is affected by varying degrees of vegetation diversity and

adjacent land use intensity. The hypothesis was that avian diversity and abundance are lower in habitats with low vegetation diversity and high adjacent land use intensity. Further, it was hypothesized that habitats with higher vegetation diversity and minimal land use intensity exhibit high avian diversity and abundance.

STUDY AREA

Twelve sites were selected to represent the breadth of Monterey pine forest habitats on the Monterey peninsula (Fig. 1, Appendix 1). Sites varied in patch size, degree and type of adjacent land use, and proximity to features such as the ocean and permanent fresh water sources. Each site was near a paved road, but was located within at least 10 acres of contiguous Monterey pine forest. Four sites were on lands managed by the Monterey County Regional Parks District; four sites were located on public lands managed by the California State Department of Parks and Recreation; four sites were on private lands held by the Pebble Beach Company; and two sites were on privately owned properties.

METHODS

Vegetation Surveys. Vegetation characteristics of each point count plot were evaluated using the relevé technique designed by Point Reyes Bird Observatory (Ballard 2002). This method is a coarse evaluation of the vegetation at a site, and can be used to identify patterns of bird-habitat interactions for further study (Appendix 1). First each 50 m-radius plot was evaluated for overall habitat features, including identification of the dominant habitat type, the nature of adjacent land use, and the presence of water, large and small snags, and fallen logs.

Next, overall percent cover of trees, shrubs, herbs, all woody vegetation and bare ground for each 50 m-radius plot was visually estimated. Finally, each plant species making up at least an estimated 5% of each sublayer (tree, shrub and herb) was identified and assigned a percentage of the total sublayer based on visual estimates of the entire 50 m plot. Each vegetation layer was delineated based on height: the tree layer consisted of any vegetation 5 m or higher; the shrub layer consisted of vegetation 0.5 - 5 m in height, and the herb layer consisted of vegetation less than 0.5 m in height. Because plants were assigned to layers based on height rather than species, a plant species normally categorized as a tree would be classified as a component of the Shrub sublayer if it was less than 5 m in height.

The degree of land use intensity within a 500 m radius of each point count plot was evaluated using a ranking system with five ranks. A land use intensity score of 1 was assigned to plots with five or fewer residences or other human structures within 500 m of the point count location and occasional (less than one person per day) to no recreational use. Sites with six to 10 residences or other human structures within 500 m of the point count location, and regular recreational use excluding dog walking and motorized vehicles were given a score of 2. Sites were given a score of 3 for land use intensity when they featured light to moderate residential development (approximately 10 – 15 structures) and frequent recreational use including motorized vehicles, dog walking and equestrian activities within 500 m of the point count location. A score of 4 was assigned to sites with moderate to dense residential development (about 15 – 20 structures and multiple paved roads) and regular to frequent recreational use within 500 meters of the

point count location. Sites were given a score of 5 when they were within 500 meters of dense residential development (approximately 20+ structures and multiple paved roads) and frequent recreational activity.

Point Counts. Point count censuses were used to evaluate overall avian diversity and abundance in Monterey pine forests. Point counts are among the least time consuming and least expensive techniques for studying bird populations, and have been widely used as a method of evaluating songbird diversity and habitat quality (Ralph et al. 1993). Relative abundances of Coniferous Forest Focal Species, identified as indicators of healthy coniferous forest environments, were analyzed in order to assess the relative health of native stands of Monterey pine forest exhibiting varying habitat characteristics and degrees of adjacent land use. Songbird diversity and abundance was assessed in 12 plots located within stands of native Monterey pine forest in Monterey County using 50 m fixed radius point counts (Ralph et al. 1993). The plots were established at several locations on and immediately south of the Monterey Peninsula, from Jack's Peak Park on the southern end of Monterey Bay, to Monterey Regional Parks District Land approximately 10 km south of the city of Carmel, California.

Point counts were conducted at each site three times during fall migration and winter, and two times during spring migration and breeding season. Fall counts were completed between 15 September 2002 and 31 October 2002, winter counts between 15 November 2002 and 15 February 2003, spring counts between 15 March 2003 and 15 May 2003, and summer counts between 15 June 2003 and 15 August 2003. Each count lasted for 5 min, during which the number of each species seen or heard within 50 m of

the point center was recorded. In order to identify the distance to a bird, several landmarks (such as trees or shrubs) located approximately 50 m from the center of the point count plots were identified; the observer was then able to judge whether a bird was seen or heard from inside or outside of the 50 meter radius of the plot. The data were divided into two categories for analysis: all birds, and CALPIF Coniferous Forest Focal Species or surrogates only.

Data Analysis. Songbird diversity at each site was quantified using the Simpson Diversity Index D, which combines estimates of species richness and species evenness to arrive at a relative diversity value. A high Simpson Diversity Index indicates relatively high diversity. The Simpson Diversity Index is calculated as

$$D = \frac{1}{\sum_{i=1}^{S} P_i^2}$$

where S equals the total number of species detected, and P is the proportion of the *i*th species (Begon et al. 1996). An overall Simpson Diversity Index for each site was calculated using MVSP software (MVSP 2004), in order to evaluate differences in diversity among sites.

Relative abundances of all species and of Coniferous Forest Focal Species were compared between sites using a 1-way ANOVA (Zar 1999), calculated using SYSTAT statistical software (SYSTAT 2000). The abundance of each species identified within the 50 m-radius plots at each site, divided by the area of the plots, was used to calculate a standardized estimate of avian density (birds/km^2). Statistically significant differences in

bird abundance between sites provided a means by which to identify sites that provided high quality habitat, where habitat quality is inferred from higher avian abundance.

Relationships between habitat features and species diversity were tested using Pearson's Product-Moment Correlation (Zar 1999), which calculates a correlation coefficient (r) as follows:

$$r = \frac{\Sigma xy}{\sqrt{(\Sigma X^2 - (\Sigma X)^2/n)(\Sigma Y^2 - (\Sigma Y)^2/n)}}$$

The correlation coefficient is then squared, providing an r^2 value that is used to evaluate the significance of the correlation between two variables. Correlations were calculated using SYSTAT statistical software (SYSTAT 2000).

RESULTS

Modest to moderate variation in the floristic diversity, vegetation cover and adjacent land use intensity was observed between point count locations (Table 1, Appendix). Tree species diversity ranged from 1 species at sites four, five and seven to 4 species at site six. Shrub species diversity ranged from 4 species at site two to 8 species at sites six, nine and eleven. Herb species diversity ranged from 3 species at sites one, seven, nine, ten and eleven, to 7 species at site four (Table 1). Percent tree cover ranged from 50% at sites six and 11, to 80% at sites two and eight. Percent shrub cover ranged from 30% at site seven to 85% at site one. Percent herb cover ranged from 30% at site one to 100% at site eight. The number of snags near point count locations ranged from zero at site four to 12 at site five (Table 1). Sites with low land use intensity (scores of 1

or 2) included sites two, three, four, five, six, 11 and 12. Sites with moderate land use intensity (score of 3) included sites nine and ten. Sites with high land use intensity (scores of 4 or 5) included sites one, seven and eight.

A total of 2,750 individuals of 43 species were detected at 12 point count locations in Monterey pine forest habitat (Table 2). Seventy-four percent were resident species, and 26% were migrants. Of the migrant species, 64% were temperate migrants and 36% were neotropical migrants. Four primary and three secondary Coniferous Forest Focal Species were identified, including Brown Creeper (*Certhia Americana*), Fox Sparrow (*Passerella iliaca*), Oregon Junco (*Junco hyemalis*), Olive-sided Flycatcher (*Contopus cooperii*), Purple Finch (*Carpodacus purpureus*), Steller's Jay (*Cyanocitta stelleri*), and Yellow-rumped Warbler (*Dendroica coronata*). Pygmy Nuthatch (*Sitta pygmaea*) was also identified as a regionally important focal species for Monterey pine forest habitat.

Species richness and diversity were similar between sites (Table 3), but differed between seasons. One-way ANOVA showed that overall avian species diversity, calculated using the Simpson Diversity Index, was significantly lower in the spring than in other seasons ($F_3 = 12.868$, $P < 0.001$; table 4), but was lowest in the fall among Coniferous Forest Focal Species ($F_3 = 3.173$, $P = 0.030$; table 4). Pearson product-moment correlation analysis indicated that overall species diversity was not correlated with land use intensity in any season.

Overall avian diversity was related to vegetation cover and floristic diversity, though no relationship with vegetation characteristics and Coniferous Forest Focal

Species was revealed. Overall avian diversity was positively correlated with diversity of shrub cover in the fall ($r = 0.640$) and with diversity of tree cover in the winter ($r = 0.644$). During the summer, avian species diversity was positively correlated with shrub diversity ($r = 0.779$) and negatively correlated with diversity of herb cover ($r = -0.640$). The diversity of Coniferous Forest Focal Species was not strongly correlated with vegetation characteristics, structural diversity or degree of adjacent land use in any season.

Avian abundance varied significantly between sites in several cases. Overall avian abundance varied significantly between sites during the winter ($F_{11} = 5.32$, $P<0.001$; table 5), with the highest abundance at site five and the lowest at site seven (Fig. 2). In the winter, Fox Sparrows were most abundant at site 11 ($F_{11} = 4.00$, $P = 0.002$; table 5), and Purple Finches ($F_{11} = 4.00$, $P=0.002$; table 5) and Pygmy Nuthatches ($F_{11} = 4.37$, $P=0.001$; table 5) were most abundant at site five (Fig. 2). In the fall, Pygmy Nuthatches were most abundant at site five ($F_{11} = 2.56$, $P=0.027$; table 5) (Fig. 3). There was no significant difference between sites in the abundance of Coniferous Forest Species in the spring. In the summer, Brown Creepers were most abundant at site six ($F_{11} = 4.57$, $P=0.007$; table 5), Oregon Juncos were most abundant at site three ($F_{11} = 2.91$, $P=0.040$; table 5), Pygmy Nuthatches were most abundant at site two, ($F_{11} = 3.55$, $P=0.020$; table 5) and Steller's jays were more abundant at site six ($F_{11} = 3.38$, $P=0.023$; table 5) (Fig 4).

DISCUSSION

The results of this study supported the hypothesis that high vegetation diversity

results in greater abundance and diversity of birds associated with Monterey pine forests, but did not support the hypothesis that greater intensity of adjacent land use resulted in lower avian diversity and abundance. As long as Monterey pine forests retain high levels of floristic and structural diversity, the impact of land use appears minimal. The data suggest a weak association between greater avian diversity and lower intensities of adjacent land use, but the results of this study detected no statistically significant relationship. Several more years of monitoring will be necessary in order to elucidate the relationships between vegetation diversity, land use intensity and bird populations in Monterey pine forests.

This study did not examine the effects of patch size or amount of edge during this study, both of which have been shown to negatively impact songbird species (Crooks et al. 2001, Bolger et al. 1997, Rafe et al. 1985). Future studies would benefit from more intensive vegetation surveys and from analyses of patch size and edge effects, to elucidate patterns of Monterey pine forest avian diversity and abundance in relation to habitat features.

The variation in avian diversity across seasons was characteristic of yearly changes in avian community composition due to migration and breeding behaviors. The majority of species identified were resident species, which is typical of coniferous forest habitats (Carlisle et al. 2004, CALPIF 2002). Avian diversity was lowest in the summer, probably because only two of the 11 migratory species detected during the study were present in the summer months. All other migrants used the Monterey pine forests only as stopover or overwintering habitat. In contrast, the number of Coniferous Forest Focal

Species present was lowest in the fall. This included three migrant species, one irruptive species (species exhibiting periodic movements related to unpredictable food resources), and four resident species. Of the migrant species, Yellow-rumped Warblers and Fox Sparrows were later arrivals, which may have affected detection of these species during the fall. The irruptive species, Purple Finch, may not have been present in the fall due to a lack of food resources in the pine forests, or an abundance of food resources elsewhere. The collection of long-term data on avian diversity and abundance would allow for the evaluation of weather effects, seasonal use of forests for recreational purposes, and other seasonal factors. Although this study did not detect any effects of land use on bird diversity, more data is needed on order to elucidate the complex and sometimes subtle effects of anthropogenic factors on bird populations in Monterey pine forests.

The significant variation in avian abundance between sites during the winter surveys suggests an interaction between seasonality and habitat. The site which yielded the highest abundance in the winter was characterized by the least land use and highest floristic diversity. These habitat features may have provided numerous and diverse shelter and food sources particularly important during inclement winter weather. Furthermore, energetic demands are difficult for temperate birds to meet during the winter, and it is possible that habitats with fewer anthropogenic disturbances provided a less stressful and more appealing habitat for birds during a season characterized by limited food resources and poor weather conditions.

Patterns of Focal Species abundance varied in a species-specific manner. Pygmy nuthatches were detected in the highest numbers at sites featuring high vegetation

diversity, many snags, and limited adjacent land use. Pygmy Nuthatches are cavity nesters that forage in bark for insects. The site at which Pygmy Nuthatches were most abundant had the highest number of snags, which are used as their nest sites. Insect prey is also likely to be more abundant at sites with higher structural and vegetation diversity. Brown-headed Nuthatches (*Sitta pusilla*), the eastern homolog of the Pygmy Nuthatch, have been shown to prefer sites with more snags and open canopy, as well as greater understory vegetation (Wilson and Watts 1999). This study suggests that the same is true for Pygmy Nuthatches.

The Purple Finch is an irruptive species, exhibiting irregular movements based on unpredictable food resources. The sites hosting the greatest number of Purple Finches were sites that exhibited high plant diversity. These sites were probably areas that provided food in the form of seeds that were unavailable in forest habitats with a lesser degree of plant diversity.

Fox Sparrow abundance appears to have been influenced by foraging habits and life history characteristics. Fox Sparrows are temperate migrants that overwinter in Monterey pine forests, and were most abundant where the habitat was characterized by little adjacent land use and a high degree of shrub and forb cover. They are shrub-associated species that scratch through deep duff for their preferred insect prey. The sites where Fox Sparrows were most abundant probably provided an ideal combination of cover and duff and had minimal human disturbance. Migrant breeders are more likely to use mature forest than stands that are in earlier successional stages (Greenberg et al. 1995), a preference that may extend to the wintering grounds. This may account for the

higher abundance of Fox Sparrows in areas with many older Monterey pines.

Inter-site variations in the abundance of Brown Creepers during the summer can be explained by the specific habitat preferences exhibited by the species. The site at which Brown Creepers were most abundant featured a riparian draw, as well as a cluster of coast redwood trees. The presence of the redwoods may have accounted for the high abundance of Brown Creepers at this site, because redwoods are a preferred foraging and nesting tree for the coastal populations (Grinnell and Miller 1944). However, the only other site featuring redwoods did not contain any Creepers. Instead, Brown Creeper abundance may have been dictated by tree species and age class diversity. Sites with high structural diversity are particularly important to Brown Creepers during the breeding season, because they use different sizes and species of trees for foraging and nesting (Lundquist and Mariani 1991). The high tree species diversity and the wide range of tree ages produced a structurally diverse habitat ideal for Brown Creepers.

Steller's Jay abundance probably differed between sites due to the influence of habitat heterogeneity. The degree of adjacent land use was also likely a factor influencing jay abundance, as they are often associated with disturbed, urban environments. Heterogenous habitats and anthropogenically altered areas provide important foraging opportunities for Stellar's Jays, particularly when meeting the energetic demands of the breeding season.

Oregon Junco abundance varied between sites due to important breeding habitat features. They were most abundant in the summer at a site with negligible residential development and moderately high vegetation diversity. The site was characterized by a

great deal of edge habitat, being bisected by a dirt track and a paved road. Oregon Juncos have been shown to prefer habitat with abundant edges during the breeding season (CalPIF 2002), which is likely the reason for the high abundance of juncos at this site during the summer months.

While the vast majority of coniferous forests face conservation issues primarily having to do with resource extraction (CALPIF 2002), the most significant conservation concern for Monterey pine forests is land development for commercial, residential and recreational purposes. Although native Monterey pine forests are considered a threatened ecosystem by the California Native Plant Society, the remaining forests are so small and fragmented that they receive little attention from the conservation community (Mathews and Nedeff 1993). Nevertheless, these remnant Monterey pine ecosystems provide important habitat for many species of birds, other animals and many plant species.

Availability of food and shelter were likely the most important factors influencing fluctuations in the abundance of avian focal species at different sites. Research in forest ecosystems has shown that differences in food availability are closely correlated with seasonal and monthly fluctuations in bird abundance (Malizia 2001). Future studies should examine the relationship between insect biomass and the abundance of insectivorous avian focal species. Prey-base studies would help to determine how food availability influences relative avian abundances in Monterey pine forests.

In order to further understand avian ecology in Monterey pine forests, future studies should evaluate and monitor productivity and survivorship of Coniferous Forest Focal Species, as well as continuing to track patterns of avian abundance and diversity.

While abundance and diversity by themselves can be helpful measures of habitat health, analysis of demographic information including productivity and survivorship will provide a more realistic picture of habitat quality. Increases in the populations of mammalian nest predators such as raccoons (*Procyon lotor*) and feral cats and nest parasites such as Brown-headed Cowbirds (*Molothrus ater*) that thrive in anthropogenically altered ecosystems may affect the productivity and survivorship of birds in Monterey pine forests (Crooks and Soule 1999). The negative impacts of increased predator and parasite populations on avian population dynamics may cause some apparently healthy habitats to become ecological sinks for birds. Songbird monitoring in Monterey pine forests will enable resource managers and conservation biologists to conserve songbirds and their habitats, and to monitor and manage the health of the remaining Monterey pine forest ecosystems.

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Figure 1. Point count locations in Monterey pine forest habitat in Monterey County, CA

Table 1. Habitat features at twelve point count locations with differing intensities of adjacent land use in Monterey pine forests in Monterey, CA, 2002–2003

Land use intensity	Site ID	Tree species diversity	Shrub species diversity	Forb species diversity	Percent tree cover	Percent shrub cover	Percent herb cover	Snags
1	3	2	6	4	60	75	80	4
1	4	1	5	7	75	85	80	0
1	5	1	6	5	40	50	60	12
1	12	2	6	4	60	40	40	3
2	2	3	4	4	80	55	75	1
2	6	4	8	4	50	75	80	2
2	11	2	8	3	50	70	75	3
3	9	2	8	3	70	70	20	1
3	10	2	5	3	55	50	10	2
4	1	3	6	3	75	85	30	4
4	7	1	7	3	80	30	60	4
5	8	2	6	5	75	80	100	5

Table 2. Birds detected in Monterey pine forests at twelve locations in Monterey County, CA, 2002–2003. Coniferous Forest Focal Species are indicated by bold typeface.

Common Name	Specific Name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
Acorn Woodpecker	*Melanerpes formicivorus*	X	X	X	X	X	X	X	X	X	X	X	X
American Crow	*Corvus brachyrynchos*	X	X		X		X	X	X	X	X	X	X
American Kestrel	*Falco sparverius*					X							
American Robin	*Turdus migratorius*	X		X			X	X		X		X	
Anna's Hummingbird	*Calypte anna*	X	X	X	X	X	X	X	X	X	X	X	X
Bewick's Wren	*Thryomanes bewickii*			X			X				X	X	
Black Phoebe	*Sayornis nigricans*				X						X	X	
Brown Creeper	***Certhia americana***	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Bushtit	*Psaltriparus minimus*	X		X	X	X	X	X	X	X	X	X	
California Quail	*Callipepla californica*	X				X				X	X	X	
California Towhee	*Pipilo crissalis*	X	X		X		X		X	X	X	X	
Chestnut-backed Chickadee	*Poecile rufescens*	X	X	X	X	X	X	X	X	X	X	X	X
Downy Woodpecker	*Picoides pubescens*	X	X		X	X	X	X	X	X	X	X	X
European Starling	*Sturnus vulgaris*	X	X		X	X	X		X			X	
Fox Sparrow	***Passerella iliaca***											**X**	
Golden-crowned Sparrow	*Zonotrichia atricapilla*	X		X		X	X	X	X	X	X	X	X
Hairy Woodpecker	*Picoides villosus*											X	X
House Finch	*Carpodacus mexicanus*	X	X	X	X		X	X		X	X	X	
House Wren	*Troglodytes aedon*					X	X						
Lesser Goldfinch	*Cardeulis psaltria*		X	X	X	X		X	X	X	X	X	X
Mourning Dove	*Zenaida macroura*	X	X	X	X		X	X		X	X	X	X
Northern Flicker	*Colaptes auratus*	X	X	X	X	X	X	X		X	X	X	X
Nuttall's Woodpecker	*Picoides nuttallii*	X	X	X			X	X			X	X	X
Orange-crowned Warbler	*Vermivora celata*		X										X
Oregon Junco	***Junco hyemalis***	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Olive-sided Flycatcher	***Contopus cooperi***					**X**	**X**						X
Pine Siskin	*Carduelis pinus*										X		
Pacific-slope Flycatcher	*Empidonax difficilis*	X	X	X	X	X	X	X		X	X	X	X
Purple Finch	***Carpodacus purpureus***	**X**	**X**	**X**	**X**	**X**							

Common Name	Specific Name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
Pygmy Nuthatch	***Sitta pygmaea***	**X**	**X**	**X**	X	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Ruby-crowned Kinglet	*Regulus calendula*	X	X	X			X			X		X	**X**
Red-shouldered Hawk	*Buteo lineatus*	X	X		X	X	X	X	X	X	X		
Red-tailed Hawk	*Buteo jamaicensis*					X							
Song Sparrow	*Melospiza melodia*	X	X		X		X			X		X	X
Spotted Towhee	*Pipilo maculatus*	X	X	X	X	X	X	X	X	X	X	X	X
Steller's Jay	***Cyanocitta stelleri***	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	X	**X**
Townsend's Warbler	*Dendroica townsendi*		X	X	X					X		X	X
White-crowned Sparrow	*Zonotrichia leucophrys*					X			X				
Western Scrub-jay	*Aphelocoma californica*	X	X	X	X	X	X	X	X	X	X	X	X
Wilson's Warbler	*Wilsonia pusilla*	X			X		X						
Wrentit	*Chamaea fasciata*	X	X	X	X	X	X	X		X	X	X	X
Yellow-rumped Warbler	***Dendroica coronata***	**X**	**X**	**X**	**X**	**X**			**X**	**X**		**X**	**X**
Yellow Warbler	*Dendroica petechia*						X						

Table 3. Species richness and diversity at 12 Monterey pine stands in Monterey County, CA, 2002–2003.

Site	Fall		Winter		Spring		Summer	
	Richness[a]	SDI[b]	Richness	SDI	Richness	SDI	Richness	SDI
Site 1	15	0.870	18	0.897	18	0.887	11	0.806
Site 2	11	0.787	16	0.870	18	0.880	10	0.680
Site 3	14	0.845	16	0.878	17	0.814	8	0.725
Site 4	11	0.841	15	0.859	14	0.850	9	0.663
Site 5	16	0.843	13	0.747	12	0.771	12	0.774
Site 6	18	0.913	14	0.885	21	0.906	11	0.834
Site 7	12	0.804	9	0.784	16	0.883	10	0.809
Site 8	12	0.859	12	0.837	13	0.864	9	0.799
Site 9	15	0.884	18	0.876	15	0.861	15	0.886
Site 10	15	0.868	13	0.862	15	0.914	13	0.794
Site 11	13	0.880	15	0.888	21	0.866	12	0.801
Site 12	13	0.862	15	0.885	15	0.903	10	0.788

[a]Species richness is the total number of species detected at each site.
[b]SDI = Simpson Diversity Index, an index of the relative richness and evenness of species at each site.

Table 4. Results of one-way ANOVA comparing overall avian diversity and Coniferous Forest Focal Species diversity between seasons at twelve point count locations in Monterey pine forests, Monterey County, CA 2002 – 2003

	n	*df*	*F*	*P*
All Birds	48	3	12.868	< 0.001
Focal Species	48	3	3.173	0.033

Table 5. Results of one-way ANOVA comparing avian abundance among twelve point count locations in Monterey pine forests, Monterey County, CA 2002 – 2003

	Fall				**Winter**				**Spring**				**Summer**			
	n	*df*	*F*	*P*	*n*	*df*	*F*	*P*	*n*	*df*	*F*	*P*	*n*	*df*	*F*	*P*
All Species	36	11	1.18	0.349	**36**	**11**	**5.32**	**0.000**	24	11	0.79	0.646	24	11	0.90	0.565
Brown Creeper	36	11	2.01	0.074	36	11	0.78	0.659	24	11	1.79	0.166	**24**	**11**	**4.57**	**0.007**
Fox Sparrow	-	-	-	-	**36**	**11**	**4.00**	**0.002**	-	-	-	-	-	-	-	-
Olive-sided Flycatcher	36	11	1.00	0.474	-	-	-	-	24	11	0.93	0.548	24	11	0.91	0.559
Oregon Junco	36	11	1.41	0.231	36	11	1.66	0.143	24	11	2.03	0.119	**24**	**11**	**2.91**	**0.040**
Purple Finch	-	-	-	-	**36**	**11**	**4.00**	**0.002**	24	11	0.93	0.548	24	11	1.30	0.330
Pygmy Nuthatch	**36**	**11**	**2.56**	**0.026**	**36**	**11**	**4.37**	**0.001**	24	11	0.68	0.734	**24**	**11**	**3.55**	**0.020**
Steller's Jay	36	11	1.24	0.313	36	11	1.37	0.250	24	11	2.38	0.076	**24**	**11**	**3.38**	**0.023**
Yellow-rumped Warbler	-	-	-	-	36	11	1.87	0.097	-	-	-	-	-	-	-	-

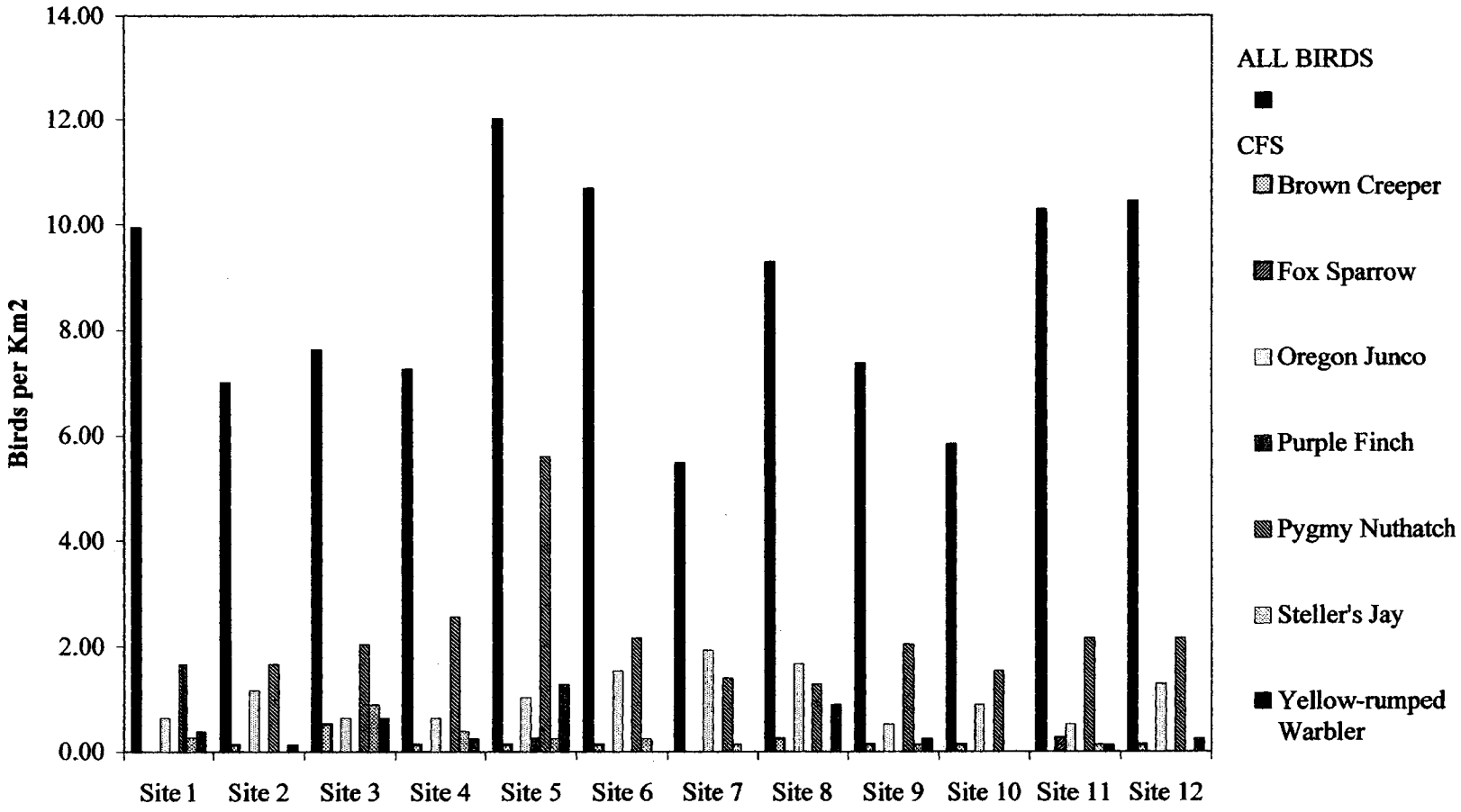

Figure 2. Abundance of all birds and of Coniferous Forest Focal Species at twelve point count sites in Monterey pine forests in Monterey county, CA, winter 2002/03. One-way ANOVA yielded significant differences in overall abundance ($P<0.001$), and the abundance of Pygmy Nuthatches ($P=0.001$), Fox Sparrows ($P=0.002$), and Purple Finches ($P=0.002$).

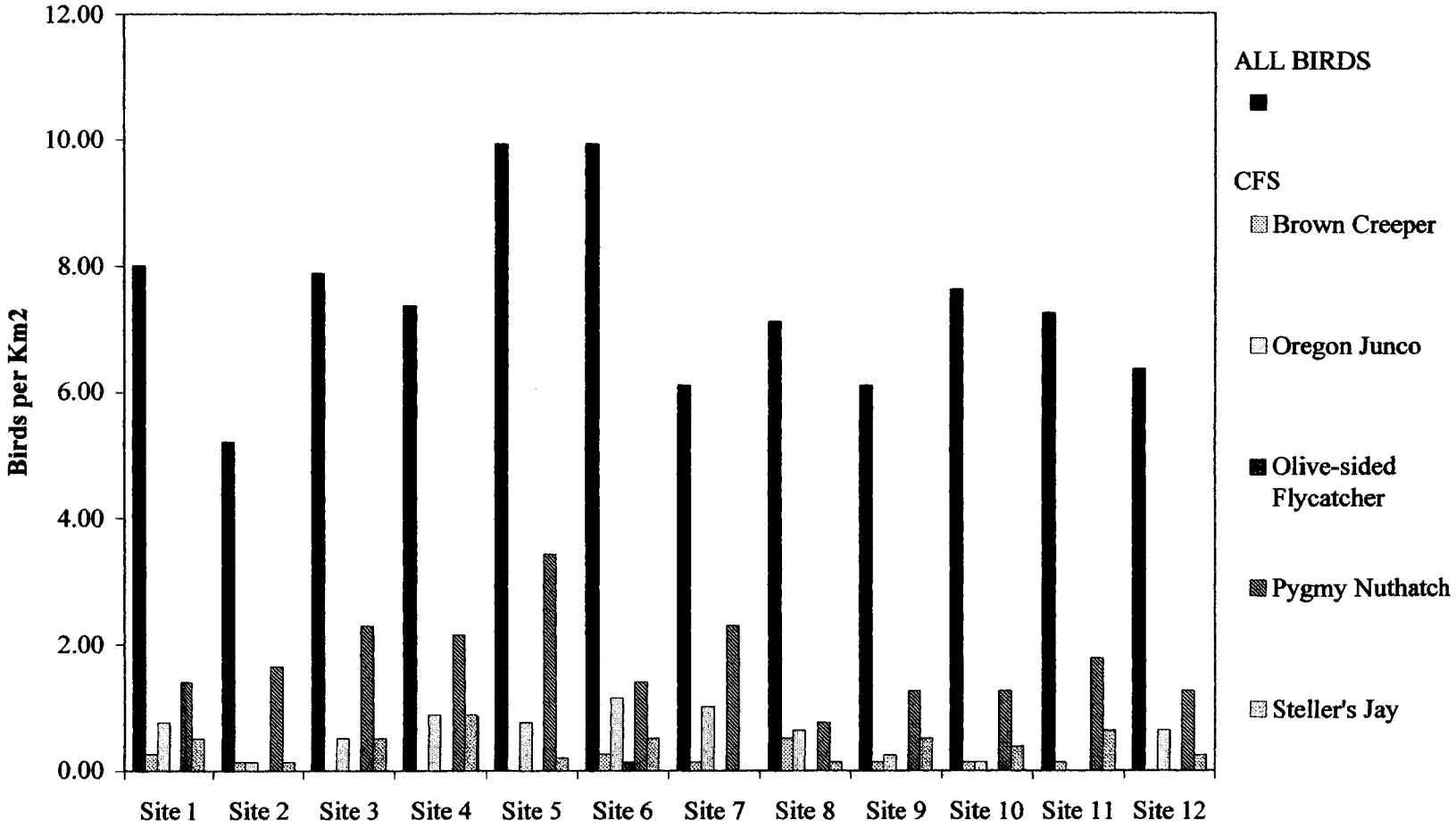

Figure 3. Abundance of all birds and Coniferous Forest Focal Species at twelve point count locations in Monterey pine forests in Monterey County, CA, fall 2002. ANOVA yielded significant differences in the abundances of Pygmy Nuthatches between sites (P=0.027).

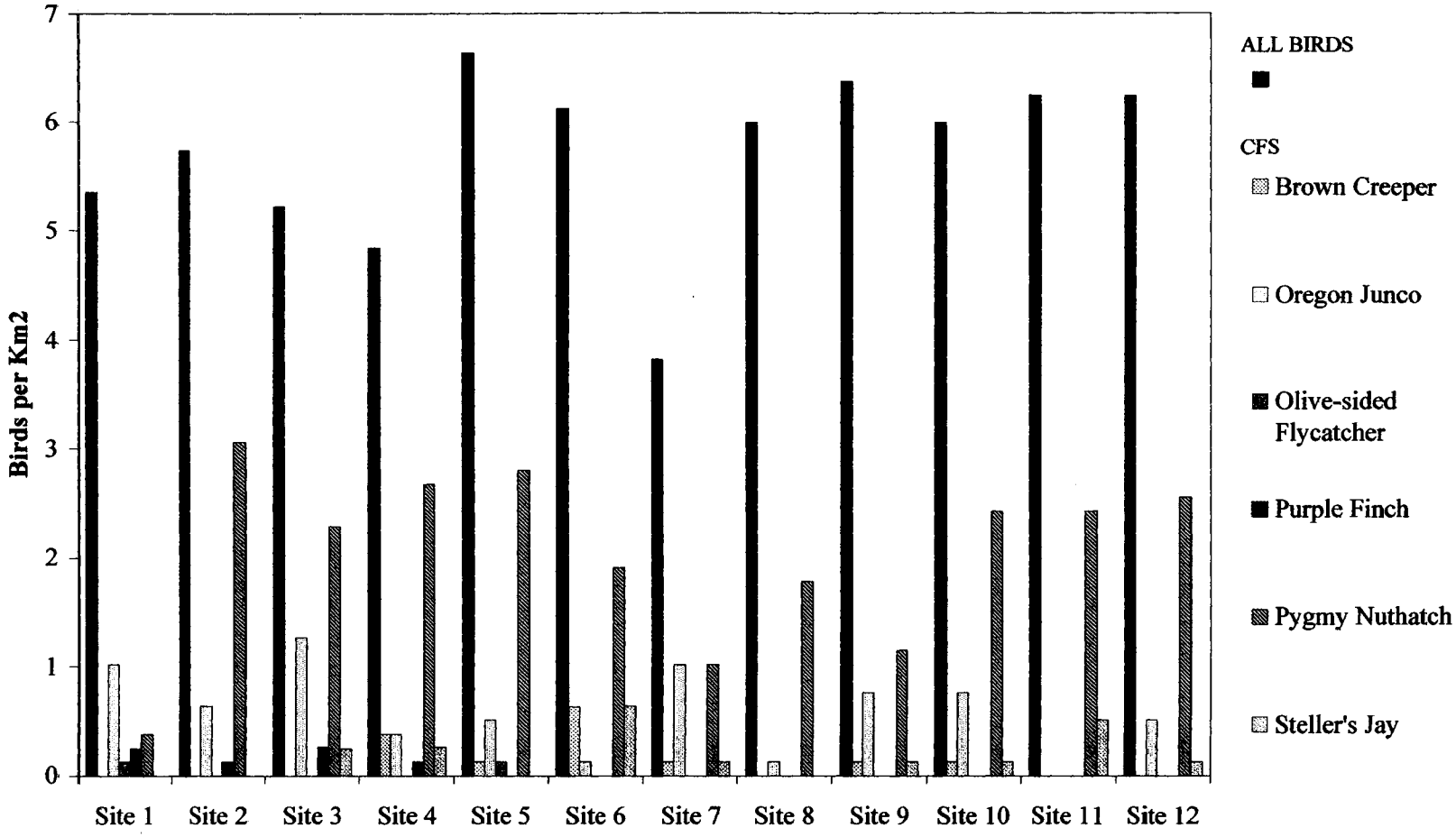

Figure 4. Abundance of all birds and of Coniferous Forest Focal Species at twelve point count sites in Monterey pine forests in Monterey county, CA, summer 2003. One-way ANOVA yielded significant differences between sites in the abundance of Brown Creepers (P=0.007), Oregon Juncos (P=0.04), Pygmy Nuthatches (P=0.02) and Steller's Jays (P=0.023).

Appendix. Detailed habitat descriptions resulting from relevé evaluations for twelve point count sites in Monterey pine forests in Monterey County, CA, 2002 – 2003.

Site 1 (Laidlawe-Apte). Site 1 was the southernmost site, and was located on an 11-acre patch of forest managed by the Monterey County Regional Parks District. This point-count plot was located within 500 meters of moderate residential development on three sides. The plot was characterized by a moderate forest canopy composed largely of Monterey pines, with coast live oak (*Quercus agrifolia*) and coast redwood (*Sequoia sempervirens*) making up a small proportion of the total canopy. The tree layer ranged from 0.5 meters to 35 meters, and the DBH ranged from 10 cm to 75 cm. The shrub layer was dominated by manzanita (*Arctostaphylos* spp.), French broom (*Genista monspessulana*) and toyon (*Heteromeles arbutifolia*); huckleberry (*Vaccinium* spp.) and live oak shrubs as well as nonnative shrubs were also present. The herb layer covered about 30 percent of the plot area, and was made up mostly of annual grasses. Bare ground accounted for approximately 10 percent of the plot, and included a narrow dirt road. The plot contained three downed logs and 4 snags.

Site 2 (Point Lobos 1). Site 2 was located within the bounds of the Point Lobos State Reserve just south of Carmel River State Beach on the western side of Highway 1. The point was sited within a public use area, and the major land uses within 500 meters of the plot include hiking and picnicking, as well as five residences and some horse pasturage. The site included two well-used unpaved trails and a small seasonal stream. Overall, bare ground accounted for 10 percent of the total plot area. The tree canopy

was made up of approximately equal amounts of Monterey pine and Monterey cypress (*Cupressus maculata*), and included small numbers of coast live oaks. The tree layer ranged in height from ground level to 24 meters, and DBH ranged from 8 cm to 65 cm. Shrubby cover in the plot was composed of poison oak (*Toxicodendron diversilobum*) and California blackberry (*Rubus ursinus*) brambles, and some live oak shrubs. The herbaceous cover was made up mostly of bunchgrass and rattlesnake grass (*Briza maxima*), but also included other annual grasses and bunches of *Juncus* spp. The plot contained over 10 downed logs and one snag.

Site 3 (Point Lobos 2). Site 3 was located on Lobos ranch, an extensive property east of Highway 1 owned by California Department of Parks and Recreation. The sole adjacent land use was sparse residential development. Bare ground accounted for approximately 10% of the plot and included a wide unpaved trail. The tree canopy was comprised almost entirely of Monterey pine, but included a few large coast live oaks. The tree layer ranged in height from 1 meter to 24 meters, and DBH ranged from 5 cm to 50 cm. The shrub layer included nearly equal amounts of coast live oak shrubs, manzanita, huckleberry, and French broom. California blackberry and coffeeberry (*Rhamnus californica*) were also present. The herb layer was dominated by annual grasses, and was sparsely dotted with coltsfoot (*Tussilago farfara*), bunch grass and dandelion (*Taraxacum* spp.). The plot contained four logs and four snags.

Site 4 (Point Lobos 3). Site 4 was located approximately 700 meters east of site 3, on the same property. Adjacent land use was restricted to very sparse residential development; no homes were within 1000 meters of the plot. The site was characterized by a moderately open canopy composed entirely of Monterey pine. Tree layer height ranged from 1 meter to 30 meters, and DBH ranged from 4 cm to 60 cm. The shrub layer was fairly dense, consisting of equal amounts of coffeeberry and French broom, occasionally interspersed with California blackberry, coast live oak shrubs and poison oak. The herb layer was diverse, including many annual grasses, miner's lettuce (*Claytonia perfoliata*), wood mint (*Stachys bullata*), *Juncus* spp., figwort (*Scrophularia californica*), bunchgrass and coltsfoot. Bare ground accounted for about 10 percent of the plot and included a narrow unpaved road and pullout. The plot included six downed logs and no snags.

Site 5 (Palo Corona). Site 5 was located in a patch of Monterey pine forest adjacent to the Carmelite monastery south of Carmel, CA, northeast of Point Lobos State Reserve. The point was located in an approximately 50-acre grove of Monterey pines surrounded by active cattle pasturage. One residence is located about 500 meters from the plot. The site was characterized by an open tree canopy entirely composed of Monterey pines, with a shrubby understory comprised mostly of poison oak, with currant (*Ribes* spp.), sticky monkey flower (*Mimulus aurantiacus*), *Ceanothus* spp., coffee berry and California blackberry occurring to a lesser degree. The tree layer ranged from 1 meter to 28 meters, and DBH ranged from 1 cm to 50 cm. Herbaceous cover was

composed of poison hemlock (*Conium maculatum*), *Juncus* spp., annual grasses, and patches of dandelion and yerba buena (*Clinopodium douglasii*). Bare ground accounted for 10 percent of the point count area, and was comprised of a narrow dirt road and patches of bare ground. The plot included 16 logs and 12 snags.

Site 6 (Pebble Beach 1). Site 6 was located approximately 800 meters past the Highway 1 gate, on the northwestern side of Pescadero Canyon. This site featured a mixed habitat composed of 95 percent Monterey pine forest and five percent arroyo willow riparian bordering a seasonal creek. Adjacent land use included moderate residential development, golf courses and hiking trails, but neither houses nor golf courses were closer than 800 meters from the point count plot. Bare ground accounted for approximately 15 percent of the plot, and included a wide dirt road and patches of bare ground. The canopy was dominated by Monterey pines, but also included coast live oak, and elderberry (*Sambucus* spp.) and arroyo willow (*Salix lasiolepis*) in the riparian zone. The tree layer ranged in height from 1 meter to 35 meters, and DBH ranged from 15 cm to 60 cm. The shrub layer of the plot was diverse, featuring coffeeberry, huckleberry, poison oak, California blackberry, coast live oak shrubs, California sagebrush (*Artemisia californica*), *Ceanothus* spp. and French broom. Herbaceous cover at the point was 50 percent annual grasses, with the remaining herbaceous vegetation being composed of poison hemlock, miner's lettuce and bracken fern (*Pteridium aquilinum*). The site included five logs and two snags.

Site 7 (Pebble Beach 2). Site 7 was located along Ronda Road, just above Robert Louis Stevenson School and Spyglass Hill Golf Course. Adjacent land use activities included moderate residential development, golf courses, equestrian activities and hiking. The site included approximately 20 percent bare ground, including a dirt pullout and road, equestrian and pedestrian trails, and patches of bare ground. The tree canopy at site 7 was composed exclusively of Monterey pines, and the tree layer ranged in height from 1 meter to 18 meters. Minimum DBH was 3 cm, and maximum DBH was estimated at 30 cm. The shrubby understory was composed of huckleberry, manzanita, sticky monkey flower, coyote brush (*Baccharus pilularis*), French broom, and occasional coast live oak shrubs. Herbaceous cover was largely annual grass, with some bunch grass and *Juncus* spp. also present. The plot contained two downed logs and 4 snags.

Site 8 (Pebble Beach 3). Site 8 was located at the corner of Jacinta Rd and 17 mile Drive, east of Spanish Bay Resort in Pebble Beach, CA. Adjacent land use included moderate residential development, golf courses, and resort development. The tree canopy was mostly comprised of Monterey pines, with some coast live oaks. The tree layer ranged from 1 meter to 24 meters in height, and DBH ranged from 4 cm to 45 cm. The shrub and herbaceous layers were particularly dense and interwoven; the shrub layer was composed of coast live oak shrubs, Monterey pine seedlings, French broom and other nonnative shrubs, California blackberry, and huckleberry. The herbaceous layer was dominated by bracken fern and bunch grass, but also included *Oxalis* spp., *Juncus* spp., and annual grasses. The site included 6 logs and 5 snags.

Site 9 (Aguajito 1). Site 9 was located approximately 1 km along Aguajito Road, east of Highway 1 at the Highway 68 West exit. Adjacent land use at the site was light to moderate residential development. Bare ground accounted for about 15 percent of the total plot, and included a stretch of paved road as well as an old unpaved road. The tree layer was composed of Monterey pines and a few coast live oaks, and ranged in height from 2 meters to 25 meters. DBH ranged from 3 cm to 30 cm. The shrub layer was diverse and dense, composed of poison oak, French broom, California blackberry, coast live oak shrubs, *Acacia* spp., huckleberry, coffeeberry and currant. The herbaceous layer was comprised of annual grasses and bracken fern, mixed with occasional bunchgrass. The site contained 4 logs and one snag.

Site 10 (Aguajito 2). Site 10 was located approximately 2.5 km along Aguajito Road, east of Highway 1 at the Highway 68 West exit. The site was approximately 20 percent bare, including a stretch of paved road. The open canopy was composed of Monterey pines and coast live oaks, and the tree layer ranged in height from 2 meters to 18 meters. DBH ranged from 15 cm to 30 cm. The open shrubby understory was dominated by French broom, with occasional coffee berry, coyote brush, poison oak, and California blackberry. Herbaceous cover was largely limited to annual grasses, though some wood mint and poison hemlock were also present. The site contained 3 logs and 2 snags.

Site 11 (Jack's Peak Park 1). Site 11 was located at the entrance to Jack's Peak Park south of Highway 68 and the Monterey International Airport. Adjacent land use included hiking, picnicking and light residential development in the western direction. The site featured a moderately open canopy comprised of Monterey pines and coast live oak, with a tree layer ranging in height from 1 meter to 30 meters, and DBH ranging from 5 cm to 40 cm. The shrub layer was also relatively open, and consisted of coast live oak shrubs, toyon, *Ceanothus* spp., coffeeberry, poison oak, California blackberry, French broom and sticky monkey flower. The herbaceous layer consisted of annual grasses, with bunch grasses and bracken fern occurring to a lesser degree. Bare ground at the site accounted for about 15 percent of the total area, and included a stretch of paved road. The site contained five logs and 3 snags.

Site 12 (Jack's Peak Park 2). Site 12 was located about 500 meters east of site 11 along the road running to the parking area of Jack's Peak Park. Adjacent land use included hiking and picnicking; residential development occurred approximately 1 km to the west. The canopy was mostly comprised of Monterey pines, with some coast live oak. The tree layer ranged in height from 1 meter to 25 meters, and DBH ranged from 8 cm to 35 cm. The shrub layer was largely composed of poison oak and coast live oak shrubs, with occasional coffeeberry, California blackberry, Madrone (*Arbutus menziesii*) saplings and *Ceanothus* spp. The herbaceous layer consisted almost entirely of annual grasses, with some sword fern (*Polystichum munitum*), bracken fern and dandelion. Bare

ground accounted for approximately 20 percent of the plot, and included a stretch of paved road. The site also contained 8 logs and 3 snags.