

DIVERSITY AND PRODUCTIVITY OF NEOTROPICAL MIGRATORY  
LANDBIRDS IN CENTRAL COASTAL CALIFORNIA

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Prepared by Nellie Thorngate, Ventana Wildlife Society (formerly Ventana Wilderness Society), 19045 Portola Dr., Ste. F-1, Salinas, CA. 93908.

nelliethorngate@ventanaws.org.

Project Officer Karen Ritchie Shihadeh, Ventana Wildlife Society (formerly Ventana Wilderness Society), 19045 Portola Dr., Ste. F-1, Salinas, CA. 93908.

karensihadeh@ventanaws.org.

## INTRODUCTION

Neotropical migratory birds face a number of small- and large-scale threats across their ranges, including climate change, habitat loss and degradation, changes in food resources, and environmental contamination (Ballard et al. 2003). Since the drafting of the Neotropical Migratory Bird treaty Act in 1918, over 35 species of birds protected under the act have gone extinct, 272 have become federally endangered or threatened and 131 are listed by the US Fish and Wildlife Service as species of conservation concern (USFWS 2006). Habitat loss has been indicated as the most important cause of declining neotropical migrant populations, particularly in western North America (DeSante and George 1994), and conservation scientists and practitioners have emphasized the importance of habitat preservation and restoration since the early 1900's, when President Theodore Roosevelt began setting aside land to serve as National Wildlife Refuges (Braun et al. 1978). Until recently the focus of land conservation and restoration has remained primarily on migratory game birds, due to their economic and recreational importance. Additionally, the complex annual cycles and wide ranges of neotropical migrants make appropriate habitat conservation and restoration efforts difficult, and

conservation biologists are still developing more effective ways of conserving non-game neotropical migrant birds and their habitats (Mehlman et al. 2005).

Riparian habitat has been identified as the single most important habitat type for neotropical migrants in all stages of their annual cycle (RHJV 2004). Riparian habitats provide rich sources of food and shelter for breeding and wintering birds, as well as offering superior food and shelter resources during migratory stopover periods. Riparian habitat is also one of the most gravely threatened habitats; in California, for example, only an estimated 5 percent of historical riparian habitat remains, and much of that is still threatened by dwindling water resources and increasing land use pressures (RHJV 2004). The conservation of riparian habitats and neotropical migratory birds are closely linked, and thus many avian habitat restoration efforts are currently focused on ways to conserve, restore and improve riparian habitats throughout North America (Skagen et al. 2005).

Beginning in 1990, California Partners in Flight, a nonprofit coalition of government agencies, conservation groups, businesses and other stakeholders concerned with the conservation of migratory birds and their habitats in California, undertook efforts to develop conservation plans for habitats and species of special importance. The plans were developed in order to guide adaptive management strategies employed by conservation practitioners, using suites of birds as focal species to assess habitat health and to suggest conservation and restoration strategies. One such plan is the Riparian Habitat Conservation Plan, developed by California Partners in Flight in 2002. The Riparian Habitat Conservation Plan details strategies for conserving, restoring and managing riparian habitat, using 17 riparian-associated bird species as indicators, or “focal species”. One important recommendation in the Riparian Habitat Conservation Plan is that different bioregions throughout the western hemisphere develop area-specific strategies, in order to more effectively manage riparian habitats (RHJV 2004).

The central coast of California is a unique bioregion, characterized by a Mediterranean climate with cool wet winters and warm dry summers, buffered by persistent coastal fog. Monterey County makes up a large portion of the central coast, containing approximately 100 miles of coastline and a representative sample of the wide array of riparian habitats throughout coastal California, including riparian areas in agricultural valleys, coast redwood drainages, coastal scrub, and valley and coast oak

woodland. The county contains two major and several moderately large watersheds, including the Salinas, Carmel and Pajaro River watersheds, as well as the Big Sur River watershed, a state Scenic River. In total, Monterey County contains approximately 14,572 ha of riparian habitat (Roberson and Tenney 1993), and thus is an important area for many neotropical migrant birds during one or more portions of their annual cycle. Monterey County supports breeding and migratory stopover habitat for over 40 neotropical migrant landbird species. A conservation plan for neotropical migratory landbirds in Monterey County, beginning with a focus on bird communities in riparian habitats, is an important step in effective all-bird conservation in the Pacific Flyway, and can be used to guide conservation and management practices throughout the central coast of California, as well as other similar bioregions.

This document provides preliminary analyses of avian abundance and diversity at seven sites in three major watersheds in Monterey County between 2003 and 2005. We used diversity and abundance data from avian population surveys and mark-recapture studies on four watersheds in Monterey County to evaluate the relative health of different riparian areas in the county, and to begin developing conservation, restoration and management recommendations for conserving and restoring riparian habitat that supports healthy populations of neotropical migratory birds.

## STUDY AREA

Monterey County comprises approximately 863,900 ha of land supporting a wide variety of habitats, including coast redwood, Valley oak woodland, pine forest, mixed hardwood forest, coastal scrub, and riparian habitat. The county currently contains an estimated 14,572 ha of riparian habitat (Roberson and Tenny 1993). Riparian areas in Monterey country are typically either Montane Riparian or Valley Foothill Riparian. Montane Riparian habitats in Monterey feature a canopy of big leaf maple, tanoak and California bay, with an understory of California blackberry, coffeeberry, wood mint, and bracken fern. Valley Foothill Riparian areas feature a canopy of sycamore, cottonwood, alder, box elder and willow, and support a diverse understory composed of California blackberry, *Baccharis* spp., elderberry, and poison oak. Valley Foothill Riparian habitats in Monterey County vary widely, and are found associated with coast redwood, coastal

scrub, pine forest, and oak woodland habitats. The major rivers of Monterey County differ in the extent and intensity of land use, as well as in community structure and adjacent habitat types.

The Big Sur River drains from the Ventana Wilderness on the western slope of the Coast Range, and is surrounded by mixed hardwood, coast redwood, and coastal scrub habitats. The majority of the lower Big Sur River watershed, the portion of the watershed included in this study, comprises over 3238 ha of mostly publicly owned, protected lands. Land use in the Big Sur Watershed is minimal, restricted to hiking, camping, and sparse residential and recreational development. Riparian habitat along the lower Big Sur River is classified as Valley Foothill Riparian, and is bordered by grassland, mixed hardwood forest and coastal scrub. The lower reaches of the watershed feature a canopy dominated by arroyo willow, black cottonwood, white alder and sycamore. The thick understory features dense mixed shrubs and forbs, including poison oak, California blackberry, coyote brush, mugwort, and annual grasses and herbaceous vegetation. The canopy was comprised of arroyo willow, black cottonwood, Western sycamore and white alder. The Big Sur River watershed is an excellent example of healthy riparian habitat. Site 1 was located along the lower Big Sur River (figure 1).

The Carmel River and its watershed comprise approximately 80,000 ha of land, draining from the Los Padres National Forest on the eastern slope of the Coast Range. The Carmel River Watershed is surrounded primarily by mixed hardwood forest. The river is dammed at two locations, and the lower reaches of the watershed support moderately intense residential development, recreational development including golf courses and equestrian centers, and some agriculture. The Valley Foothill Riparian habitat bordering the Carmel River is a patchwork of mature riparian forest, restored early successional riparian forest, and unrestored habitat undergoing varying degrees of development. The riparian corridor along the Carmel River features an arroyo willow, cottonwood, alder and sycamore canopy. The understory is diverse, and may include poison oak, California blackberry, coyote brush, twinberry (*Lonicera involucrata*), horsetail (*Equisetum* spp.), mugwort and other vegetation. Site 2 was located at the mouth of the Carmel River (figure 1), and sites 3, 4 and 5 were located along the lower reaches of the river (figure 1).

The Salinas River Watershed surrounds the largest river in Monterey County, encompassing an estimated 11,000 km<sup>2</sup> in Monterey and San Louis Obispo counties. Monterey County contains approximately half (550,000 ha) of the Salinas River Watershed, which runs along the eastern slope of the Coast Range. The Salinas River Watershed incorporates oak woodland, chaparral, and coniferous forest habitats, and several towns and cities. Approximately 45% of the Salinas watershed is used for agricultural purposes including crop farming, vineyards, and cattle ranching (Watson et al. 1999). The Salinas River Watershed features broad floodplains converted to agriculture or residential developments, interspersed with stretches of Valley Foothill riparian habitats. The canopy layer of riparian habitats along the Salinas River and its tributaries typically features Fremont cottonwood, red willow and box elder. The understory ranges from sparse to dense, and may consist of blue elderberry (*Sambucus mexicana*), poison hemlock (*Conium maculatum*), European thistle, milk thistle, coyotebush (*Baccharis pilularis*), poison oak (*Toxicodendron diversilobium*), and mulefat (*Baccharis salicifolia*), as well as patches of rushes and cattails. Site 6 was located on the upper Salinas River, and site 7 was located on the lower Nacimiento River, just before it meets the Salinas (figure 1).

## METHODS

### *Avian Count Surveys*

We evaluated avian diversity and abundance using area search surveys (Ralph et al. 1993). Area search plots were established at seven sites within the Big Sur, Carmel and Salinas watersheds, and corresponded with sites chosen for concurrent mark-recapture studies. The sites were not randomly selected, but instead were chosen represent the breadth of riparian habitat available in Monterey County currently undergoing avian ecological studies. Each plot was delineated as the area within a 50 meter boundary of all net locations at a mark-recapture site. During 2003 – 2005, area searches were conducted at site 1 and site 2. In 2003 and 2004, area searches were conducted at sites 3, 4 and 5, and in 2004 and 2005 area searches were conducted at sites 6 and 7. Area searches were conducted on each day that bird banding took place between May 1 and August 8 of each year. The number of searches conducted per site ranged

from about 10 per year at sites 3-7, to about 13 per year at site 2 and 20 at site 1. Counts were conducted between 0.5 and 4 hours after sunrise, and lasted for 20 minutes. Differences in the number of searches reflect differences in the goals of long-term study designs established for each site. Because not all sites were surveyed in each year, comparisons between sites were made only for 2004.

#### *Mark-recapture studies*

Between May 1 and August 8 each year, we collected data from our study sites using guidelines established by the Institute for Bird Populations' Monitoring Avian Productivity and Survivorship (MAPS) program (Ralph et al. 1993, DeSante et al. 2004). The MAPS program outlines standardized protocols for operating mist-nets and banding birds, and collecting standardized demographic and morphometric data. Data were collected at sites 1 and 2 in 2003, 2004 and 2005. Study sites 3, 4 and 5 were operated in 2003 and 2004, and sites 6 and 7 were operated in 2004 and 2005. Because not all sites were run in each year, comparisons between sites were made only for 2004.

We used 12 meter by 2.5 meter mist nets with 30 mm gauge netting to capture birds at each site. Locations of the nets were not random, instead being located in areas deemed most likely to maximize capture efficiency (Ralph et al. 1993). We deployed 10 nets at each site, except site 2 (Carmel River Mouth), which had 13 nets and site 1 (Big Sur River), which had 21 nets. Nets were operated for 5 hours after opening, beginning 0.25 hours after sunrise. Each site was run once during every 10-day period between May 1 and August 8, except site 2 (Carmel River Mouth), which was run once per week, and site 1 (Big Sur River), which was run 5 days per week. We checked nets and extracted birds at strict 40-minute intervals.

For each bird captured, we applied a uniquely numbered aluminum leg band issued by the USGS Bird Banding Lab, and recorded capture status (new capture, recapture, or unbanded), species, age and sex, ageing and sexing criteria (degree of skull pneumaticization, presence or absence of external breeding characteristics, feather molt, wear, and plumage), amount of fat, wing length, weight, date, time, and net of capture. Age and sex classes were determined using the Identification Guide to North American Birds (Pyle 1997). Hummingbirds and game birds were not banded but similar morphometric and phenological data were recorded. We also recorded daily site data

including the date, net opening and closing times, percent sky cover, temperature, wind speed and direction, and precipitation. Mist net effort (net hours), calculated as the sum of number of hours each net was open, was recorded for each site each day. Capture rates were calculated as birds/1000 net hours.

### *Statistical Analyses*

For all analyses, we evaluated the entire population of landbirds at each site, and then evaluated neotropical migrants only. We evaluated diversity and abundance at each site, and compared sites for 2004, the only year in which data was collected at all sites.

### Diversity

Species Richness was defined as the number of species detections. The Species Diversity Index (SDI) was derived from the Shannon-Wiener index and reflects both the number and relative proportion of species present in a sample. The diversity index increases as species richness and evenness increase. We used the following formula to calculate species diversity (Begon et al. 1996):

$$H = - \sum_{i=1}^S P_i \ln P_i$$

where  $S$  = the number of species in the sample, and  $P_i$  = the proportion of all individuals belonging to the  $i$ th species. The index varies from 0, in which all individuals belong to the same species, to a relatively high number with many species and an even distribution of individuals among species.

### Relative Abundance

Relative abundance was calculated for area search counts as the number of birds detected per count. Relative abundance was defined for mist-net captures as capture rate (birds/1000 net hours), determined by dividing the number of birds captured by net effort for the site. Comparisons between sites were made using one-way ANOVA for all birds and for neotropical migrants.

## RESULTS

### *Area Searches*

Species richness and diversity for all sites are summarized in Table 1. During 2004, species richness was highest at site 1 (78 spp) and lowest at site 5 (40 spp). Richness of neotropical migratory species was highest at site 1 (32 spp) and lowest at sites 6 and 7 (12 spp). Species diversity was significantly higher at site 2 than at all other sites ( $P < 0.001$ ; table 2), and was lowest at site 6. Diversity of neotropical migrants differed significantly between sites, with site 7 having a much lower diversity of neotropical migrant species than any other site ( $P < 0.001$ ; table 2).

We calculated relative abundance for all birds and for neotropical migrants. Abundances are summarized in Table 3. In 2004,  $\chi^2$  goodness of fit tests revealed no significant differences in relative abundance between sites for all birds combined or for neotropical migrants.

### *Captures*

We captured 6,557 birds of 90 species between 2003 and 2005. Table 4 summarizes capture rates for each site. Total species richness was highest at site 1 (55 spp) and lowest at site 4 (25 spp). Richness of neotropical migrants was highest at site 1 (27 spp) and lowest at sites 4 and 5 (9 spp). Analysis of variance did not reveal any significant variation in diversity of birds between sites in 2004.

Capture rates were significantly higher at site 7 than at any other site in 2004 ( $p < 0.001$ ; table 5). Capture rates were lowest at site 2.

## DISCUSSION

### *Species Richness and Diversity*

The richness and diversity of avian landbird species varies widely among different watersheds in Monterey County. Interestingly, count data and capture data differed in the site with the highest species diversity. However, both count and capture data indicated that the sites with the highest diversity were sites that also exhibited the most extensive heterogenous, mature, undisturbed riparian habitat. Numerous assessments of bird-habitat relationships have indicated that avian density and diversity are positively correlated with floristic diversity and structural heterogeneity of the habitat (i.e. Lee and Rotenberry 2005, Anderson and Ohmart 1983, Karr and Roth 1971, James

1971). The initial species richness and diversity values presented in this study for riparian habitats in Monterey County suggest that sites 1 and 2 provide the best examples of healthy riparian habitat, and that sites 4 - 7 might benefit from habitat restoration efforts. However, the sites exhibiting lower richness and diversity are inland sites, while sites 1 and 2 are coastal. The differences in species richness and diversity may be a factor of geographic location rather than relative habitat health. Experimental habitat restoration at inland sites, directed towards increasing habitat heterogeneity to levels comparable to sites 1 and 2 would clarify the relative influences of habitat structure and geography on avian diversity and abundance.

#### *Avian Abundance*

In contrast to richness and diversity, count data revealed no differences in the abundance of birds between sites, while avian abundance calculated from capture data was highest at a site that exhibited relatively low habitat heterogeneity. This is likely due to the presence of high numbers of resident species such as Song Sparrow, Bewick's Wren and Bushtit, all generalist species who appear to thrive in habitats that are not heterogenous enough to attract other species.

#### *Neotropical Migrants*

Neotropical migrants were detected at all sites, but were most diverse and abundant at site 1, which features a coastal location and diverse, mature riparian habitat. Sites 4, 5 and 7 appeared to have the lowest diversity and abundance of neotropical migrants, which could either be explained by the inland nature of these sites, or perhaps by differences in habitat structure. Riparian habitats are critically important habitat for neotropical migrants during the breeding season, particularly in the west (Kelly and Hutto 2005, RHJV 2004, Kreuper 1992), but the exact nature of the habitat features that promote high productivity and survivorship of neotropical migrants in different geographic regions remains largely unknown (Donovan et al. 2002). In Monterey County, neotropical migrants appear to be most abundant and diverse at coastal locations exhibiting high floristic and structural diversity.

## MANAGEMENT RECOMMENDATIONS

### *Avian Monitoring*

Long-term monitoring of neotropical migrants and other landbird species in Monterey County riparian habitats is critical in order to understand patterns of habitat use, the role of geography and habitat structure, and the influences of development, agricultural land use, and habitat restoration on bird populations. In order to determine the actual and potential importance of Monterey County riparian habitats to neotropical migratory birds, monitoring efforts should be established and maintained at multiple locations along all major watersheds in the county. Choosing monitoring sites that vary with respect to geographic location, habitat heterogeneity, and degree of land use intensity will allow for the exploration of the relative importance of a wide range of habitat variables on avian diversity and abundance. We recommend the eventual establishment of five to ten avian monitoring sites along each major watershed in Monterey County.

Monitoring efforts should include both count and capture surveys. Area search and point count censuses provide important information about avian diversity and relative abundance, while capture data will allow for analysis of productivity and survivorship trends in each watershed. A combination of these two methods is an effective and thorough strategy for elucidating patterns of neotropical migratory bird ecology in Monterey County.

#### *Habitat Analysis and Restoration*

A thorough evaluation of riparian habitats throughout Monterey County is necessary in order to determine the actual and potential availability of that habitat type for neotropical migrants. Yearly or twice-yearly habitat evaluations at each study site based on the Habitat Structure Assessment protocol developed by the institute for Bird Populations will provide important information about habitat structure, floristic diversity and land use intensity. These habitat variables can then be correlated with avian population parameters in order to determine the habitat features that support the healthiest populations of neotropical migrants, and what restoration needs exist in watersheds throughout Monterey County.

Additionally, active restoration at multiple sites in Monterey County watersheds can answer questions about the impact of restoration efforts on neotropical migratory bird populations, and allow us to separate the effects of geographical location from habitat

structure and land use effects. Current theory asserts that riparian habitats providing high floristic diversity and habitat heterogeneity provide healthier habitats for neotropical migrants and other landbirds, and there is no evidence that increasing those habitat values has a negative impact on bird populations. Active restoration efforts can potentially replace recently lost riparian habitat, as well as improving existing riparian areas in Monterey County, providing increased breeding habitat for neotropical migratory birds as well as other landbird species.

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Figure 1. Location of seven avian monitoring sites in three Monterey County Watersheds

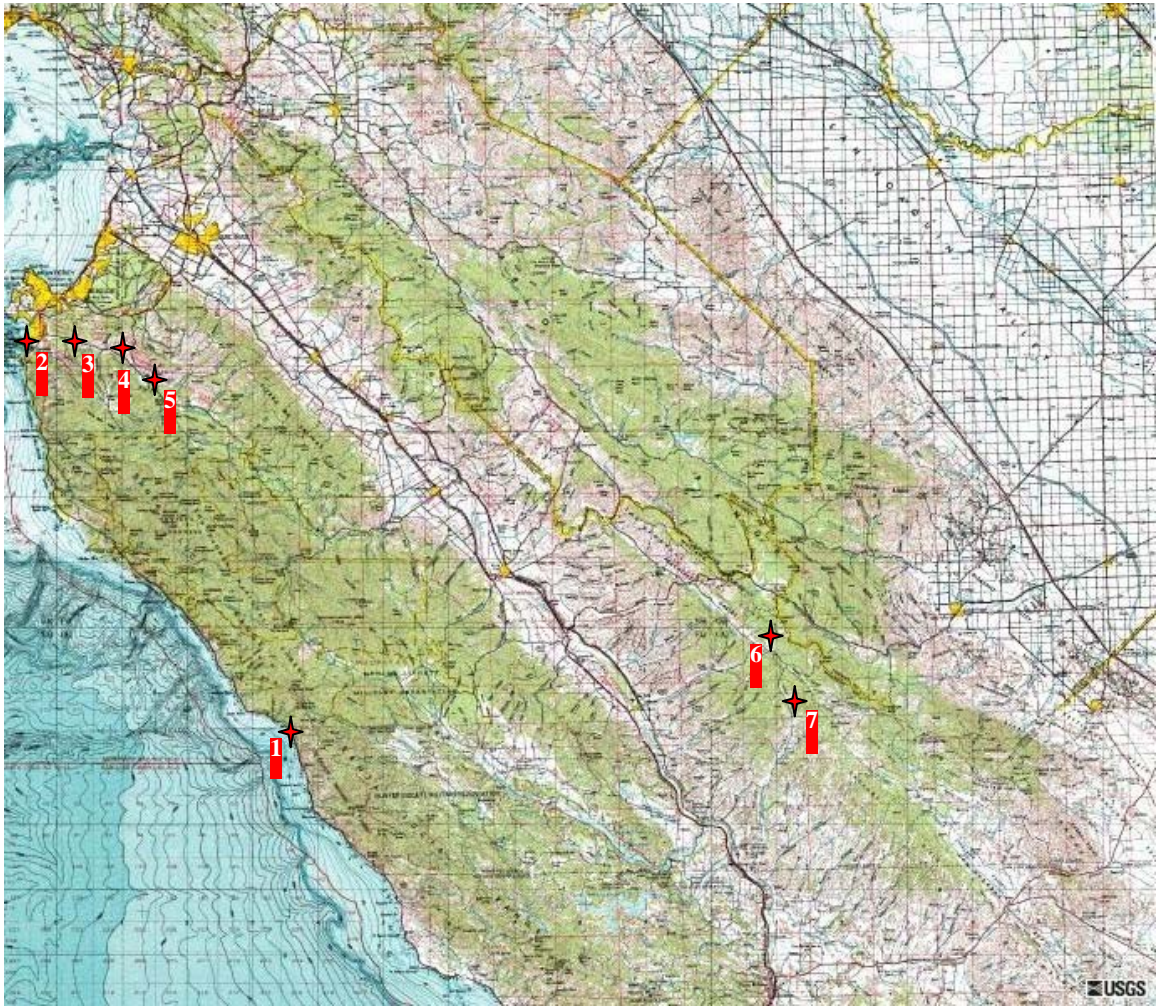


Table 1. Avian species richness and diversity calculated using area search count data collected from seven sites in three watersheds in Monterey County during breeding seasons 2003-2005.

	2003		2004		2005	
	Richness	SDI	Richness	SDI	Richness	SDI
Site 1	N/A	N/A	78	2.59	78	2.38
Site 2	41	3.07	50	3.32	36	2.94
Site 3	38	3.20	42	3.26	N/A	N/A
Site 4	44	3.22	41	3.23	N/A	N/A
Site 5	47	3.31	40	3.19	N/A	N/A
Site 6	N/A	N/A	43	2.98	47	2.89
Site 7	N/A	N/A	44	2.98	39	3.14

Table 2. Results of one-way ANOVA to determine differences in avian diversity calculated using area search count data collected from seven sites in three watersheds in Monterey County during breeding seasons 2003-2005.

	<i>n</i>	Sum of Squares	df	F-ratio	<i>P</i>
Overall Diversity	123	4.041	6	6.734	< 0.001
Neotropical Migrant Diversity	123	10.864	6	8.193	< 0.001

Table 3. Relative abundance of all birds and neotropical migrants calculated using area search count data collected from seven sites in three watersheds in Monterey County during breeding seasons 2003-2005.

	2003		2004		2005	
	All Birds	Neotropical Migrants	All Birds	Neotropical Migrants	All Birds	Neotropical Migrants
Site 1	N/A	N/A	52.14	20.05	53.07	17.00
Site 2	15.09	4.34	30.54	8.50	26.58	6.92
Site 3	54.25	6.75	44.60	9.80	N/A	N/A
Site 4	54.63	10.50	48.40	11.20	N/A	N/A
Site 5	65.00	13.00	47.80	17.00	N/A	N/A
Site 6	N/A	N/A	63.50	26.50	97.78	12.98
Site 7	N/A	N/A	55.00	21.11	42.40	11.40

Table 4. Capture rates of birds caught at seven sites in three watersheds in Monterey County during breeding seasons 2003-2005.

	2003			2004			2005		
	Captures	Net Hours	Capture Rate	Captures	Net Hours	Capture Rate	Captures	Net Hours	Capture Rate
Site 1	1449	6477.15	22.37	1292	6732.92	19.19	1391	6689.53	20.79
Site 2	266	904.48	29.40	231	827.78	27.91	173	753.18	22.97
Site 3	174	493.42	35.26	247	487.59	39.58	N/A	N/A	N/A
Site 4	222	479.56	46.29	151	477.33	31.63	N/A	N/A	N/A
Site 5	216	478.32	45.16	231	483.85	47.74	N/A	N/A	N/A
Site 6	N/A	N/A	N/A	159	496.83	32.00	158	495.00	31.92
Site 7	N/A	N/A	N/A	240	394.57	60.83	424	448.76	94.48

Table 5. Results of one-way ANOVA to determine differences in capture rates at seven sites in three watersheds in Monterey County during breeding seasons 2003-2005.

n	Sum of Squares	df	F-ratio	P
135	3896568.653	6	7.308	< 0.001