Final Report

The Effects of Helicopter Noise on the Coastal California Gnatcatcher at Marine Corps Air Station Miramar Contract Number N68711-05-M-1008

Prepared for:
Marine Corps Air Bases Western Area
Naval Facilities Engineering Command, Southwest

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HUBBS-SEAWORLD RESEARCH INSTITUTE

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EXECUTIVE SUMMARY

As part of the Department of Defense 1993 Base Realignment and Closure Act, Naval Air Station Miramar became Marine Corps Air Station (MCAS) Miramar (Station) on 01 October 1997. This realignment resulted in the addition of rotary-wing aircraft to Miramar, which previously supported only fixed-wing aircraft. The introduction of the helicopters, specifically the CH-46 and the CH-53E, required an analysis of the effects of the noise produced by these helicopters on the coastal California gnatcatcher (*Polioptila californica californica*) (California gnatcatcher, gnatcatcher), a federally threatened species that resides on MCAS Miramar.

In 1996, the United States Fish and Wildlife Service issued Biological Opinion 1-6-95-F-33. After considering the potential effects of the helicopter noise on the coastal California gnatcatcher, the Marine Corps proposed a study to determine any effects on the gnatcatchers. The Biological Opinion states "the effect of helicopter noise on gnatcatchers is currently being studied on the Station." Any impacts determined to be significant will require re-initiation of this consultation to determine appropriate terms and conditions." Subsequently, MCAS Miramar initiated a 4 year study to study the effects of helicopter noise and a one year follow-up study to monitor reproductive success. The follow-up study was done to insure the accuracy of the analysis of the data on the flight patterns identified by the Station's aircraft noise study (Wyle, 2004). Through a series of scientific reviews, technical experts from Hubbs-SeaWorld Research Institute, United States Fish and Wildlife Service, WEST Statistical Services, California State University, Fullerton and San Diego State University agreed upon a possible study design that was the basis for this study and documented in the final work plan (Regional Environmental Consultants (RECON), 1997) and the Revised Final Work Plan (Hubbs-SeaWorld Research Institute (HSWRI), 1998). It was recognized by this group of experts, that a variety of factors, both natural and anthropogenic would likely influence coastal California gnatcatcher nesting success. For this reason, in addition to a suite of noise metrics, a variety of factors were quantified including, vegetation structure and composition, disturbance rates, predator density, distance to roads, geographic indices and climate. These additional data were used to develop multiple variable statistical models that could be used to control for these additional factors. This approach is similar to methods used to adjust human health studies for the affects of age and demographics in human populations. Data collected were used to test the null hypothesis of no adverse effect to nesting success rates, fledgling production rates and nest site selection patterns due to changes in helicopter noise levels as a result of Station realignment.

Coastal California gnatcatcher nests were monitored for nesting productivity. Nests were monitored in 1998, 1999, 2000 and 2001 resulting in 421 nests available for analysis. When data was available from previous coastal California gnatcatcher studies and the metrics were consistent, analysis was conducted on 760 nests monitored from 1995 through 2001. A nest was considered successful if it fledged one young. Nesting success rates throughout the study (pre- and post-helicopters) averaged 33 percent for the entire study period and produced 2.35 fledglings per pair. Sound was monitored at coastal California gnatcatcher nests for a total of 6176 days during 620 runs at 328 locations. Run time during each sampling period averaged 10 days, ranging from 6 to 18 days. Most of the monitoring of nest sites was completed from April to September, depending on the length of the nesting during the year. The factors in nesting success considered in this study included habitat selected for nesting, vegetation structure and species composition, topography, climate and other factors. Data used for this analysis provide one of the largest databases from which to infer the ecological, habitat requirements and noise environment necessary for coastal California gnatcatcher reproductive success.

Statistical models were developed to test for association between coastal California gnatcatcher reproductive parameters and covariate indicators of biological processes including habitat metrics, physical parameters, indices to climatic conditions, and environmental noise. Resulting models of reproductive endpoints were overlaid on sound contours based on average measured post-realignment (1999-2001) noise levels. Noise levels were developed through geostatistical models based on measured noise values.

Model results for predicted probability of nest success, predicted probability of nest site selection and predicted number of fledges per pair show:

Nesting Success

- The coastal California gnatcatcher will find and inhabit suitable nesting habitat, in spite of the noise environment recorded at MCAS Miramar. Nest success is equally likely in quiet and noisy areas within the MCAS Miramar.
- Coastal California gnatcatcher nesting success was negatively associated with tall stands of broom baccharis (*Baccharis sarothroides)* and black sage (*Salvia mellifera)* with an understory dominated by dead leaf litter.
- Habitat, topography and fall rainfall were positively associated with reproductive success.

- Nesting success was not associated with any of the noise metrics measured; suggesting that noise from helicopters was not detrimental to coastal California gnatcatcher reproductive success.
- Nesting success rates increased with distance from flight tracks. However, after adjusting for covariation with habitat, climate and physical metrics, success rates for nests close to helicopter flight tracks were statistically similar to those more distant nests.

Nest Site Selection

- The three most important factors controlling coastal California gnatcatcher nest site selection were elevation, and distribution of *Artemisia californica* and *Baccharis sarothroides*.
- After adjusting for spatial variation with habitat, nest site selection patterns were not associated with noise levels.

Fledges Per Pair

- Height of *Salvia mellifera* was negatively associated with the number of fledges per pair.
- Coastal California gnatcatchers fledged more chicks in noisy than in quiet areas, although this association was not statistically significant.

Specifically, nest success was highest in areas that were concave up such as drainage bottoms, with relatively tall stands of *Lotus scoparius* and interspersed gaps in shrub cover vegetated with forbs and grasses suitable for coastal California gnatcatcher prey production and when the Palmer Hydrological Drought Index was high during the fall prior to the breeding season. They were less successful in tall (older) stands of *Baccharis sarothroides* and *Salvia mellifera* with an understory dominated by dead leaf litter.

Coastal California gnatcatchers tended to select areas to nest in that are dominated by shrub stands of *Artemisia californica*, *Baccharis sarothroides* and *Eriogonum fasciculatum* and avoided habitats dominated by *Isocoma menziesii*, *Malosma laurina*, *Baccharis salicifolia*, *Lotus scoparius* and *Rhus integrifolia*. It is interesting that gnatcatcher pairs would select for areas dominated by shrub stands of *Baccharis sarothroides,* which was negatively associated with nest success and avoid areas with *Lotus scoparius* which was positively associated with nest success. We believe that the successional stage of coastal sage species may be an important factor in determining success rates.

This study provides important information regarding the management of the coastal California gnatcatcher. For the first time ecological and noise level factors important to a population level nesting success have been quantified. Coastal California gnatcatchers have higher nest success rates in large expanses of early successional, low growing, coastal sage scrub habitat with a well-developed forb understory. If the coastal sage scrub habitat is late successional, with dead leaf litter overtaking the forb layer with few gaps and a high proportion of *Baccharis sarothroides* and *Salvia mellifera* the chances for successful nesting decreases. These data suggest that environmental noise did not affect nesting success, nest site selection or fledges per pair.

Management strategies for the coastal California gnatcatcher that focus on habitat as opposed to attempting to modify the noise environment would appear to be more effective for enhancing reproductive success.

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1.0 INTRODUCTION

As part of the Department of Defense 1993 Base Realignment and Closure Act, Naval Air Station Miramar became Marine Corps Air Station Miramar (MCAS Miramar, Station) on 01 October 1997. This realignment resulted in the addition of rotary-wing aircraft to Miramar, which previously supported only fixed-wing aircraft. Currently, Miramar is home for eight F/A-18C & F/A-18D Hornet jet squadrons, four CH-46 Sea Knight helicopter squadrons, four CH-53E Super Stallion helicopter squadrons, one KC-130 transport and refueling squadron, and nine station support aircraft for a total of about 260 aircraft.

As part of a biological assessment, the Marine Corps proposed analysis of the potential effects of the noise produced by the introduction of the helicopters, specifically the CH-46 and the CH-53E, on the coastal California gnatcatcher (*Polioptila californica californica,* California gnatcatcher, gnatcatcher, CAGN), a federally threatened species that occurs on Miramar. Although birds on Miramar have been exposed to noise from fixed-wing aircraft for many years, helicopters fly different maneuvers and altitudes than most fixed-wing aircraft and thus produce different sound profiles. As part of the Section 7, Endangered Species Act consultation with the U.S. Fish and Wildlife Service, the Marine Corps proposed to conduct a study to evaluate the effects of the addition of helicopters to Miramar on the reproductive success of the California gnatcatcher.

This report describes the final results of a study to assess the effects of helicopter noise on the reproductive success (nest success, numbers fledged) of California gnatcatcher at Miramar conducted under contracts N68711-97-C-8707 and N68711-05-M-1008. This study was designed to determine if breeding success of the coastal California gnatcatcher is influenced by helicopter noise and if so, to estimate the magnitude of these potential effects. This study was designed using a two-step approach. The first step tested for an association between reproductive success and environmental noise levels. If such a relationship were found, the second step would identify the contribution of helicopter noise to any apparent effect. This report includes the analyses of the rotary- and fixed-wing flight procedures provided by MCAS Miramar in 2005.

A total of five years of data was collected (1997 through 2001). The first year of data was collected under work plan titled "Final Work Plan for the Effects of Noise on Passerines at MCAS/NAS Miramar of December 19, 1997" (Regional Environmental Consultants 1997). This study was designed to collect base line data on the gnatcatcher population before the helicopters were deployed, and to use as a basis for discussion for the revised work plan technical advisory group. Upon the development of new methods years 2 through 5 (1998 through 2001) of the study were performed under the methods described in the "Revised Final Work Plan for The Effects of Noise on California Gnatcatchers at MCAS Miramar" (Hubbs-SeaWorld Research Institute 1998). The first two years serve as baseline data since there were no helicopters based at Miramar until 01 September 1998.

1.1 OBJECTIVE

The objective of these contracts was to evaluate the existence of potential effects of helicopter noise on California gnatcatcher reproduction and if present to determine the magnitude of these effects. Reproductive success of the California gnatcatcher, as measured by the proportion of successful nests and the number of young fledged, was the primary focus. Flight procedures provided by MCAS Miramar were used in the analyses.

1.2 RATIONALE

In 1996, the United States Fish and Wildlife Service issued biological opinion 1-6-95-F-33, in which it was agreed that Miramar would study the effects of helicopter noise on the reproductive success of the California gnatcatcher. Subsequently, Miramar initiated this 5-year study monitoring reproductive success. Through a series of scientific reviews, technical experts in statistical design, acoustics, and the coastal California gnatcatcher, from West Statistical Services, San Diego State University, Hubbs-SeaWorld Research Institute, the United States Fish and Wildlife Service and the Department of Defense arrived at consensus on an appropriate study design that was documented in the final work plan (Hubbs-SeaWorld Research Institute 1998). It was recognized by this group of experts, that a variety of factors, both natural and anthropogenic would likely influence CAGN nesting success. For this reason, the study took a "two step" approach to addressing the question of whether the noise associated with helicopter operations relocated to MCAS Miramar as a result of BRAC realignment have an effect on California gnatcatcher reproductive success. The "first step" addresses whether total noise was associated with the reproductive success of the gnatcatcher, without regard to the source (due to the difficulty in separating the noise from fixed-wing aircraft, rotary-wing aircraft, and other sources). If a "noise effect" was identified, the "second step" would attempt to determine the existence and magnitude of the affect associated with the addition of helicopters to MCAS Miramar. The rationale behind this approach being that if there was no affect associated with noise ("first step"), there was no need to proceed with attempting to determine the affect specifically attributable to the realigned helicopters ("second step"). The study tested for a noise effect after adjusting for vegetation structure and composition, disturbance rates, predator density, distance to roads, geographic indices and climate. Reproductive endpoints tested were nest success rates, fledge production rates and nest site selection.

1.3 STUDY AREA

MCAS Miramar encompasses approximately 24,000 acres and is located in San Diego County on the southwest coast of California within the incorporated area of the City of San Diego. State Route 52 (SR52) bounds the southern end of the Station, Interstate 805 (I805) the western boundary and is bisected by Interstate 15 and State Route 163. Along the northern boundary lie the communities of Mira Mesa, Scripps Ranch and Poway, within the western half of the Station aircraft activity is heavy over most of the area. To the east, there is a large area extending to Santee, which is infrequently exposed to high sound levels. Figure 1 shows the regional location of the Station and Figure 2 shows the study area.

1.4 CALIFORNIA GNATCATCHER LIFE HISTORY

The California gnatcatcher is recognized by the US Fish and Wildlife Service (USFWS) as a threatened species (USFWS 1993) and by the State of California as a species of special concern. Loss of habitat and fragmentation of the population throughout most of its range has reduced the gnatcatcher population.

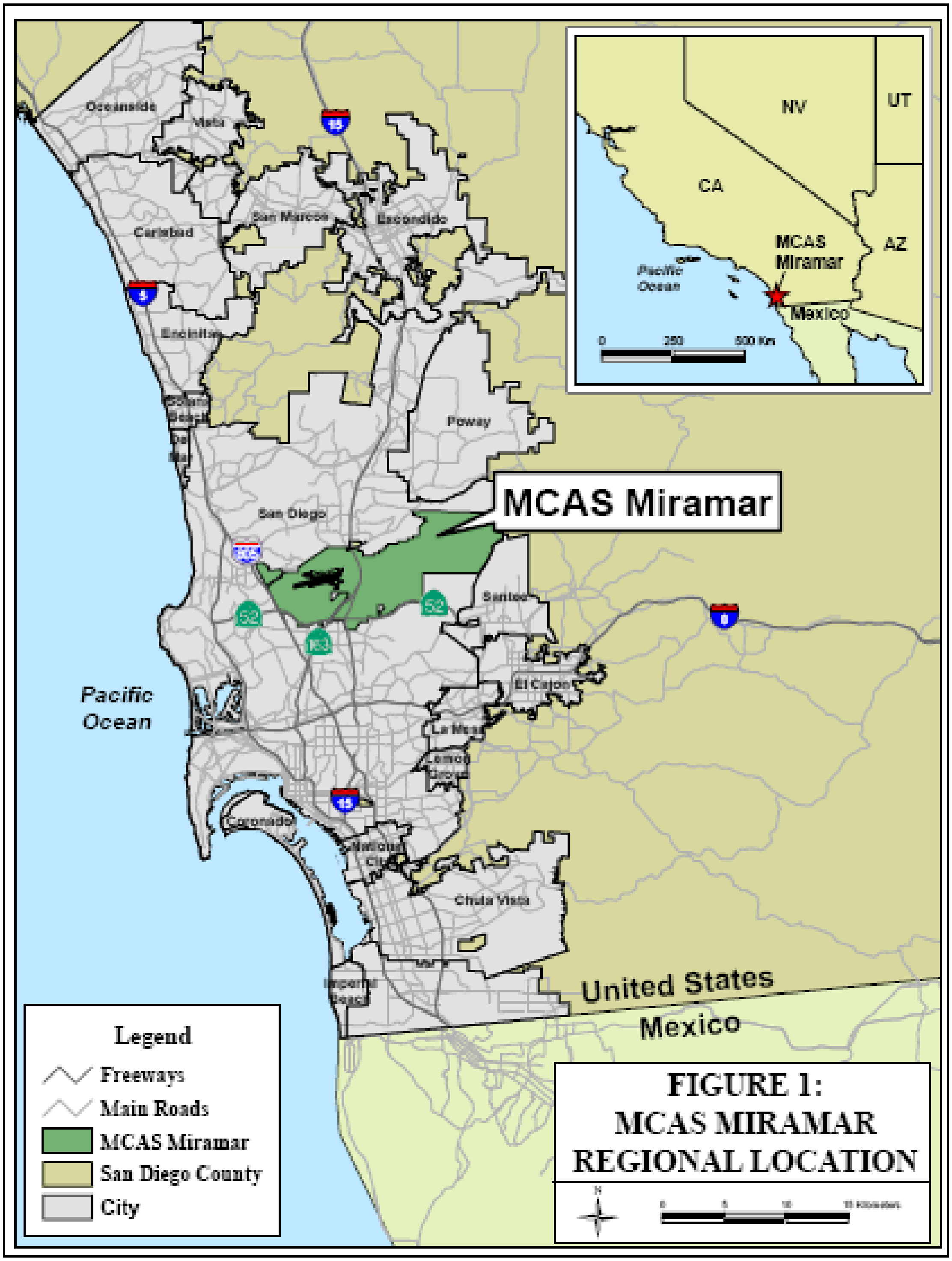
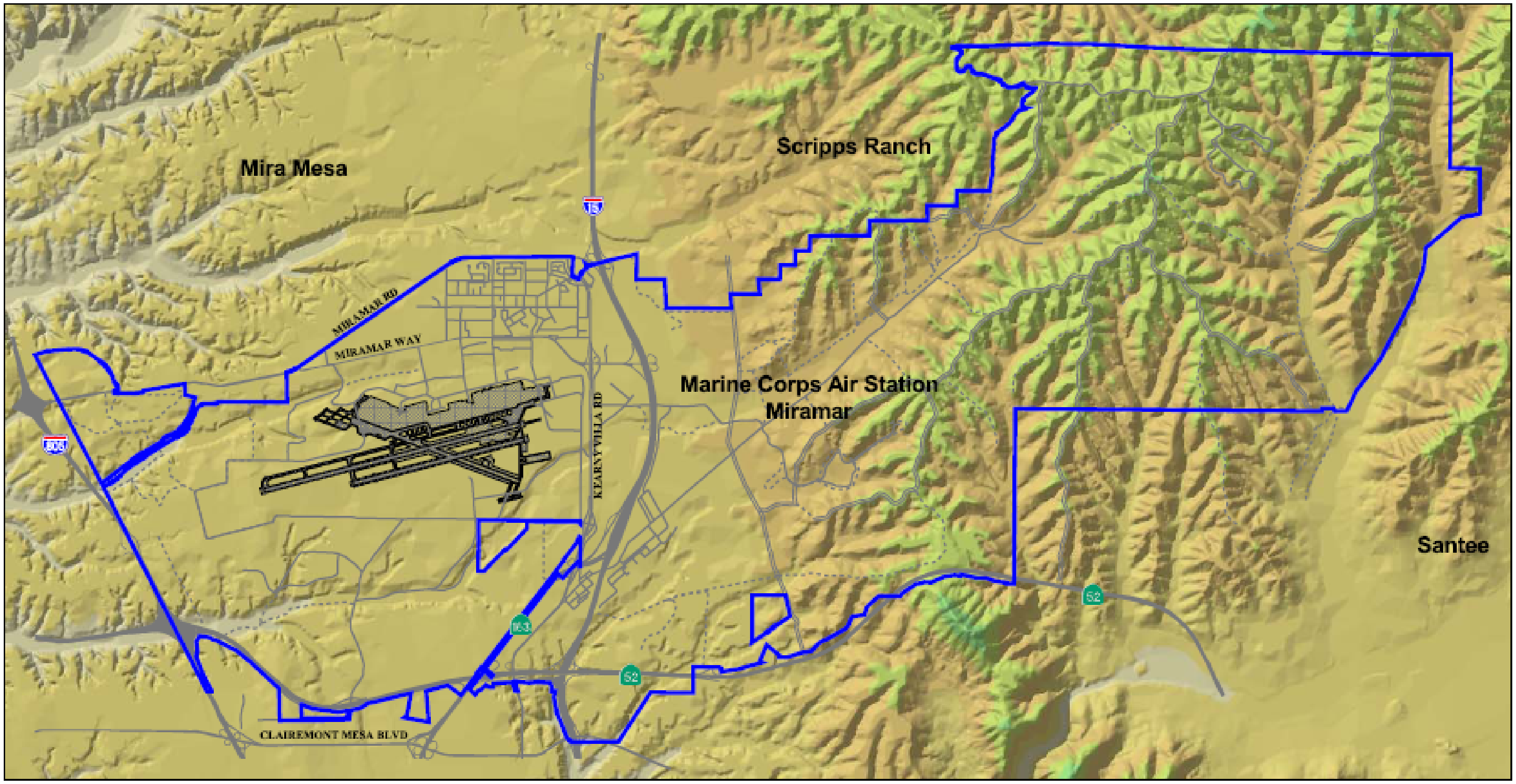


FIGURE 1:
MCAS MIRAMAR
REGIONAL LOCATION



Legend

Features	Elevation (feet)
MCAS Miramar Boundary	40 - 300
Airfield	300 - 550
Paved Road	550 - 800
Dirt Road/Fire Road	800 - 1050
Fuel Break	1050 - 1280

FIGURE 2:
MARINE CORPS
AIR STATION MIRAMAR

1000 0 1000 2000 Meters

N

The California gnatcatcher is a small gray songbird (Figure 3) that weighs 5-6 grams and is considered an obligate resident of the coastal sage scrub, an indigenous southern California vegetation community. The subspecies *Polioptila californica californica* ranges from Los Angeles County south to the Mexican border, throughout lower elevations in Orange, Riverside, San Bernardino, and San Diego counties. The species as a whole ranges into Baja California south to approximately 30 degrees north latitude near El Rosario (American Ornithologists' Union 1998; Atwood 1980, 1990; Jones and Ramirez 1995). The gnatcatcher is a year-round resident of southern and Baja California. The home range varies in size from 2 to 45 acres. They have a bimodal, diurnal activity pattern - active and vocal during the morning (0600-1100) and the afternoon (1500-dusk), resting deep in shrubs the rest of the day. Wind speeds over 15 mph, low temperatures (below 55^{o}F) and high temperatures (above 95^{o}F) tend to restrict their activity. Gnatcatchers are secretive birds that spend most of their time close to the ground (<2 meters) in vegetation.

Gnatcatchers produce a thin, high-pitched whistle having most of its energy in the range from 1-3 kilohertz (kHz) that appears well designed to prevent localization by potential predators, particularly during the nesting period. The source sound level [A-weighted RMS SPL] of their song is low, ~50 decibel (dBA) (Awbrey 1993). Males call frequently during territory establishment and courtship, but only a small proportion of time is spent calling once they have mated. Single males advertise from high perches at the edge of their home ranges but when mated, adopt more unobtrusive perches. Both adults scold constantly while defending their territory from predators. The scolding pish call is in a lower frequency.

California gnatcatchers breed between February and August. Most chicks fledge by the last week of July, but stragglers occur through the rest of the season. Figure 4 shows a nest with eggs and nestlings less than one week old. Both members of the pair build the nest, taking four to fourteen days (Ogden 1992). One egg is laid each day until a clutch is complete. The clutch size ranges from three to five eggs with a mode of four eggs (Atwood1988, Hunsaker, Awbrey and O'Leary 1998). Incubation begins after the last or next-to-last egg has been laid and continues for 14 to 15 days. The chicks hatch synchronously. Nestlings fledge about 11 to 14 days after hatching and the parents continue to care for them from two to five weeks

Female coastal California gnatcatcher

Male coastal California gnatcatcher

Coastal California gnatcatcher	Figure 3

Coastal California gnatcatcher nest with eggs

Coastal California gnatcatcher chicks

Coastal California gnatcatcher eggs and chicks approximately 5 days old	Figure 4

before they disperse from the nesting area. Gnatcatchers are persistent and will continue to renest until the pair has a successful clutch or the breeding season ends. Occasionally a pair will have two successful nests in a season. On average, they have a 33% nest success rate (Hunsaker, O'Leary and Awbrey, 2000) based on a nest successfully fledging at least one young in a nesting season. The greatest causes of mortality are predation and inclement weather, which also affect insect stocks and nest predators.

The coastal sage scrub plant community is important to the survival of California gnatcatchers and it is the plant community that gnatcatchers have typically nested in on the Station. O'Leary, Stow and Coulter (2002), define undisturbed Diegan coastal sage scrub as habitat where greater than 50% of the ground cover is composed of low, soft-woody shrubs and subshrubs with mostly bare ground in between. Disturbed Diegan coastal sage scrub has between 20 to 50% ground cover of low, soft-woody shrubs and subshrubs and coastal sage scrub-chaparral scrub has greater than 70% ground cover attributable to evergreen sclerophyllous chaparral species and drought-deciduous malacophyllous sage scrub species (O'Leary, et al, 2002). Ideally, the bare ground lacks significant cover and the presence of non-native herbs is minimal. Dominant species in all three vegetation communities include California sagebrush *(Artemisia californica)*, California buckwheat *(Eriogonum fasciculatum)*, black sage *(Salvia mellifera)*, white sage *(Salvia apiana)*, monkey-flower *(Mimulus aurantiacus)*, and saw-toothed goldenbush *(Hazardia squarrosa)*, along with laurel sumac *(Malosma laurina)* and lemonade-berry *(Rhus integrifolia)*. Dry wash areas tend to contain most of the above species with additional substantial coverage of broom baccharis *(Baccharis sarothroides)*.

2.0 METHODS

The following sections describe the procedures for bird monitoring, sound level monitoring, vegetation monitoring and statistical analysis conducted in years 1998-2001 based on the "Final Work Plan for the Effects of Noise on Passerines at MCAS/NAS Miramar of December 19, 1997" (Regional Environmental Consultants 1997) and the final revised work plan (HSWRI, 1998). The methods were designed to measure spatial and temporal variation in the breeding success of the California gnatcatcher within the study area. Breeding success was then compared to acoustic measurements to determine whether noise had a detectable impact on gnatcatcher productivity. The analysis used a two step approach, first to determine if the breeding success was influenced by the total sound levels from all sources recorded at the nest sites. If there were no impacts associated with these noise levels, then the assumption was made that the helicopter noise portion had no effect on breeding success. If an effect was noted, the second step was taken to determine how much of the effect was due to noise generated by helicopters.

A nest-based sampling of sound was used, which is also amenable to analysis as a systematic sampling. The meters were moved to a nest site for one week and moved to another nest (territory) at the end of each one-week period. By using this rotation, the sound environment at each pair location was sampled at least twice during the breeding season. In addition, sound data was collected at an array of 56 randomly sampled permanent plot points

In nest monitoring, the report recommended all gnatcatchers on MCAS Miramar should be monitored. The number of gnatcatcher pairs present on Miramar during the four years of the study could not be accurately predicted. Gnatcatchers did not need to be banded since pairs hold their territories during breeding season and can be identified by territory. Nesting activity was monitored from a distance so as not to increase the risk of predation at the nest.

Environmental covariates were also measured, which would reflect the gnatcatcher's response to climate, habitat quality, disturbance and density of important competitors, predators and parasites. The main focus of the covariates were: Climate, Habitat Quality and Disturbance.

2.1 COASTAL CALIFORNIA GNATCATCHER MONITORING

Station-wide population censuses for California gnatcatchers were conducted throughout the 1998, 1999, 2000 and 2001 breeding seasons. The breeding season is defined as the time when California gnatcatchers are participating in territory establishment, nest building, egg laying, brooding, and care of fledglings close to the nest. Each year field surveys on the Station began 01 February and continued through August. Three levels of priority were placed on surveying areas for pairs. Initial surveys were conducted for pairs that were studied during the previous breeding season. Second, any area that historically supported gnatcatcher pairs or dispersing individuals prior to the previous breeding season was surveyed. Finally, all historically unoccupied gnatcatcher habitats (which included all coastal sage scrub and coastal sage scrub chaparral and habitat occurring on the station plus a 100 meter buffer) were surveyed. All areas of coastal sage scrub occurring within the Study Area that might serve as habitat for gnatcatcher were surveyed a minimum of three times throughout the breeding season.

Once a pair was located, intensive efforts were made to locate nests as early in the breeding cycle as possible. The nests were located by searching appropriate vegetation and by observing breeding adult behavior. Once a nest was located, the host plant (nest substrate) was identified to the species level. If the nest was found during the laying, hatching, or nestling period, the date for the onset of laying was estimated. The values used for this estimation were three days for laying, fourteen days for incubating, and fourteen days for feeding the nestlings.

To minimize disturbance during the breeding season, active nests were checked no more than once every seven days. If a nest was intact with no adult present, it was checked by permitted personnel to verify the status or age of the chicks. Whenever possible, nests were observed from a distance with binoculars so that the incubating or brooding adult was not disturbed. If the status of the nest could not be determined from a distance, then the observer waited until the adult left the nest before checking the contents. For the remainder of the nesting cycle, the nest was checked from a distance. If a nest was abandoned or predated, attempts were made to determine the cause of the nest failure.

A nest was considered predated if it was found empty after it had contained at least one egg or nestling that had not fledged. Cases wherein only part of a clutch or brood disappeared were considered partially predated, except when it eventually resulted in a total loss. Cowbird parasitism was considered a form of predation if the nest resulted in a loss. A nest was considered abandoned if activity at the nest ceased, as evidenced by unfinished nests, cold eggs or dead nestlings.

The geographic coordinates of each nest were recorded with a Global Positioning System (GPS) unit with sub-meter accuracy. These values were subsequently translated and plotted to give a spatial representation of nest locations with respect to each other and to sound level meter locations.

In addition to collecting data on productivity, additional information was collected to more fully describe what occurred in the gnatcatchers territory throughout the breeding season. This required collecting information on overflights, predators, extraneous noises and disturbances. This data was used to create an index for statistical models.

For overflights, data was collected while monitoring gnatcatcher pairs. Information recorded included pair name and block of time spent in the area, the number of overflights that flew through a 45 degree circle above the gnatcatchers territory. These observations were sorted into the following categories: helicopter, jet, prop plane, large plane and other. The information was collected as a point count for aircraft. Time was recorded whether or not any overflights occurred.

Similar methodology was followed when collecting information on predators including: the number and type of predators observed in a gnatcatcher territory, start time, end time and date of the predation observational period. See Table 1 for a list of potential predators.

Information was also collected on disturbances and extraneous noise occurring in or near a gnatcatcher territory. Information collected included pair or nest name, start time, end time and date of the observational period, observer and type of disturbance for example gun fire, Amtrak train, construction or troop training (Appendix A and B). The noise level of the

Table 1. Potential Predators

Species	Scientific Name	Observed	Diet
Avian			
Osprey	*Pandion haliaetus*	Yes	Fish, rodents, birds, small verts, crustaceans
White-tailed Kite	*Elanus leucurus*	Yes	Rodents, birds, snakes, lizards, frogs, large insects
Northern Harrier	*Circus cyaneus*	Yes	Voles, birds, snakes, frogs, insects, carrion
Sharp-shinned Hawk	*Accipiter striatus*	Yes	Birds, small mammals, frogs, lizards, insects
Cooper's Hawk	*Accipiter cooperii*	Yes	Birds, small mammals, reptiles, amphibians
Red-shouldered Hawk	*Buteo lineatus*	Yes	Small mammals, reptiles, amphibians, birds
Red-tailed Hawk	*Buteo jamaicensis*	Yes	Small mammals, birds, reptiles, insects
Golden Eagle	*Aquila chrysaetos*	Yes	Small mammals, birds, reptiles, insects
American Kestrel	*Falco sparverius*	Yes	Insects, small verts, small mammals, birds
Merlin	*Falco columbarius*	No	Birds, small mammals, insects
Prairie Falcon	*Falco mexicanus*	No	Birds, small mammals, insects, lizards
Peregrine Falcon	*Falco peregrinus*	No	Birds
Greater Roadrunner	*Geococcyx californianus*	Yes	Insects, mammals, reptiles, rodents, birds, fruit, seeds
Barn Owl	*Tyto alba*	Yes	Small mammals, birds, amphibians, reptiles, insects
Short-eared Owl	*Asio flammeus*	No	Small mammals, birds, insects
Long-eared Owl	*Asio otus*	No	Small mammals, birds
Great Horned Owl	*Bubo virginianus*	Yes	Small mammals, birds, small verts, insects
Western Screech-Owl	*Otus kennicottii*	No	Small mammals, insects, small verts, birds
Burrowing Owl	*Athene cunicularia*	No	Insects, rodents, lizards, birds
Western Scrub-Jay	*Aphelocoma californica*	Yes	Insects, other inverts, small verts including bird eggs, nestlings, fledglings
American Crow	*Corvus brachyrhynchos*	Yes	Insects, other inverts, carrion, small verts, bird eggs, nestlings, seeds
Common Raven	*Corvus corax*	Yes	Carrion, small verts, bird eggs and nestlings, insects, other inverts, garbage, seeds, fruit
Loggerhead Shrike	*Lanius ludovicianus*	Yes	Large insects, birds, mice, lizards
Northern Mockingbird	*Mimus polyglottos*	Yes	Insects, fruits, small verts
Reptilian			
San Diego Alligator Lizard	*Elgaria multicarinatus webbi*	Yes	Insects, small animals such as young mice and birds, tree frogs, other lizards
Coastal Rosy Boa	*Lichanura trivirgata roseofusca*	Yes	Small mammals and birds

Western Yellow-belly Racer	*Coluber constrictor mormon*	Yes	Small mammals, reptiles, frogs, insects
Red Coachwhip	*Masticophis flagellum piceus*	Yes	Small mammals, birds and their eggs, lizards, snakes, insects, carrion
California Striped Racer	*Masticophis lateralis lateralis*	No	Frogs, lizards, snakes, small mammals, birds, insects
Coast Patch-nosed Snake	*Salvadora hexalepis virgultea*	No	Small mammals, lizards and reptile eggs
San Diego Gopher Snake	*Pituophis catenifer annectans*	Yes	Rodents, rabbits, birds and their eggs, lizards, insects
California Kingsnake	*Lampropeltis getulus californiae*	Yes	Snakes, lizards, small turtles, reptiles eggs, frogs, birds and their eggs, small mammals
Western Long-nosed Snake	*Rhinocheilis lecontei lecontei*	No	Lizards and their eggs, small snakes, small mammals, birds
California Lyre Snake	*Trimorphodon biscutatus vandenburghi*	No	Lizards, birds, small mammals, including bats
Northern Red Rattlesnake	*Crotalus ruber ruber*	Yes	Rodents, rabbits, birds
Southern Pacific Rattlesnake	*Crotalus viridis helleri*	Yes	Small mammals, birds, lizards, snakes, amphibians
Mammalian			
Opossum	*Didelphis virginiana*	Tracks	Fruits, vegetables, nuts, meats, eggs, insects, carrion
Coyote	*Canis latrans clepticus*	Yes	Rabbits, hares, ground squirrels, gophers, rodents, birds, insects
Gray Fox	*Urocyon cinerioargenteus californicus*	Yes	Small mammals, insects, fruits, acorns, birds and their eggs
Bobcat	*Lynx rufus californicus*	Yes	Small mammals, birds
Striped Skunk	*Mephitis mephitis holtzneri*	Yes	Mice, eggs, insects, grubs, berries, carrion
Long-tailed Weasel	*Mustela frenata*	No	Small rodents, rabbits, birds
Raccoon	*Procyon lotor psora*	Tracks	Fruits, nuts and grains, insects, frogs, crayfish, bird eggs
California Ground Squirrel	*Spermophilus beecheyi nudipes*	Yes	Vegetation, seeds, acorns, mushrooms, fruits, berries, birds, eggs and insects

disturbance was then estimated on a scale from 1-5, with 5 being the loudest.

2.2 ACOUSTIC MONITORING

Acoustic monitoring was conducted to obtain noise exposure metrics throughout the Station. This acoustic monitoring data was used to determine whether any correlation with gnatcatcher productivity, nest site selection or fledgling success could be determined and, if so, which sound metrics were highly correlated. This required collecting noise exposure metrics in the immediate vicinity of nest sites during the breeding season (Figure 5) and at permanent sound and vegetation sampling locations (Figure 6).

All terminology and definitions of sound metrics conformed to American National Standards Institute (ANSI) S1.1-1994 standards for acoustical terminology (Acoustical Society of America 1994) and ANSI S1.4-1983 specifications for sound level meters (Acoustical Society of America 1983). Appendix A contains a glossary that defines acoustical terms, abbreviations and symbols. Appendix B lists the data types collected for each meter run.

2.2.1 Nest-based Acoustic Monitoring

Noise monitoring was conducted in the vicinity of each gnatcatcher nest. In cases where nests were closely spaced, a single sound monitor was sometimes used to provide coverage for several nests. This approach insured a representative estimate of noise exposure while minimizing the disturbance at individual nest sites.

Specifically, sites were chosen to:

- Limit disturbance to nesting gnatcatchers
- Ensure that meter and nest(s) were at comparable altitude
- Ensure that meter and nest(s) had the same aspect (were oriented in the same direction along a canyon or hillside)
- Ensure that meter and nests(s) were in comparable vegetative cover
- Ensure accessibility for maintenance
- Limit the possibility of equipment theft

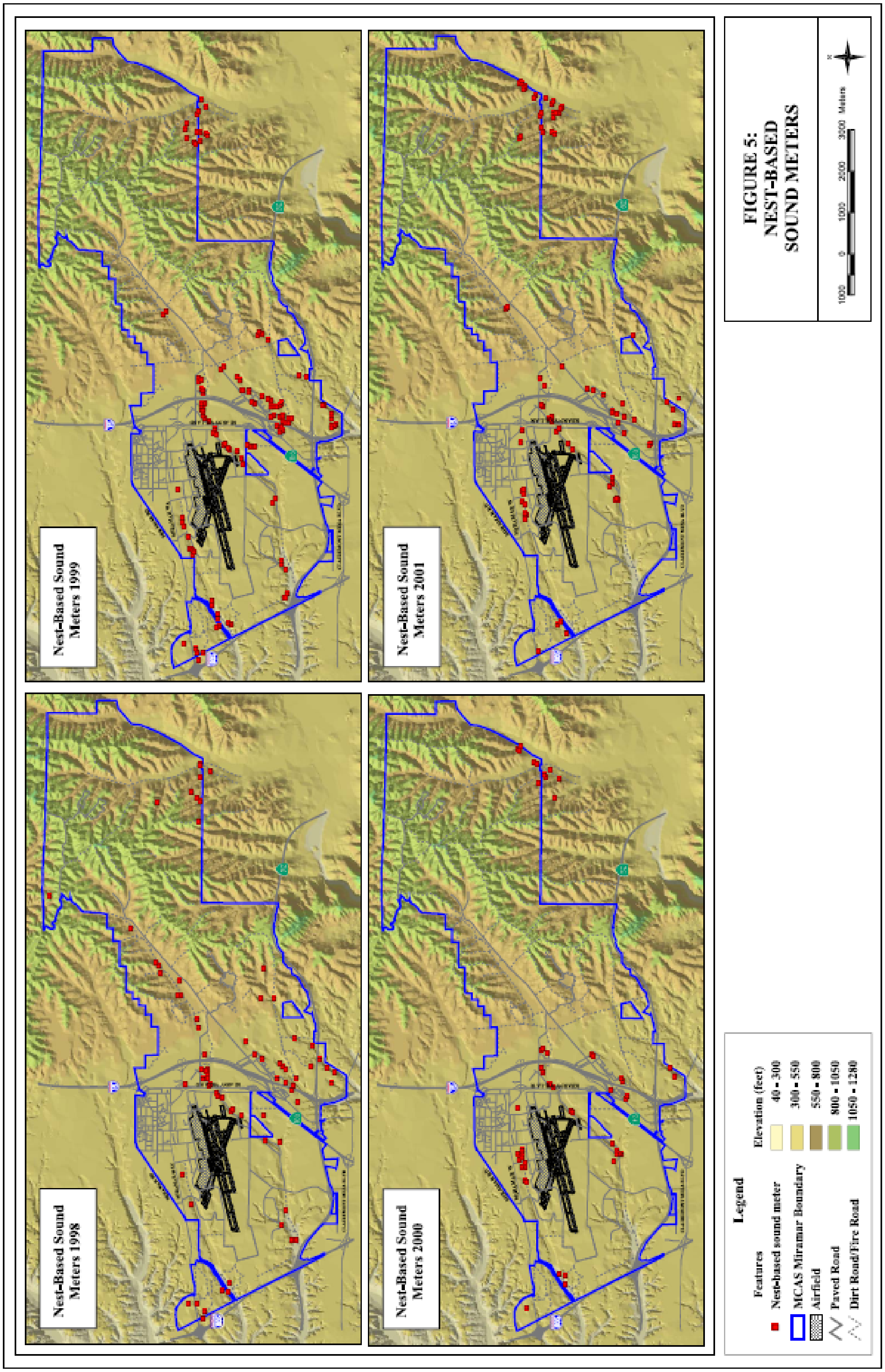


FIGURE 5: NEST-BASED SOUND METERS

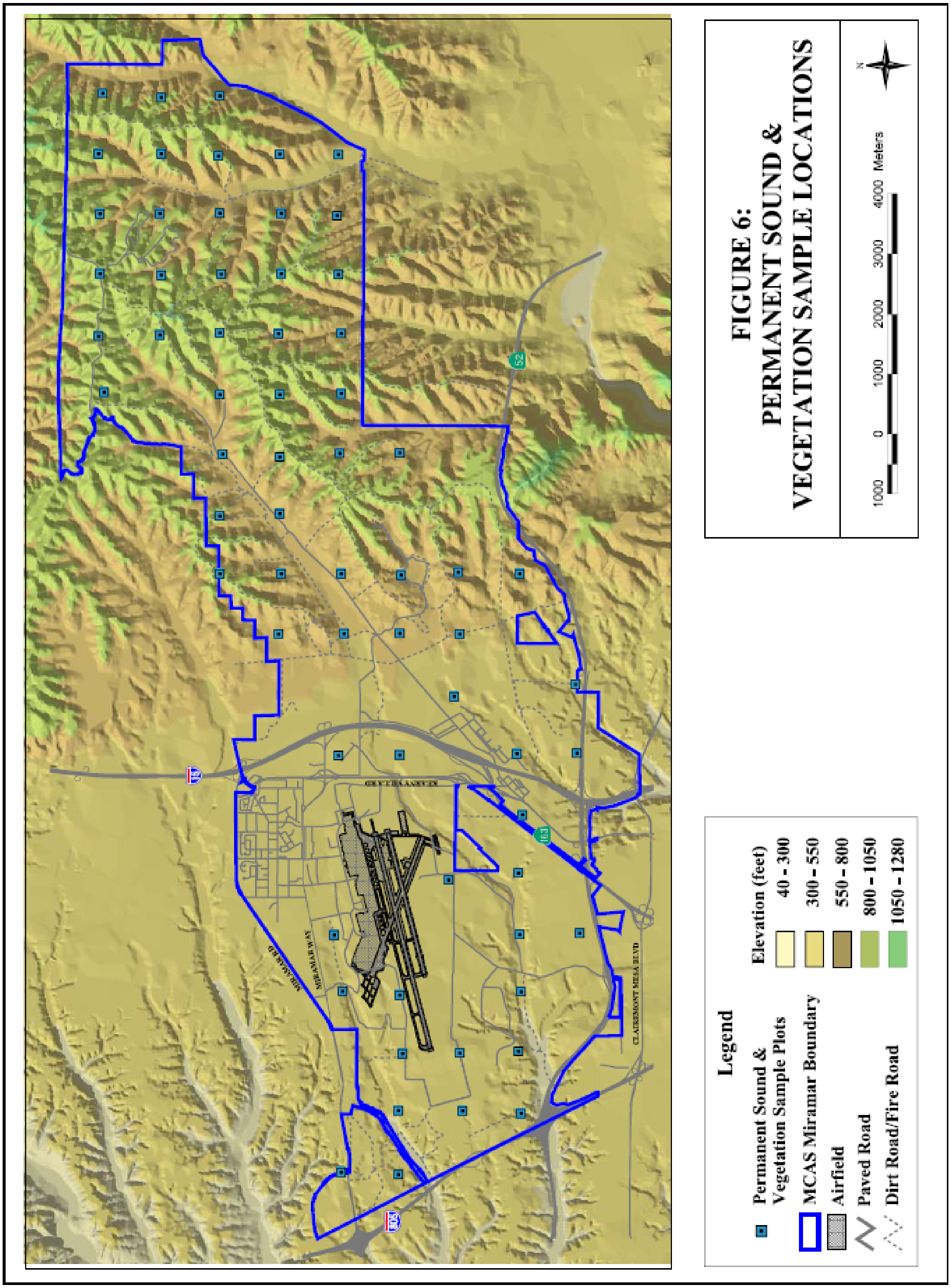


FIGURE 6:
PERMANENT SOUND &
VEGETATION SAMPLE LOCATIONS

Larson-Davis model 720 community noise meters (LD 720s, sound monitor) were used to collect noise data. These battery-operated, integrating sound level meters consist of a microphone, an analog to digital converter, a microprocessor to accumulate data and calculate metrics and summary statistics, and memory to store the resulting data. The LD 720 meets ANSI S1.4-1983 Type II specifications for general noise measurement. To ensure that the accuracy and precision of each instrument remained high throughout the monitoring period, each sound level meter was calibrated each time it was deployed. This was done with a Larson-Davis CAL150 acoustic calibrator. The calibrator underwent annual recalibration by the manufacturer. Any instrument found to be outside the Larson-Davis specifications was returned to the manufacturer for repair.

The instrument microphone was mounted 1.3 meters (4 feet) above ground level atop a galvanized pole (Figure 7). Each microphone was covered with a 15-centimeter open-pore foam windball to prevent contamination of data by wind noise. In addition, each microphone and windball was enclosed in a close-fitting, thin (15 mm) plastic bag to prevent water damage. Previous experience has shown that heavy rain could saturate the windball and damage the microphone in the absence of this protective covering. The plastic bag reduced effective microphone sensitivity by only 0.6 dBA at frequencies produced by aircraft (<8 kHz; this is also the effective upper limit of bird hearing [Dooling and Bowlin 1982]). Microphone cables were encased in flexible metal tubing to shield against electromagnetic interference (e.g., from radar and high voltage power lines) and damage by chewing animals. To prevent overheating, the weatherproof enclosure for the analyzer and its battery were placed under a reflective sun shield.

Each breeding season sound measurements were taken for each California gnatcatcher nest beginning with the initiation of the first nest and continuing until all nests had been sampled. If the nest was active, sound monitors were placed 20 meters from the nest to ensure that instrument maintenance did not disturb the nest or the adults. If the nest was in a canyon, every effort was made to place the meter at the same elevation, slope and aspect as the nest. Throughout the breeding season, each sound monitor recorded data continuously for a period of one week before rotation to a new nest

Field Setup of Community Noise Analyzer

Figure 7

location. Nests were sampled for two separate rotations producing a total of two one-week periods of data collection. Because flight patterns on the Station are typically consistent this method of monitoring adequately characterizes the exposure at any given location.

Acoustic data collected during unusual events, such as the annual Miramar Air Show, were not included in the statistical analysis unless nests were active during that period. In 1999, the Air Show occurred 30 July-1 August when two nests were active. Sound level meters were deployed at these nests to ensure that the noise from the Air Show was accurately characterized. Any meters deployed during unusual events were left in place for an additional week to determine normal exposure patterns during the rest of the nesting period.

After monitoring at the site was complete, data were downloaded to a portable computer, the battery was replaced, and the unit was calibrated and redeployed at a new location. All data were transferred to a computer at Hubbs-SeaWorld Research Institute for processing and inspection to ensure the quality of the data. Microsoft *Excel*© templates were used to convert raw data from the analyzers into tables and graphs for examination.

A large number of metrics and summary statistics were collected for examination, although only a few were considered for analysis. Most metrics were A-weighted. The rationale for this choice of weighting function is described in detail in the study plan (Final Work Plan For the Effects of Helicopter Noise to the Coastal California Gnatcatcher on Marine Corps Air Station Miramar, HSWRI 1998). The work plan stated that it was anticipated that covariates which will be investigated will include habitat quality indices, climate indices (year to year variation), slope, aspect, elevation, distance to construction projects, and other covariates which may be readily available from existing data sources or GIS coverages. The results of these models were used to predict the effects of noise throughout Miramar and displayed in the form of maps. In brief, some form of weighting (filtering) was needed to eliminate wind noise which predominates at low frequencies. Although the A-weighting function was developed for use in studies of human community response to noise, it is also reasonable for use with birds, at least when studying sounds that have most of their energy at low frequencies (<8 kHz). This approach was reasonable because any function based on bird hearing would be an approximation (the hearing of gnatcatchers has not been studied) and weighting functions have not yet been developed specifically for birds.

Cumulative measures of exposure were collected by hour, day, and sampling period (e.g., hourly, daily and period average sound level [L_{eq}]). Measures of individual event intensity were collected for sounds exceeding a preset threshold (70 dBA fast A-weighted SPL). Meters were set to collect event data if a sound exceeded 70 dBA for longer than five seconds. When sound levels dropped below 61 dBA, the meter stopped recording the event. This was intended to characterize overflights.

The cumulative metrics collected by run included average equivalent continuous sound pressure level (L_{eq}, averaged hourly, daily, and overall), sound exposure level (ASEL calculated by event, hourly, daily and overall), the maximum and minimum fast sound pressure levels (L_{max}, L_{min}) and the A-weighted and unweighted maximum instantaneous peak sound pressure levels (Peak). In addition, event metrics were summarized by the number of overflight events per run, the percentage of time that sound levels exceeded 60 and 80 dBA (L_{eq}), the number of overflight events in excess of 70 and 80 dBA (L_{max}) and the values for L_5, L_{50}, and L_{99}. Data for each monitoring site were then examined for quality and overall trends, summary metrics were prepared for the entire sampling period at each nest site.

2.2.2 Systematic Noise Monitoring

Sound monitoring in the immediate vicinity of nest sites was optimal for evaluating CAGN noise exposure, but was inadequate to develop noise contours throughout the Station. To correct for this, sound was also monitored at a systematic grid of locations evenly distributed throughout the Station (See Figure 6). The systematic grid was positioned with a random starting location to insure an unbiased sample of noise levels throughout the Station. This sampling design is known as systematic with a random start (Cochran 1977). See Section 2.3.2 for additional details. This sound monitoring data was used to produce a model of noise exposure across the entire Station. Methodology for collection of sound data is the same as that described in Section 2.2.1 Nest-based Sound Monitoring.

2.2.3 Geostatistical Noise Modeling

In anticipation of potential noise effects, geostatistical noise models were developed in order to predict noise at any area of the Station. These maps were designed so that potential for noise effects could be evaluated quantitatively and visually through maps of environmental noise levels across the Station. Data collected from the nest-based and systematic sound sampling design was used to create these noise maps. The geostatistical method known as kriging (Cressie 1991) was used to interpolate measured noise levels to unsampled locations so that maps could be constructed. For the 1997 and 1998 sound map there were no systematic sampling data so no geostatistical modeling was done. Geostatistical sound maps were created for 1999, 2000 and 2001 as well as a combined noise map for years 1999-2001.

2.2.4 Real-Time Monitoring

Real-time monitoring was conducted to identify the source of the noise detected by the sound level meters. As described, noise metrics collected by the LD 720 do not identify noise sources or the ensemble of noises that produce the background levels recorded in each area of the Station. To estimate the contribution of each source to the overall exposure reported by the LD 720s, a set of ten representative sites (Figure 8) were chosen and real-time recordings were made by observers who remained on site throughout the recording periods. Detailed real-time monitoring methods and results are included in Appendix C.

2.3 VEGETATION

The vegetation-sampling portion of the project was used to develop indices to habitat structure and composition at nesting sites and at a sample of available nesting sites. These indices quantified the effects of habitat variation on gnatcatcher nesting success and nest site selection. The sampling design was derived in part from O'Leary et al. (2002). Selected modifications to this sampling program were designed to provide additional data. The vegetation sampling portion of the project involved sampling at nest-based transects as well as available habitat transects.

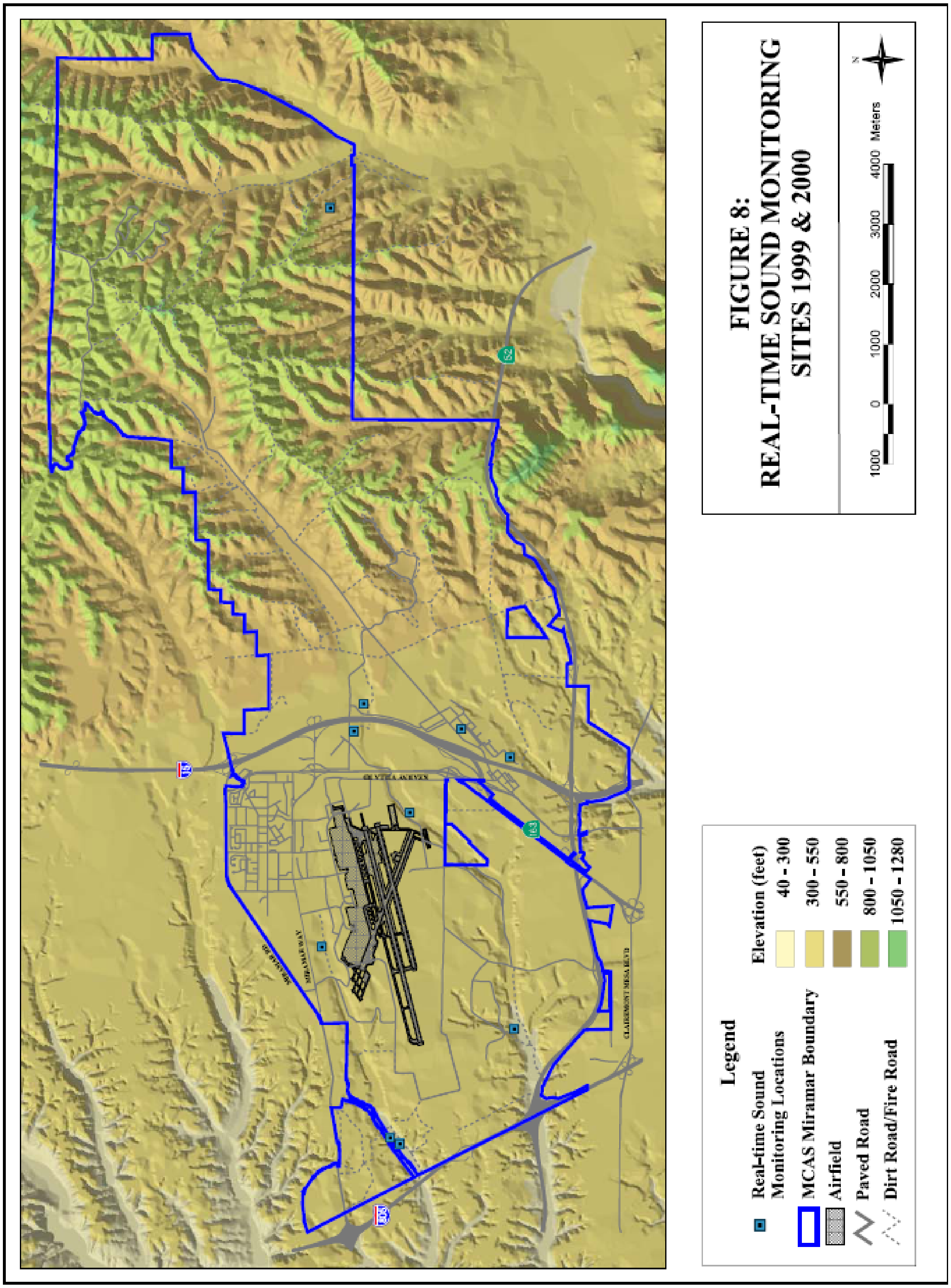


FIGURE 8:
REAL-TIME SOUND MONTORING
SITES 1999 & 2000
1000 0 1000 2000 3000 4000 Meters
N
Legend
Real-time Sound Monitoring Locations
MCAS Miramar Boundary
Airfield
Paved Road
Dirt Road/Fire Road
Elevation (feet)
40 - 300
300 - 550
550 - 800
800 - 1050
1050 - 1280

2.3.1 Nest-based Habitat

The basic experimental unit for the vegetation-sampling program was the nest site location. The nesting habitat is defined as a square 2500-meter quadrat (50 meters on each side) centered on the nest site. Six ten-meter transects were located within each 50 meter quadrat, with one transect centered at the nest site and the remaining five transects randomly located throughout the quadrat. Each transect was sampled as a line-intercept transect and the species intercepted were recorded. Due to the complexity of separating individual species, forbs and grasses were recorded as either (a) annual grass, (b) perennial grass, or, (c) by species for the forbs. Additional categories recorded may have included bare ground, rock, litter and wood.

The 1x10 meter quadrat was placed to the right of the line-intercept when viewed from the 0-meter mark. All individual shrubs greater than 20 centimeters occurring within the quadrat were recorded as to species and height. Height was defined as the second highest stem on the plant. The tallest stem was eliminated in that it frequently extends significantly above the other stems within the crown and overestimates the height. The quadrat data allows for quantification of shrub species frequency (as opposed to percent cover). The height data, when taken in conjunction with the gap data, provides a measure of the three-dimensional (or geometric) structure of the shrub vegetation. The floristic composition of the grass and forb cover was provided by the point intercepts. Additionally, indices related to the gap structure can be developed using ratios such as number of gaps to percent cover by shrubs.

2.3.2 Available Nesting Habitat

A systematic sample of 50 x 50 meter quadrats was selected from available habitat at Miramar. For the purposes of this study, available habitat is defined as all areas of Miramar with appropriate habitat for California gnatcatchers regardless of whether or not the habitat is currently occupied, has been occupied in the past, or has never been occupied by gnatcatchers during the study period. For this study appropriate habitat was defined as Diegan coastal sage scrub (disturbed and undisturbed), coastal sage scrub/chaparral mix and a 100 meter buffer surrounding these vegetation types.

To select the sample, a regularly spaced grid of points was overlaid on a Geographic Information System (GIS) map of available habitat at Miramar. A sampling increment was chosen so that 66 of the regularly spaced quadrats would sample available habitat. This is called a systematic sample with a random start (Cochran 1977). See Figure 6 for the location of the 66 systematically located quadrats of available habitat.

At each of these 66 50 x 50 meter quadrats six ten-meter line-intercept transects with random orientation were laid out in the same manner as the nest-based vegetation transects. It was assumed that the available nesting location was in the center of each quadrat. The same sampling protocol described above for the nest-based samples was implemented at each of the locations. These data were directly compared to the vegetation characteristics at nesting locations. This sampling design was implemented to allow assessment of the effects of habitat and noise on nesting productivity and success over time. Comparing characteristics at nest sites with these available sites provided data to test the hypothesis that either noise, habitat characteristics or both may influence nest site selection.

2.4 STATISTICS

The statistical methods were designed to incorporate a two-step approach. The first step tested for an association between reproductive success and environmental noise levels. If such a relationship was found, the second step would identify the contribution of helicopter noise to any apparent effect.

To evaluate the potential effects of helicopter noise on coastal California gnatcatcher nesting success, fledging success and nest site selection, statistical models describing the association between CAGN reproductive parameters and covariate indicators of biological processes were developed. These models adjusted for covariation between physical biological processes and reproductive success before testing for association with noise metrics. In the statistical literature this approach is often referred to as analysis of covariance (Neter et al. 1996). The glossary of technical terms, Appendix A, includes all the statistical terms used in the text.

In order to estimate the impact of sound on the reproductive success of CAGN, it is important to control for other factors like vegetation type, disturbance, and year-to-year variability due to weather. This study is observational, so that these factors cannot be controlled through traditional experimental procedures such as randomization and replication. Instead, these factors need to be controlled statistically during the analysis of the field data. Statistical control is accomplished by adding important processes as covariates during the analysis (Dr. Douglas Deutschman, Assistant Professor of Biology, San Diego State University, personal communication, 2000).

Initial models including biological and physical indicators of environmental conditions were developed by first identifying a subset of these variables that were individually associated with nesting success rates using logistic regression (Hosmer and Lemeshow 1989). The intent was to then include these variables in a multiple variable logistic regression model to find a subset of variables that best predicted reproductive success.

However, this subset of variables included pairs of variables that were inter-correlated. This intercorrelation violates the assumption that the independent variables in a logistic regression are statistically independent. This problem is known as multicolinearity. To correct this problem, correlated pairs were first identified as those pairs with Spearman rank correlation coefficients, which measures the association between two variables but does not assume a linear relationship, (Lehmann and D'Abrerra, 1998) greater than 0.40. Then one member of each pair was eliminated from consideration in the models. The variables retained for modeling were selected based on biological interpretability.

This set of uncorrelated predictors was included in a multiple variable logistic regression model and those subsets resulting in the lowest Akaike Information Criterion (AIC; Akaike, 1973) were identified. Models within 3 AIC points of each other were considered to have similar quality of model fit. Noise metrics were then added to these best environmental models to determine, if after adjusting for covariation with environmental conditions, nesting success rates were associated with noise metrics. If associations between reproductive success and noise metrics were detected in this first step of the two-step process, additional analyses were undertaken. Logistic regression was used to test for a difference in the reproductive success/noise metric relationship before and after Station realignment to partition helicopter noise effects. This additional analysis represents the second step.

Logistic regression analyses were conducted using SAS (SAS Institute Inc. 1996).

Factors considered for evaluation included vegetation cover, height and density, by species and grouped; topographic features, such as elevation, slope aspect and curvature, 6 noise metrics (Total Leq dBA, Total ASEL, L5, Lmax, Maximum event ASEL, Percent time greater than 60 dBA and 80 dBA) and physical variables such as distance to roads, distance to expected noise sources and distance to training flight patterns. Although the distance metrics are not a direct measure of noise, they represent an index to noise levels. Any covariate that was determined to be significant in the univariate comparisons was included in nest success, nest site selection and fledgling success multivariate models. Predictions of nest success rate, probability of nest site selection, and expected number of fledges per pair were also overlaid on maps of the noise environment to provide visual evaluation of the association between reproductive and noise metrics. The glossary of technical terms, Appendix A, includes the technical acoustical, ecological and statistical terms used in the text.

2.4.1 Nest Success

The first component of the analysis was to test for and if present characterize the magnitude of effects of noise (unwanted sound) on the reproductive success of the coastal California gnatcatcher on the Station. Over 100 variables measured in the vicinity of each nest location (Table 2) were tested for association with CAGN nest success using simple logistic regression (Hosmer and Lemeshow 1989). Those factors found to predict nest success were considered for development of multiple logistic regression models of the form

$$\text{logit(p)} = \log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + \beta_n x_n \qquad (1)$$

where *p* represents probability of nest success, and β_i are regression coefficients. In this analysis, each nest was treated as an independent binomial trial. We recognize that the success rates of multiple nests

Table 2. Covariates Used in Statistical Modeling

Covariates Used in Statistical Modeling	
Nest Covariates	Nest-associated variables were measured in the field. These included characteristics of the shrub in which the nest was built (the "host" species) as well as physical characteristics of the nest itself.
Noise	There were 30 noise variables obtained from sound level meters placed at the nest and at the random stratified locations throughout the study area. Of these, Total L_{eq} dBA, Total ASEL dBA, Max Event ASEL, L5, Percent Time >60dBA and Percent Time >80dBA were selected for analysis
Habitat Characteristics Biological Factors	Species that shared characteristics of form, ecology, and/or phylogeny were classified into common groups. These include primary coastal sage scrub, secondary coastal sage scrub, primary chaparral, secondary chaparral, primary other, gap, leaf litter, deadwood, native forbs, non-native forbs and grass. In addition, primary coastal sage and primary chaparral species were investigated individually
Landscape Characteristics	The landscape characteristics were obtained from a GIS analysis of the study site. These included distances to man-made features such as roads, flight line, and flight procedures and various measures of topographic characteristics such as curvature, elevation and slope.
Climate	As the sole indicator of climate, we used the Palmer Hydrologic Drought Index (PHDI) for all months as well as a fall index, which included the months of October, November and December. PHDI is indicative of water storage in the environment, reflecting soil moisture, stream flow, and lake levels more closely than do other climatic indices. Negative values indicate drought conditions, while positive values of PHDI indicate wet conditions.
Disturbances, Overflights and Predators	Disturbance data were only collected years 1999-2001. These data were based on field observations of various types of potential disturbances in the vicinity of a breeding pair. Potential disturbances included overflights of aircraft, presence of predators, and various human-caused noises, e.g., gunfire, traffic, and construction. All such activities were expressed as frequencies – number of disturbances of a particular type per hour of observation per pair.

constructed by a single gnatcatcher pair may not have been statistically independent and may have resulted in pseudoreplication (Hurlbert 1984). However, in this situation, the presence of pseudoreplication would increase the power to detect effects, which would be conservative (i.e. protective) toward CAGN welfare.

2.4.2 Nest Site Selection

The nest site selection analysis was conducted to determine if the coastal California gnatcatcher avoided suitable nesting habitat due to high noise levels. To the extent that CAGN nest in areas out of proportion to their availability we say that CAGN are selective (Manly et al 1993). For this analysis, habitat characteristics, noise data and physical characteristics at nesting sites and at the systematic grid of available habitat locations were compared. These locations represent an unbiased sample of the habitat, noise and physical conditions available to CAGN on the Station.

Factors considered for evaluation included vegetation cover, height and density, by species; topographic features, such as elevation, slope aspect and curvature, 6 noise metrics (Total Leq dBA, Total ASEL, L5, Lmax, Maximum event ASEL, Percent time greater than 60 and 80 dBA) and physical variables such as distance to roads, distance to expected noise sources, and distance to training flight patterns. Each of these metrics was tested separately for association with CAGN nest site selection using logistic regression (Hosmer and Lemeshow 1989). A description of these terms is included in Appendix A, a glossary of technical terms.

2.4.3 Fledges Per Pair

Because CAGN commonly renest after failed nesting attempts, differential nesting success rates may be compensated by multiple nesting attempts. Therefore, factors that affect nesting success rates may not ultimately influence the number of chicks ultimately fledged by a particular pair. This portion of the analysis was conducted to evaluate the effects of variation in habitat and the noise environment on fledge production. The factors found to be associated with nest success were tested to determine their association with the number of chicks fledged per pair. Each CAGN pair was treated as the experimental unit for this analysis.

Each noise metric was then tested individually for an association with the number of chicks fledged per pair using Poisson regression (McCullough and Nelder 1989) to determine if gnatcatcher pair's successfully fledge similar numbers of chicks in both noisy and quiet areas.

3.0 RESULTS

Gnatcatcher monitoring data, acoustic data and vegetation data collected during the study were used in the statistical analysis to characterize the magnitude of the effects of helicopter noise on coastal California gnatcatcher reproductive success. Observed reproductive parameters were tested for association with noise levels.

3.1 COASTAL CALIFORNIA GNATCATCHER MONITORING

Productivity data was collected for 218 pairs of coastal California gnatcatchers. Figure 9 shows nest locations of all gnatcatcher pairs monitored during the 1998-2001 breeding seasons and totals for 1997- 2001 breeding seasons are shown in Table 3. Of the 760 nests monitored between 1995 and 2001 542 nests were available for analysis of which 509 produced fledglings. This resulted in an average of 2.35 fledglings per pair making 33.0 percent of the nests successful.

Heavy rainfall and inclement weather caused increased nest failure rates, particularly in February and March of 1998, which is the early part of the breeding season. These are important months for establishing territories, pair bonds and initiating nest building. The frequent cold, wind and rainstorms did not permit these kinds of activities and delayed the onset of the breeding season. The rainfall data for the San Diego area is maintained on an annual basis by the National Weather Service (NWS). Complete data for 92 years were used to calculate the "normal" average rainfall per year for the area, based on measurements at Lindbergh field. This average is 10.29 inches of precipitation. Values above or below this figure can be expressed as percent of normal for the periods referred to. Total's for the rainfall season, which is considered to be the period of seasonal rainfall from October of one year to September of the next, is maintained from records of the San Diego County Water Authority. They have records for the past 40 years on which to base their averages. These data are also useful since it includes the rainfall during the months before as well as during the breeding season (Table 4). The rainfall in the late fall and winter provides the available moisture that determines the amount of vegetative growth and habitat quality for the breeding season. Nesting success of the CAGN was positively associated with the fall Palmer Hydrology Drought Index (PHDI). It is convenient to have

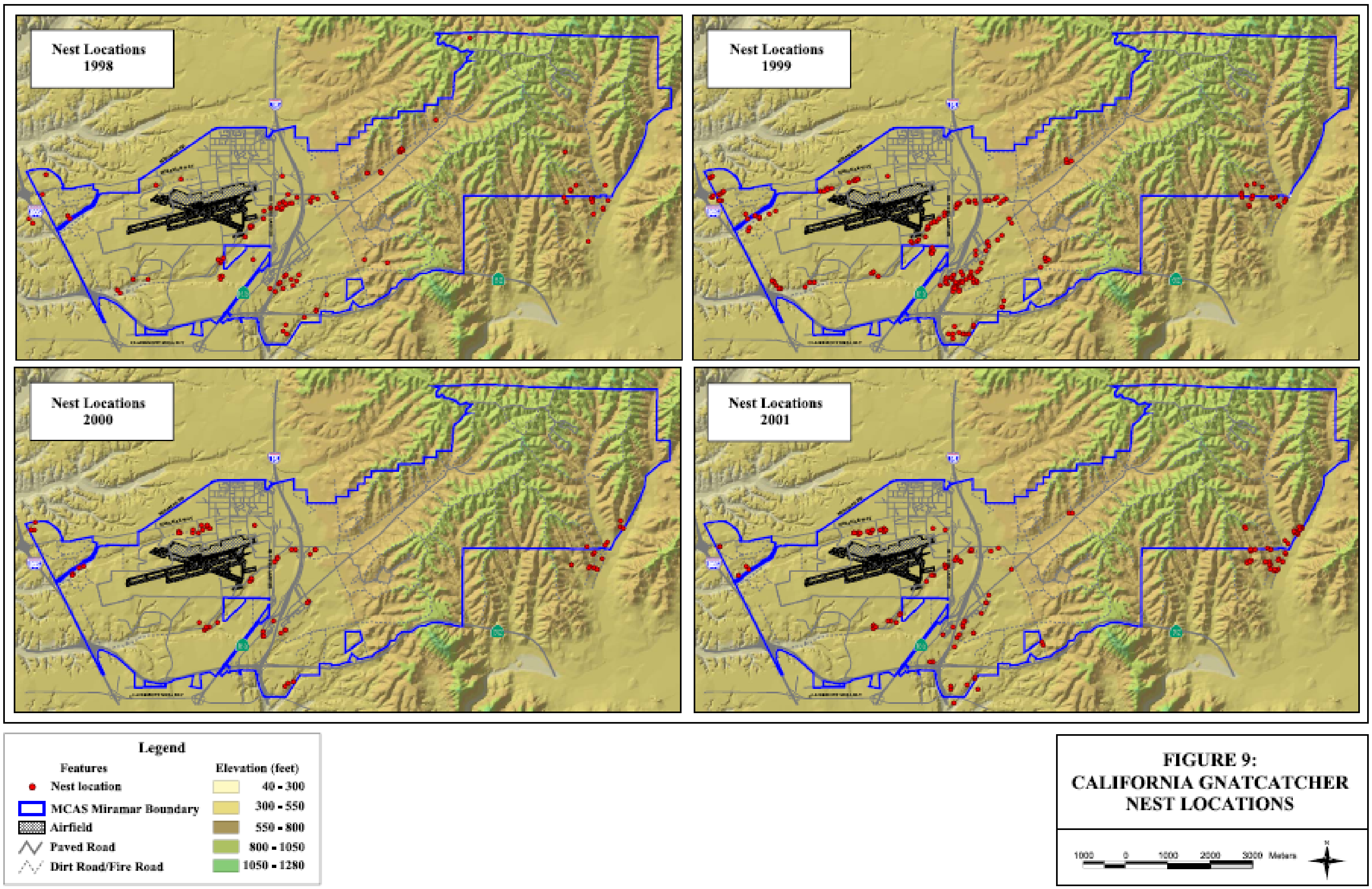


FIGURE 9:
CALIFORNIA GNATCATCHER
NEST LOCATIONS

Table 3

Coastal California Gnatcatcher Monitoring Results *

	1997	1998	1999	2000	2001	Total	Average
Number of Pairs	37	53	61	24	43	218	43.6
Number of Nests	79	96	181	67	119	542	108.4
Number of Fledged	78	116	135	68	112	509	101.8
Average Proportion Successful	0.32	0.47	0.25	0.32	0.27	1.63	0.33
Average Fledglings Per Pair	2.1	2.18	2.21	2.83	2.6	11.92	2.35
Number of Disturbances	--	--	669	412	757	1838	612.67
Number of Predators	--	--	2435	889	1329	4653	1551
Number of Overflights	--	--	3593	1377	2294	7264	2421.33

* The coastal California gnatcatcher data represented in this table is not exclusive to pairs residing on Miramar. Pairs located adjacent to but not on the Station are also represented.

Table 4

1997-2001 SAN DIEGO RAINFALL DATA

NWS Lindbergh Field		San Diego County Water Authority		
NWS Annual (in)	**Breeding Season**	**Rainfall Year**	**Rainfall (in)**	**% of Normal**
7.00	1997	October 1996-September1997	8.74	85
16.05	1998	October 1997-September 1998	20.89	203
5.43	1999	October 1998-September 1999	6.51	63
6.90	2000	October 1999-September 2000	5.77	56
8.47	2001	October 2000-September 2001	8.82	86

NWS Lindbergh Field Monthly Rainfall Data 1997-2001 (inches)

YEAR	JAN	FEB	MAR	APRIL	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1997	3.02	0.31	0	0.28	0	0	0	0	0.85	0.02	1.17	1.35	7
1998	2.68	7.65	2.21	1.11	0.64	0.1	0.2	0	0.03	0.08	0.69	0.66	16.05
1999	1.54	0.7	1.09	1.62	0.06	0.04	0	0	0.02	0	0.04	0.32	5.43
2000	0.17	3.67	1	0.54	0	0	0	0.01	0	1.24	0.26	0.01	6.9
2001	3.28	2.38	0.63	0.76	0.01	0	0	0	0	0	0.95	0.46	8.47

the rainfall season data available since it does not require two years of rainfall data to calculate. We have included both data sets in this report.

The NWS data for San Diego recorded 16.05 inches of rain for the year 1998, with the majority of precipitation from January to June, which totaled 14.39 inches with February being unusually wet. Fifty-three pairs of California gnatcatchers were monitored during the 1998 breeding season. Due to the heavy rains during the early part of the season, several pairs located during the survey portion of the study were unable to be located before any nesting data was collected.

Unlike 1998, the weather during the 1999 breeding season was mild, with the total precipitation for the year of 5.43 inches. The cloud cover associated with June lasted long into July, keeping the temperature down, but there was only 6.5 inches of rainfall from October 1998 to September 1999, the season of rainfall that is important to the vegetation growth and prey base for CAGN. Sixty-one pairs of birds were monitored during this breeding season. Eight pairs attempted to build nests after one successful attempt, and six of these were successful.

The annual precipitation for the area was 6.90 inches for the year 2000. In the rainfall season and spring breeding season, there were only 5.7 inches of rainfall recorded from October 1999 to September 2000. This lack of rainfall combined with very little rainfall the previous year caused a delayed leafing out of the coastal sage scrub vegetation as well as the adjacent vegetation communities, postponing the start of the breeding season. The first nest was not found until 28 March 2000 unlike the other study years when the first nests were found in late February or early March. In addition, the number of pairs monitored on the Station declined to 24 pairs for the 2000 breeding season resulting in a 40.0% decline in the gnatcatcher population on MCAS.

The NWS recorded 8.47 inches of rainfall for the year 2001. Although rainfall was below normal for the 2001 breeding season, the amount was greater than rainfall in 2000. The number of pairs monitored during 2001 breeding season was thirty-seven. This was a 54.0% increase in the population from the 2000 breeding season.

In addition to the productivity data, information on overflights, predators and disturbances was collected during the 1999, 2000 and 2001 breeding seasons for all pairs. This information was collected to provide an index to the amount of activity occurring in each coastal California gnatcatcher pair's territory and helps to define the noise environment for the pairs in more detail. For disturbances, notes were taken regarding construction, trains, trucks, hikers, horses, dirt bikers, landfill noise, etc. For overflights, information was collected on number and type of aircraft overflights in each gnatcatcher territory. Data collected include 1,838 disturbances, 4,653 predators and 7,264 overflights. Coastal California gnatcatcher monitoring results (Table 3) were used in the univariate and multivariate analysis.

3.2 SOUND MONITORING

The noise metrics that were considered can be separated into two basic types, those directly measuring sound levels such as Total L_{Aeq}, Total ASEL, Maximum Event ASEL, L_5 and those representing time above specified thresholds such as percent time exceeding 60 dBA and percent time exceeding 80 dBA. See Appendix A for definitions of the terms.

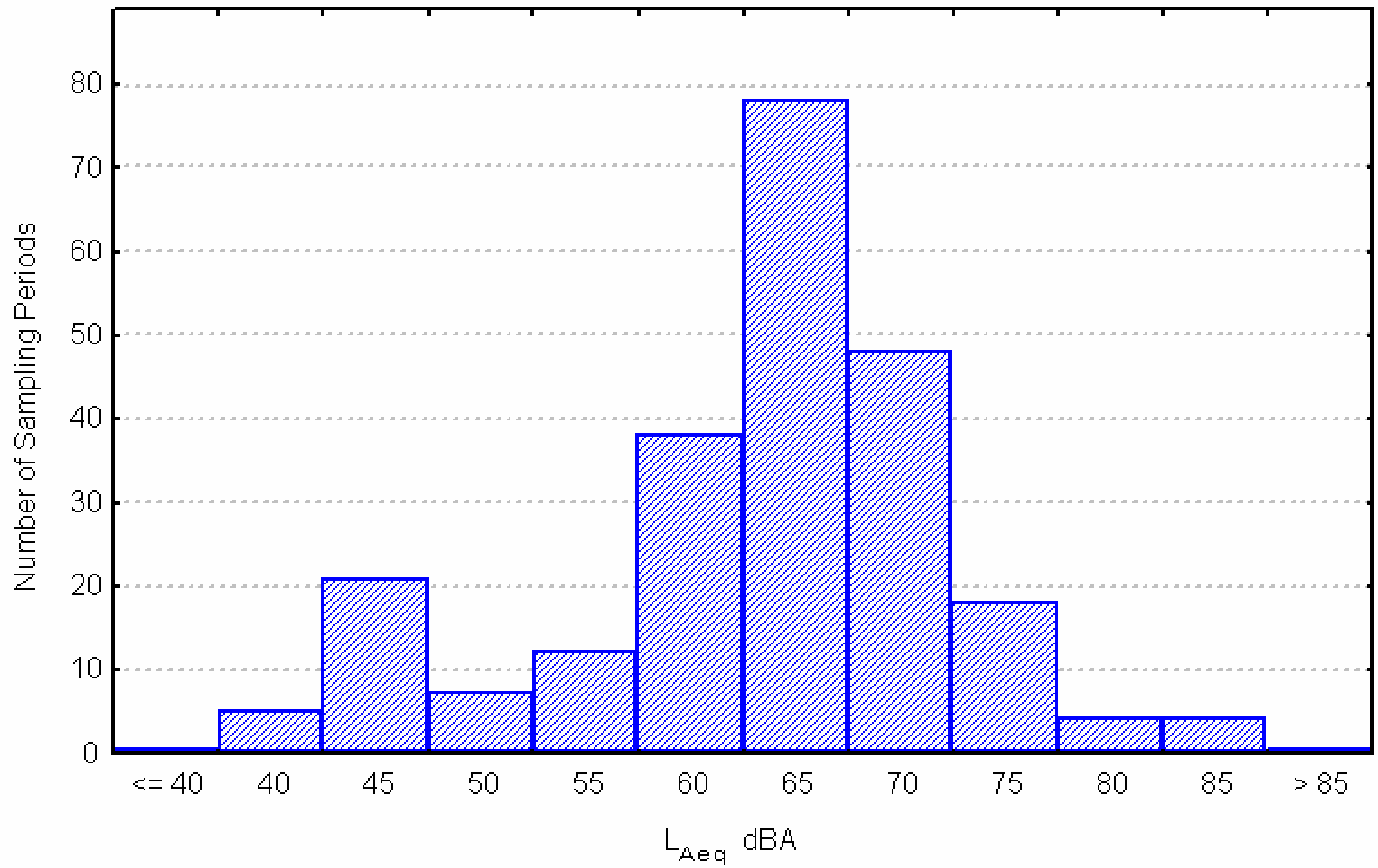
A total of 6,176 days of nest-based sound monitoring were completed during 620 runs at 328 locations (Table 5). Run time during each sampling period averaged 10 days, ranging from 6 to 18 days (most lasted 8 to 11 days). The bulk of the monitoring at the nest sites was completed from April to September. In addition, sound data was collected at an array of 66 randomly sampled permanent plot points (See Figure 6), for a total of 266 runs and 2,616 meter-days.

For human community noise monitoring applications, the noise metric most commonly used is the Leq, the equivalent continuous sound level or 'average sound level'. This metric is a measure of average noise exposure. It is most useful under conditions where noise exposures are generally constant. It is unclear whether this metric is useful for intermittent overflights because such events cannot be considered continuous noise. Average sound levels at nest sites on the Station are shown in Figure 10. In undeveloped areas of the Station, average sound levels vary as a result of wind, plant motion, flowing water, and biotic sources (birds, insects). Typically, however, they are lower than average sound levels in urbanized areas (20-50 dBA vs. 50-80 dBA). At many of the sites on Miramar the prevalence of average sound levels near 60 dBA reflects the presence of highways and other continuous noise sources.

Table 5

Sound Monitoring Results

	1997	1998	1999	2000	2001	Total
Nest Meters	63	74	124	52	78	391
Nest Meter Runs	132	140	231	105	145	753
Random Stratified Meter Runs			92	106	68	266
Nest Meter Days	1955.21	1310.23	2355.34	980.61	1537.22	8138.61
Random Stratified Meter Days			838.72	1118.40	659.12	2616.24
Nest Meters Hours	46926.29	31460.51	56554.482	23545.78	36909.33	195396.39
Random Stratified Meter Hours			20129.33	26640.87	15819.08	62589.28



Average Sound Levels at Nest Sites

Figure 10

Humans experience significant annoyance when exposed to average noise levels (L_{eq}) in the range from 60 to 80 dBA. This is largely the result of interference with the ability to communicate. The threshold for such interference for small passerines is thought to be the same for humans, approximately 60 dBA, although no scientific data are available to support this threshold for gnatcatchers. Additionally frequency weighting and other important parameters of the metric have not been specified for gnatcatchers. Although there is a general belief that anthropogenic noise, especially that generated by especially intense sources such as military aircraft, is a source of great harm to birds, there is very little evidence to support that belief. Recent reviews of the scientific literature on the subject show that it is dominated by anecdotal reports and small studies (Bowles, 1995; Larkin et al. 1996) that suffer from small size and failure to adhere to standards that would allow comparison or replication (Bowles et al. 1993b). Furthermore, the results of most such studies appear in unpublished reports for various agencies and sponsors rather than as papers in the referenced literature, a situation that is partly due to the nature of funding for noise effects studies and partly to the difficulty of publishing negative results.

Aircraft noise can affect individual birds physiologically through stress, behavioral change, or increased energetic cost (reviewed in Bowles 1995). There is also the possibility of noise-induced hearing loss, although our data show that it is unlikely because noise doses are not high enough to be of great concern (Awbrey and Hunsaker 1997a) and because bird ears regenerate lost hair cells spontaneously (Cotanche et al. 1994; Ryals and Rubel 1988). However, effects on individuals are of limited consequence unless they reduce fledgling success or they increase mortality or emigration so much that the population as a whole cannot compensate.

Sound level meters measured sound exposure levels for nest sites throughout the sampling period. Throughout the study, data were collected during events that exceeded 60 dB A-weighted fast (fast integration time is over a 125 ms time period) SPL and 80 dBA. Thus, while birds were exposed to moderate to high (>80 dBA) noise sources, the total time spent in the presence of such sources was small, on average approximately 0.5% of the monitoring period. Even in the unlikely circumstance that every event was the result of an aircraft overflight, this represents a very limited level of exposure.

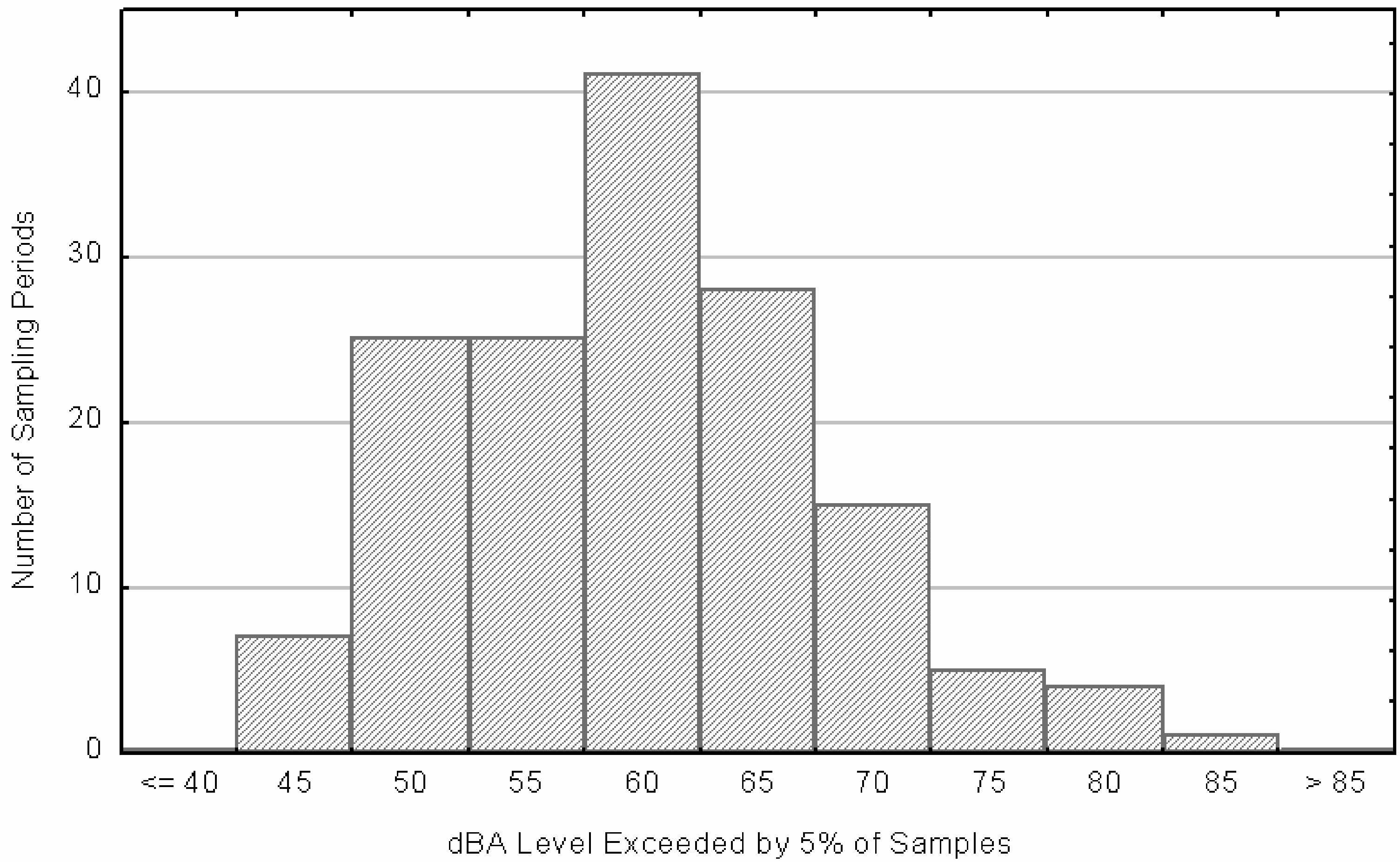
Most sites were exposed to noise in excess of 60 dBA for less than 5% of the monitoring period. The most intensely exposed sites in 1999 were located in lower San Clemente Canyon, alongside of Kearny Villa Road, near I-15, and directly under the inbound flight path of Miramar airfield. During some runs, these sites were exposed to levels in excess of 60 dBA for more than 50% of the time and in excess of 70 dBA for more than 20% of the time. The most intense exposures occurred during the annual Miramar Air Show.

Another useful measure was L_5, the decibel level exceeded by 5% of A-weighted noise samples. Since noise events represented a very small proportion of the total noise exposure, this measure was in many ways reflective of the noise likely to be triggered by aircraft (Figure 11). By this measure, sites experienced a wide range of exposures from quiet conditions (only 5% of the time at levels > 45 dBA) to very noisy conditions (5% of the time at levels > 85 dBA). Although it is easy to presume that military aircraft cause most of the noise exposures throughout the Station, other noise sources contribute significantly in several areas. They include highway and street noise, trains, gunshots from pistol and skeet shooting ranges, noise from heavy machinery at the Miramar Landfill and Hanson Plant, birdsongs, human voices, barking dogs, detonations and dirt bikes.

The maximum event A-weighted sound exposure level (ASEL) and peak sound pressure levels at each site were collected as a measure of the worst-case exposures experienced by gnatcatchers. These predict the potential for acute effects, such as hearing loss. Maximum event ASEL varied from 92 dBA to 140 dBA (the most intense levels that can be expected from jet aircraft overflights) (Figure 12). Peak unweighted event levels at a few locations near the flight line reached or exceeded the maximum levels that could be detected by the recording system (>140 dBA ASEL).

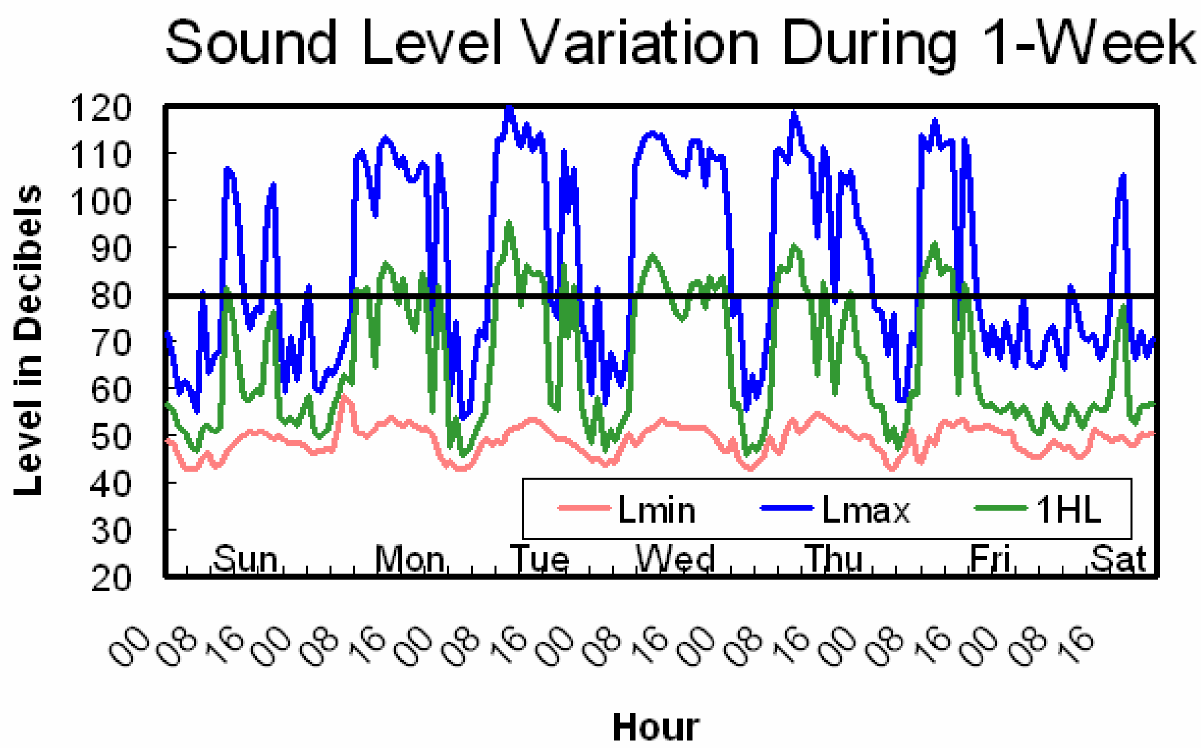
3.2.1 Geostatistical Noise Model

Geostatistical noise models were developed in order to predict noise at unsampled areas of the Station (Figure 13). These maps could be used to estimate the extent and magnitude of potential noise effects across the Station. The nest-based and systematic sound sampling data were required to create each map.



Proportion of Exposures Attributed to Aircraft

Figure 11



Sound Pressure Level

Figure 12

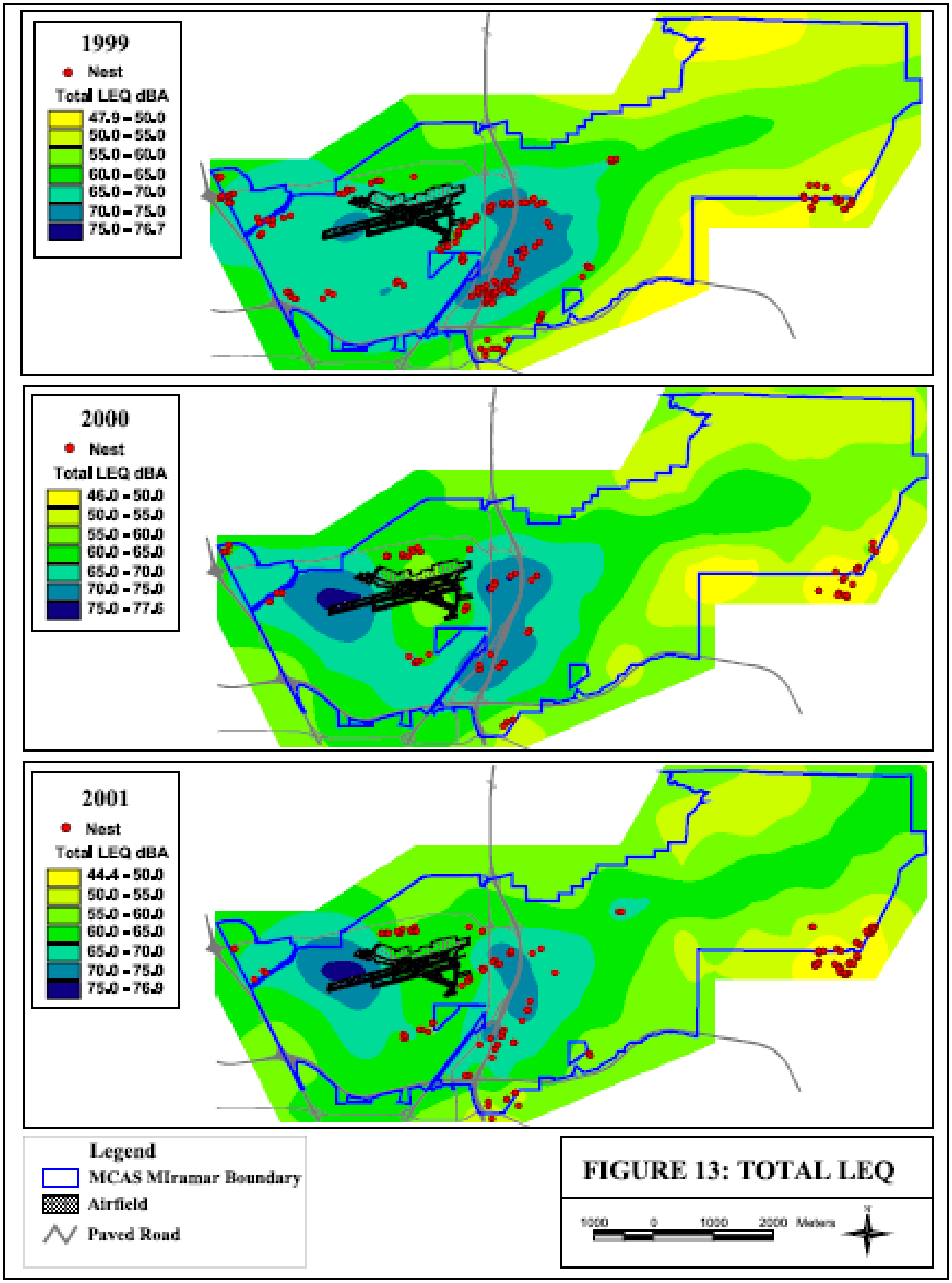


FIGURE 13: TOTAL LEQ

3.2.2 Real-Time Monitoring

In order to get a representative sample of different types of noise environments, a total of ten days of real-time recording in conjunction with LD 720 monitoring was completed at ten sites on the Station between 8 June and 6 July 1999 and 23 May and 10 August 2000 (See Figure 8). Sites were chosen to monitor a representative sample of noise exposure across the Station. Detailed real-time monitoring results have been included in Appendix C.

3.3 VEGETATION SAMPLING

The vegetation sampling portion of the project involved sampling at nest-based transects as well as available habitat transects. Data was collected on a total of 2712 nest-based transects and 1182 available habitat transects with a total of 280 plant species. The total number of species found on all transects include 80 shrub and tree species, 200 species of forbs, non-native forbs and grasses. In addition to plant species, 37 types of non-vegetation, such as spatial gaps in the vegetation "gaps", man made, roads, etc., were recorded on transects. Data collected were used as predictors in statistical models of reproductive endpoints.

3.4 REPRODUCTIVE MODELS

The statistical analyses were conducted to evaluate the potential effects of helicopter and other noise sources on coastal California gnatcatcher nesting success, nest site selection, and number of fledges per pair.

Statistical estimates for probability of nest success, probability of nest site selection and predicted number of fledges per pair are overlaid on the noise distribution in Figure 14. These statistical estimates are based on the logistic regression models. Probability of nest success represents the proportion of nests successfully producing fledges. Probability of nest site selection is the probability that a pair will locate a nest at a particular location. Predicted number of fledges represents the number of fledges that a pair is expected to produce under the particular conditions at each nest site.

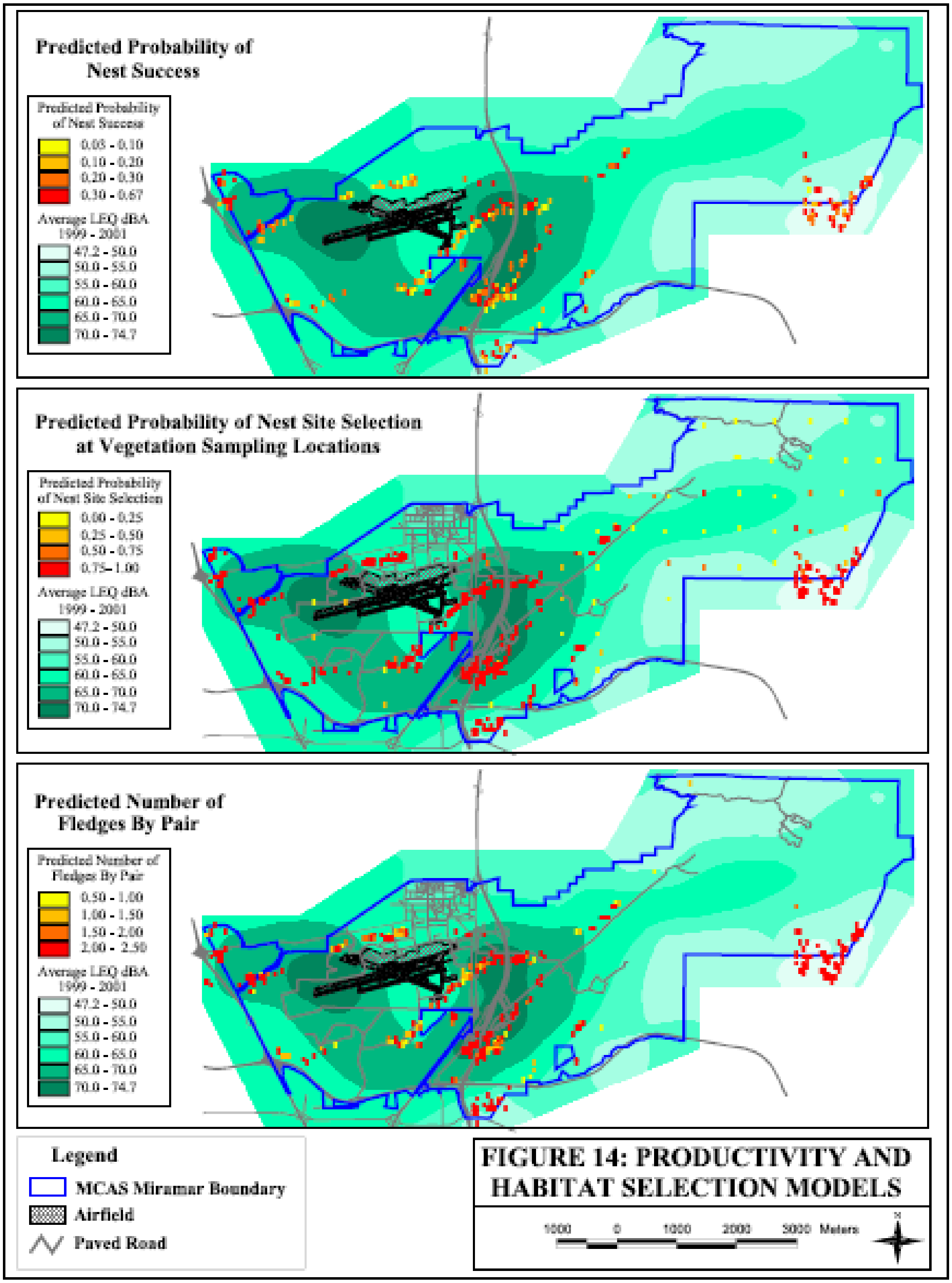


FIGURE 14: PRODUCTIVITY AND HABITAT SELECTION MODELS

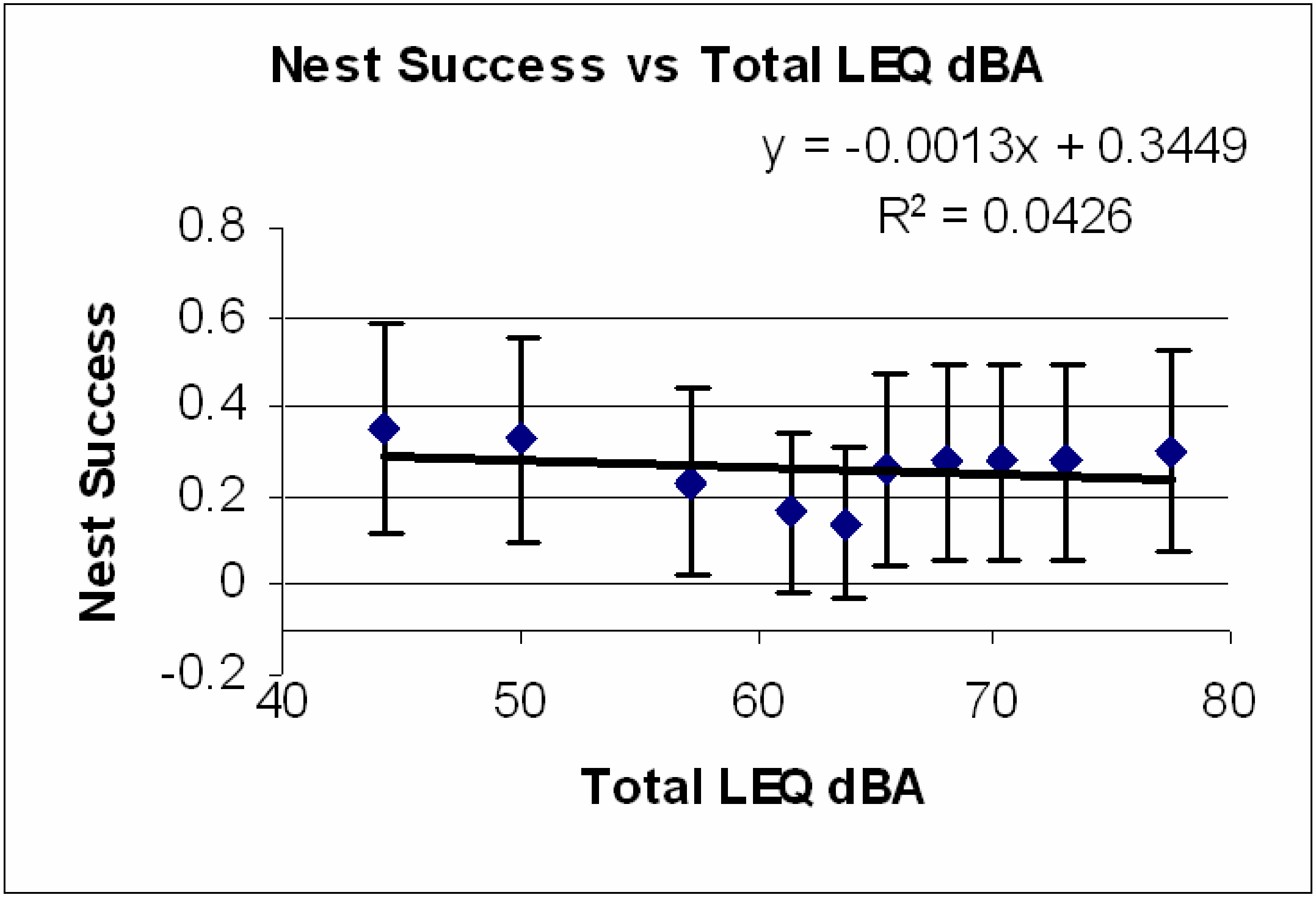
Noise data from the sound level meters registered noise from all sources. Figure 14 uses data from the recorded noise levels. If reproductive parameters were found to be associated with spatial and or temporal gradients in noise from all sources; subsequent analyses were conducted to partition the general effects of the recorded noise levels and additional potential effects due to introduction of helicopters. If there was no effect from all noise sources, there would be none from only the helicopters which were the source of only a part of the total noise.

3.4.1 Nest Success

The objective of this analysis involves characterizing the magnitude of effects of noise of helicopters on the reproductive success of the coastal California gnatcatcher. Over 100 variables measured in the vicinity of each nest location were used in the analysis (See Table 2). Each of these metrics was tested for association with gnatcatcher nest success using logistic regression (Hosmer and Lemeshow 1989). If reproductive parameters were found to be associated with spatial and or temporal gradients in noise from all sources, subsequent analyses were conducted to partition the general effects of the recorded noise levels and additional potential effects due to introduction of helicopters.

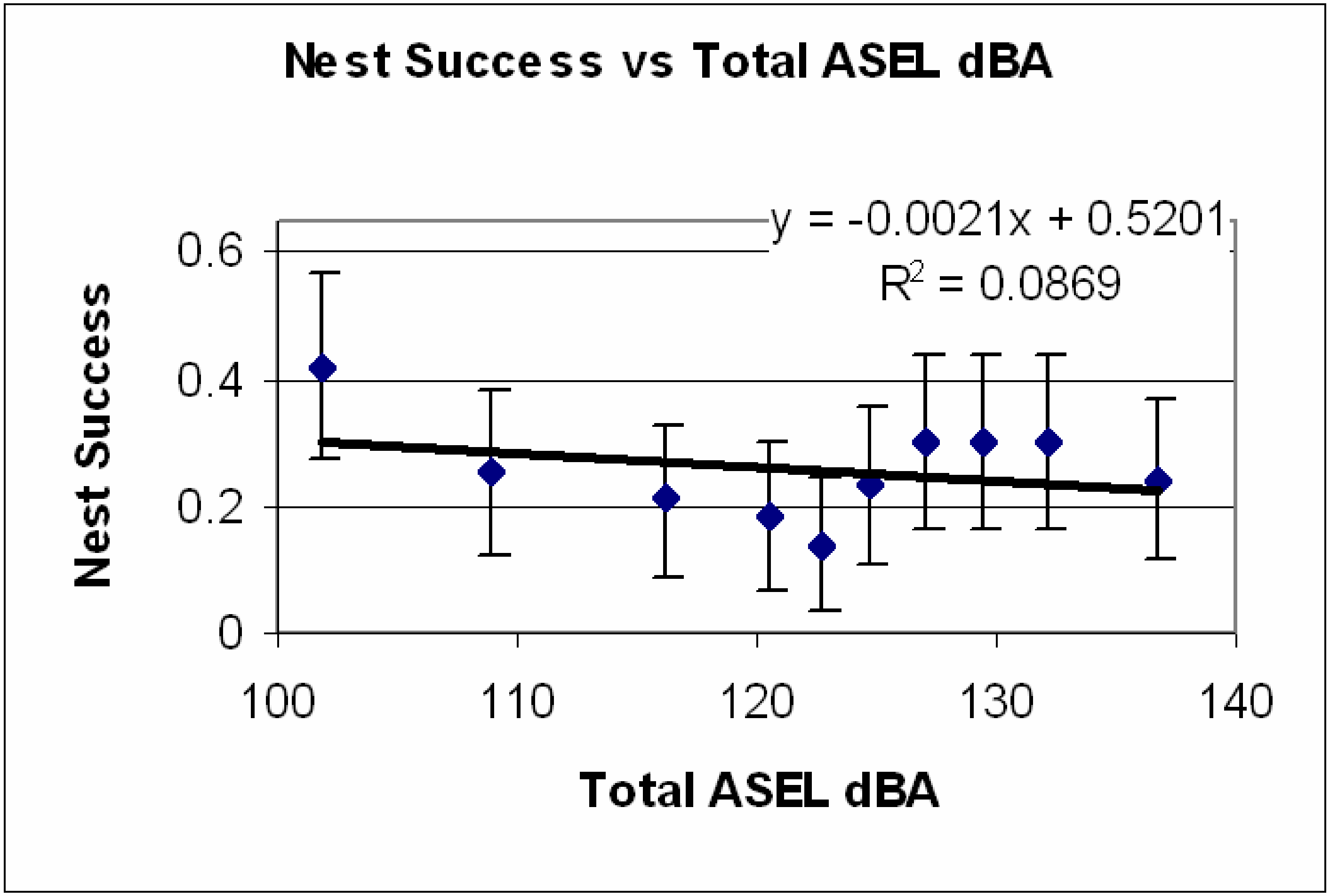
3.4.1.1 Noise Metrics

The noise metrics that were considered were separated into two basic types, those directly measuring sound levels (Total L_{Aeq}, Total ASEL, Maximum Event ASEL, L_5) and those representing time above specified thresholds (Percent time exceeding 60 dBA and Percent time exceeding 80 dBA. Based on logistic regression analyses between nest success and each of these noise metrics, none were associated with nest success (N=421; Total L_{Aeq}, p=0.43 (Figure 15); Total ASEL, p=0.27 (Figure 16); Maximum Event ASEL, p=0.46 (Figure 17); L_5, p=0.27 (Figure 18); Percent time exceeding 60 dBA, p=0.77 (Figure 19); and Percent time exceeding 80 dBA, p=0.88 (Figure 20). In these figures, the vertical Y axis is the dependent variable, nest success, with the X axis the various independent variables that are considered to have a potential effect on nesting success including Total Leq, Total ASEL, Shrub Height and Number of Gaps in the vegetation etc. The R^2 value shown on the figure denotes the proportion of variation in the



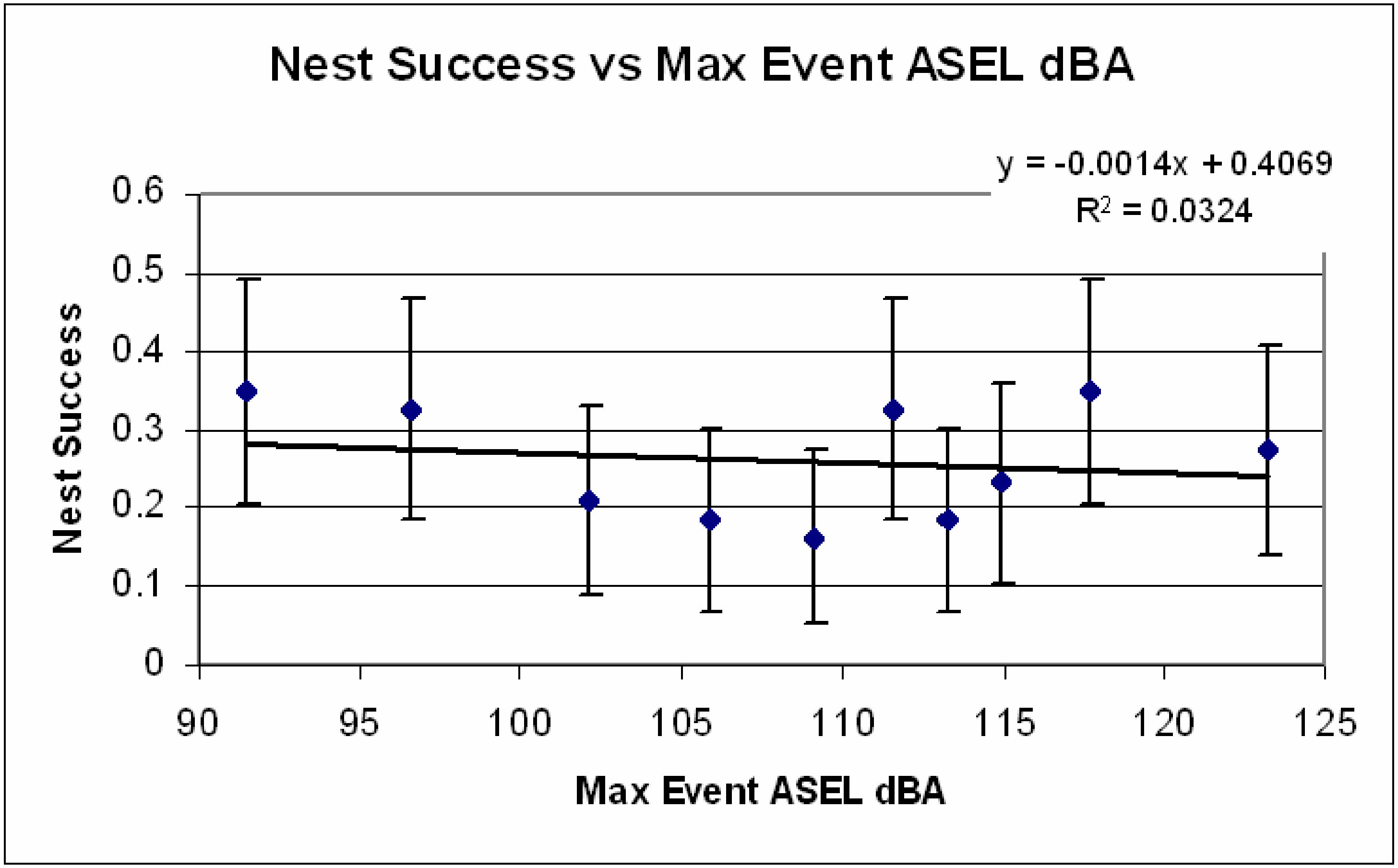
Nest Success vs Total LEQ dBA

Figure 15



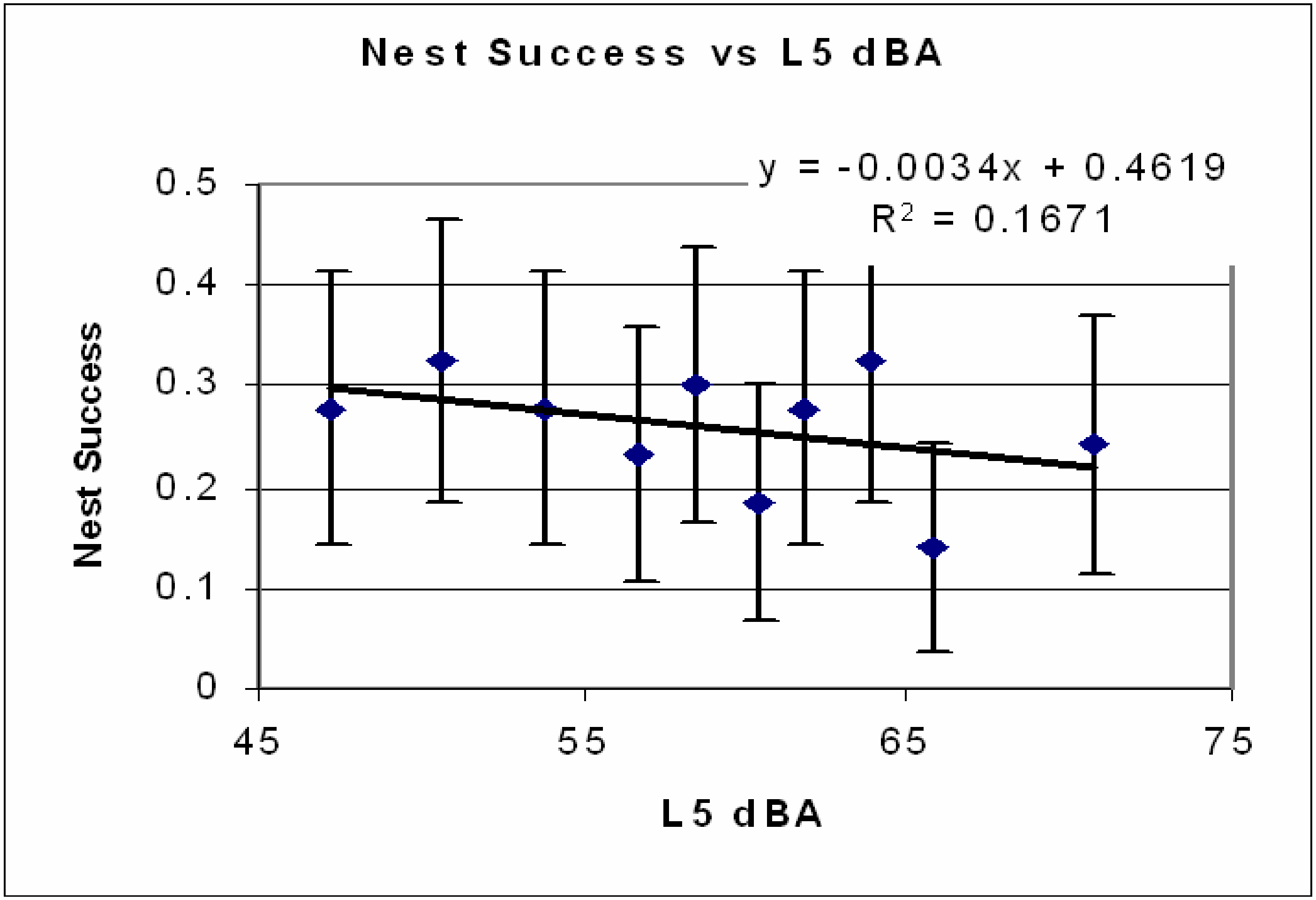
Nest Success vs Total ASEL dBA

Figure 16



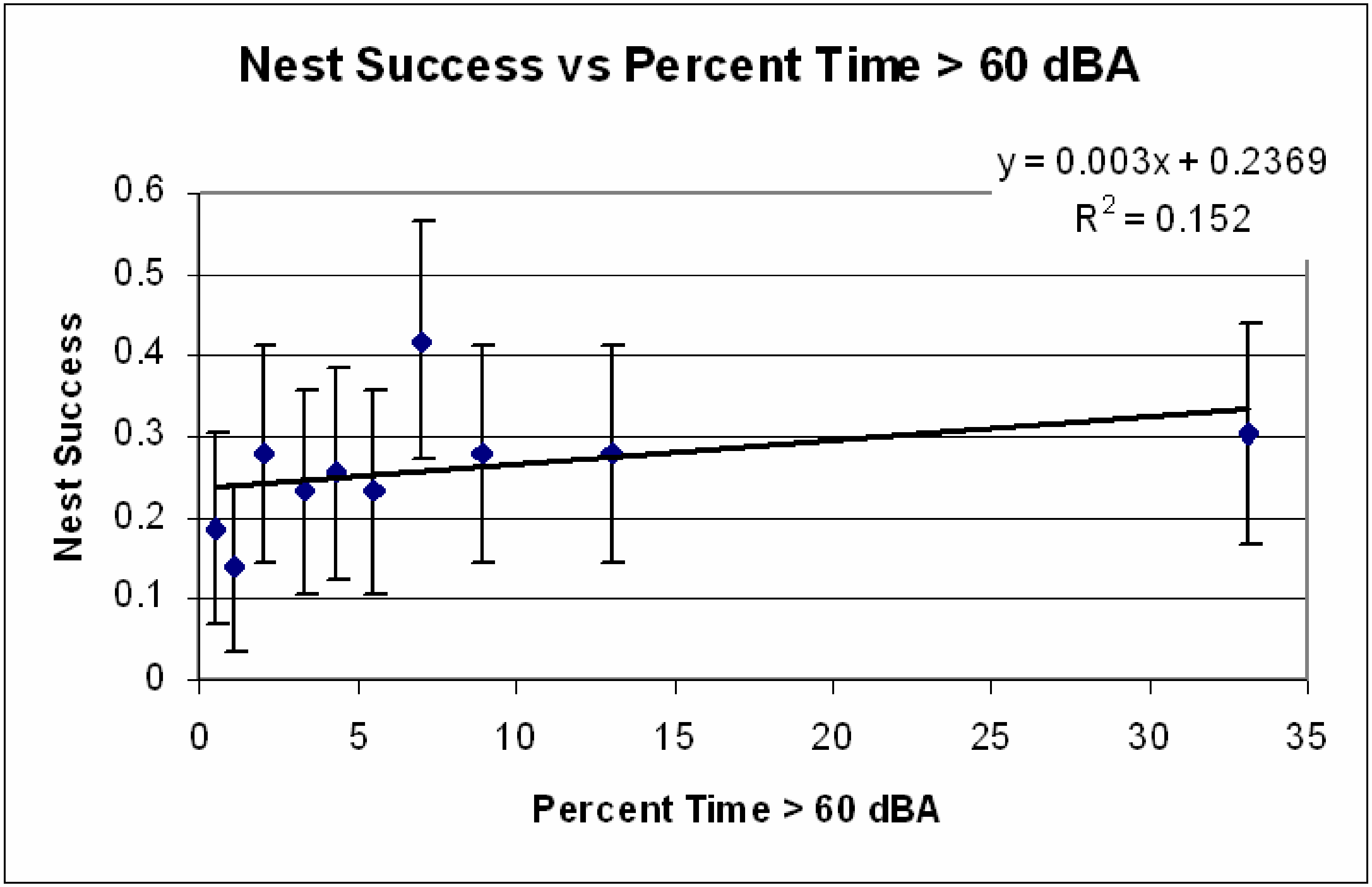
Nest Success vs Max Event ASEL dBA

Figure 17



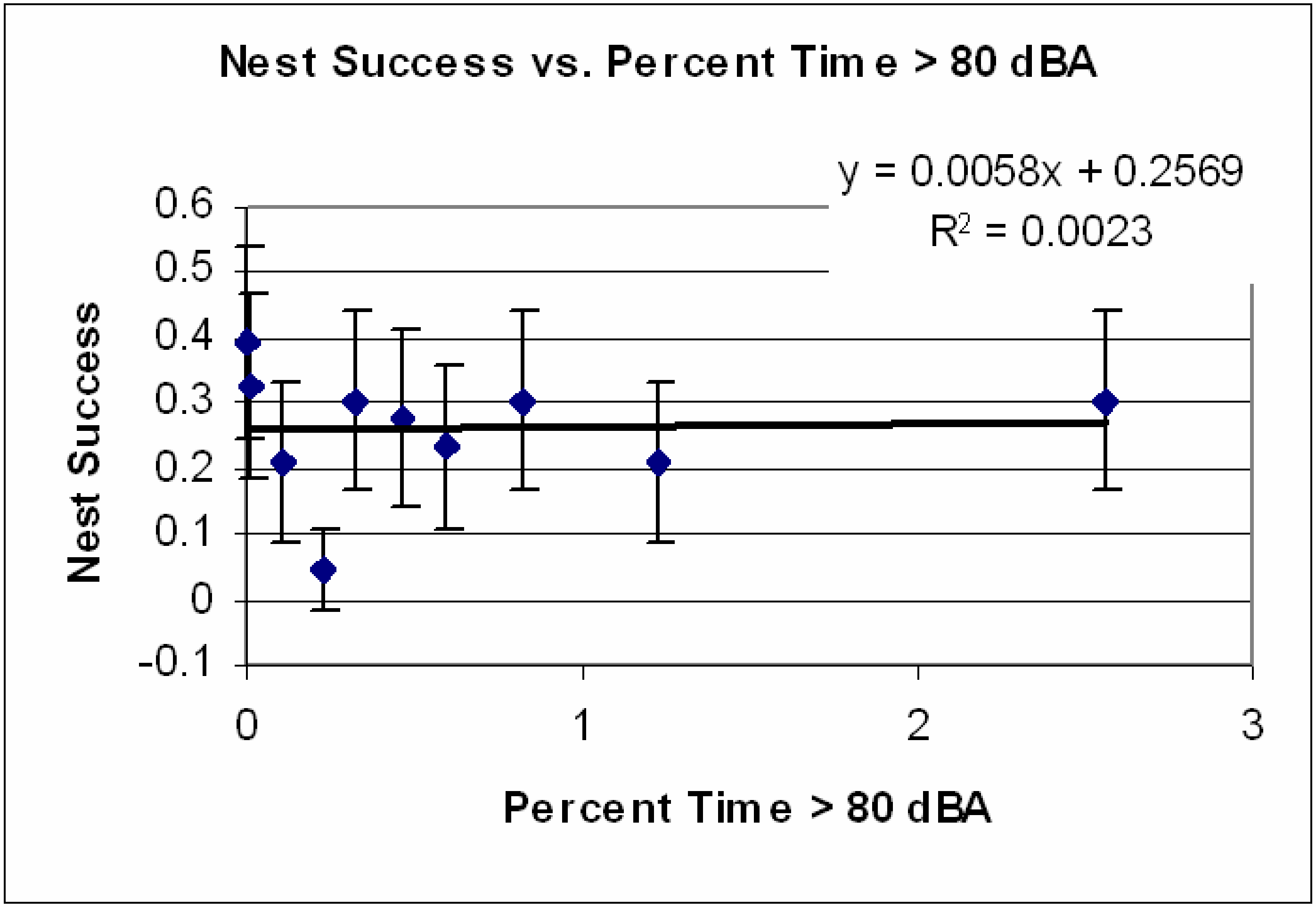
Nest Success vs L5 dBA

Figure 18



Nest Success vs Percent Time >60 dBA

Figure 19



Nest Success vs. Percent Time >80 dBA

Figure 20

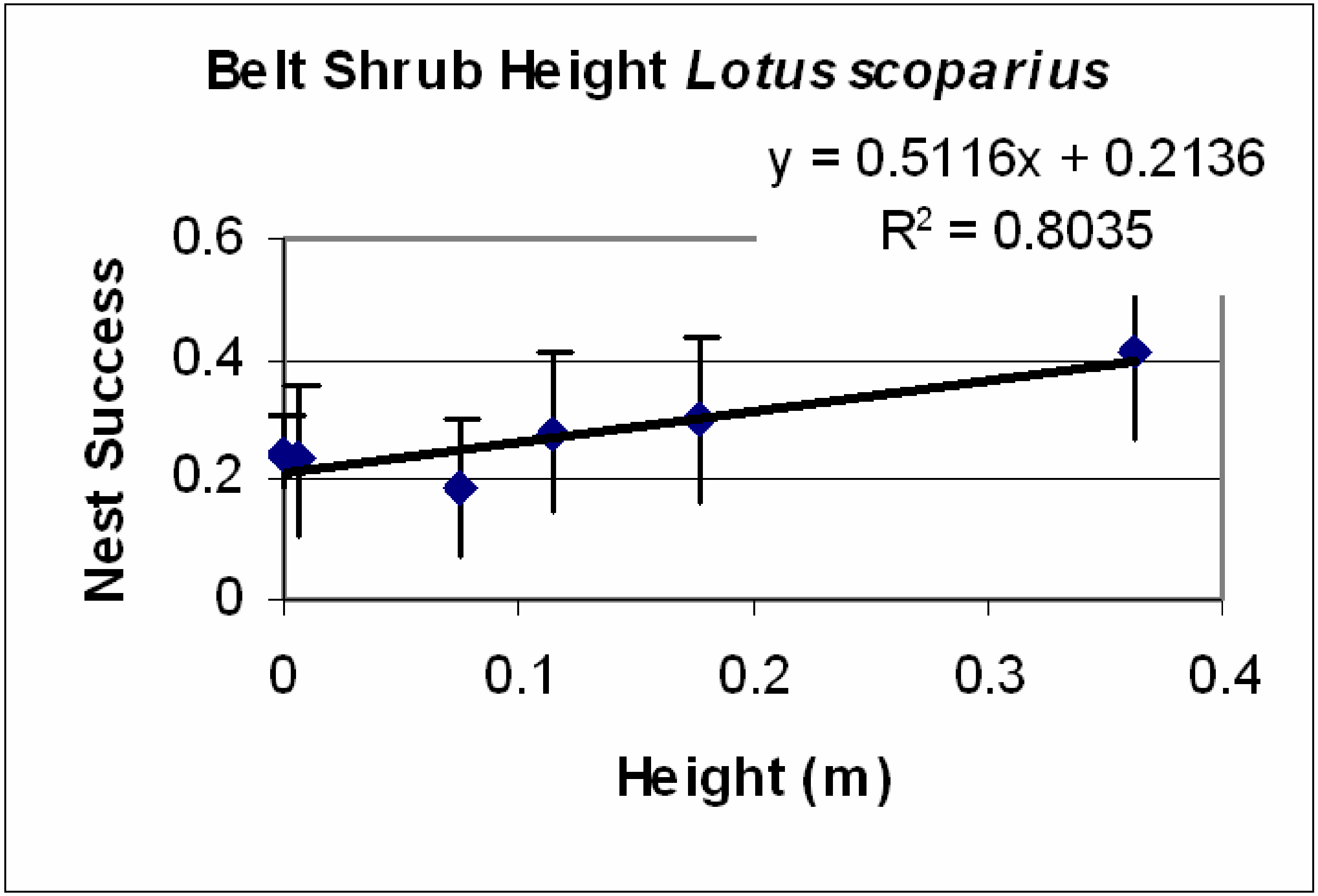
dependent variable (nest success) accounted for by the independent variable displayed on the X or horizontal axis. Appendix A is a glossary of technical terms that includes sound and acoustics and Appendix B is a summary table of noise metrics used in the analysis.

3.4.1.2 Vegetation Metrics

Nesting success had a strong positive association with the height of *Lotus scoparius* shrubs (p=0.005; Figure 21, Table 6) and the number of measured distances between shrubs (i.e. gap count) along the 10-m transects (p=0.014; Figure 22, Table 6). Nesting success was negatively associated with the height of *Salvia mellifera* shrubs (p=0.001; Figure 23, Table 6) and the height of *Baccharis sarothroides* (p=0.008; Figure 24, Table 6). Other vegetation metrics that were associated with nesting success were strongly correlated with these metrics (Table 7) and hence were not included in further multiple-variable analysis. These tables included data on the height of various species in the Belt Shrub Transects (BSH) used to describe the structure of the vegetation, and the spatial gaps between the plants in the transects and a variety of other variables that are included in the Appendix A, glossary of technical terms. In some cases the names of plants are abbreviated to fit the space available in the tables, i.e. Smell for *Salvia mellifera*. Appendix D is a summary table of all the vegetation group classes, plant species and abbreviations used in the analysis.

3.4.1.3 Physical Variables

Physical and habitat characteristic variables were tested for association with nesting success and if significant included in multiple variable analyses. It was found that nesting success was positively associated with the index to curvature (p=0.0027; Figure 25, Table 6) distance to rotary-wing flight tracks (p=0.05; Figure 26, Table 6) and distance to the center of the airfield (p=0.04; Table 6). The apparent association between nesting success and distance from rotary-wing flight procedures is shown in Figure 26 for data collected before and after realignment. If there were realignment effects associated with introduction of rotary-wing aircraft, one would expect either a shift in the intercept or a difference in slopes among lines fitted to pre- and



Lotus Scoparius (Deerweed)

Figure 21

Table 6

Univariate Logistic Regression for CAGN Nesting Success Statistically Significant Coefficients Were Considered Candidates for Multiple Variable Models								
						Odds Ratio		
Variable	DF	Estimate	Standard Error	Wald Chi-Square	Statistical Significance	Estimate	Lower 95% Limit	Upper 95% Limit
Belt Shrub Height Primary CSS	1	-1.5375	0.4056	14.3674	0.0002	0.2149	0.0971	0.4759
Shrub Height Primary CSS	1	-1.3207	0.38	12.0786	0.0005	0.2669	0.1268	0.5622
Belt Shrub Height Deadwood	1	-1.2116	0.3678	10.8532	0.001	0.2977	0.1448	0.6122
Shrub Height *Salvia mellifera*	1	-1.1925	0.368	10.5022	0.0012	0.3035	0.1475	0.6242
Belt Shrub Height *Salvia mellifera*	1	-1.0978	0.3554	9.5409	0.002	0.3336	0.1662	0.6695
Curvature	1	0.7808	0.2599	9.0229	0.0027	2.1832	1.3118	3.6335
Shrub Length *Salvia mellifera*	1	-0.3792	0.1286	8.6959	0.0032	0.6844	0.5319	0.8806
Shrub Height *Baccharis sarathroides*	1	-0.6919	0.2459	7.9144	0.0049	0.5006	0.3092	0.8106
Forb Length Leaf Litter	1	-0.1588	0.0569	7.7903	0.0053	0.8532	0.7631	0.9538
Belt Shrub Height *Baccharis sarathroides*	1	-0.6221	0.2329	7.1319	0.0076	0.5368	0.3401	0.8474
Gap Length	1	0.1915	0.0719	7.0985	0.0077	1.2111	1.0519	1.3943
Shrub Height *Lotus scoparius*	1	2.2975	0.865	7.0551	0.0079	9.9493	1.8259	54.2119
Belt Shrub Cover *Salvia mellifera*	1	-0.2761	0.1059	6.8002	0.0091	0.7587	0.6165	0.9338
Gap Count	1	0.307	0.1242	6.1076	0.0135	1.3593	1.0656	1.7340
Belt Shrub Height Primary Other	1	-0.6598	0.2741	5.7951	0.0161	0.5170	0.3021	0.8846
Distance to Rotary-Wing Flight Procedure	1	0.1898	0.0791	5.7553	0.0164	1.2090	1.0354	1.4118
Shrub Length *Baccharis sarathroides*	1	-0.2424	0.1015	5.698	0.017	0.7847	0.6432	0.9575
Belt Shrub Cover *Eriogonum fasciculatum*	1	0.0535	0.023	5.4034	0.0201	1.0550	1.0085	1.1036
Belt Shrub Cover *Baccharis sarathroides*	1	-0.1135	0.0493	5.2907	0.0214	0.8927	0.8105	0.9833
Belt Shrub Cover *Mimulis auranticus*	1	-0.911	0.3986	5.2245	0.0223	0.4021	0.1841	0.8783
Shrub Height Deadwood	1	-0.6975	0.3065	5.1791	0.0229	0.4978	0.2730	0.9078
Shrub Length *Lotus scoparius*	1	1.2517	0.5501	5.1778	0.0229	3.4963	1.1895	10.2769
Shrub Length Primary CSS	1	-0.1221	0.0545	5.0285	0.0249	0.8851	0.7954	0.9848
Distance To Patch	1	0.00221	0.001	4.8581	0.0275	1.0022	1.0003	1.0042
Shrub Length Primary Other	1	-0.3241	0.1571	4.2591	0.039	0.7232	0.5315	0.9839
Belt Shrub Cover Primary Other	1	-0.074	0.0359	4.2419	0.0394	0.9287	0.8656	0.9964
Belt Shrub Height *Lotus scoparius*	1	1.4379	0.6997	4.2231	0.0399	4.2118	1.0687	16.5985
Distance to Flight Line Center Point	1	0.000059	0.000029	4.1462	0.0417	1.0001	1.0000	1.0001
Belt Shrub Height *Mimulus aurantiacus*	1	-1.9895	0.9798	4.1233	0.0423	0.1368	0.0200	0.9332
Shrub Length *Mimulus aurantiacus*	1	-1.5659	0.7819	4.0105	0.0452	0.2089	0.0451	0.9672
Shrub Length *Eriophyllum confertiflorum*	1	-7.7525	3.8799	3.9926	0.0457	0.0004	0.0000	0.8625
Shrub Height Secondary Chaparral	1	-0.3479	0.1767	3.8773	0.0489	0.7062	0.4995	0.9984
Shrub Height *Mimulus aurantiacus*	1	-2.4752	1.267	3.8165	0.0507	0.0841	0.0070	1.0082
Distance to Rotary-Wing Flight Procedures	1	0.000058	0.00003	3.7673	0.0523	1.0001	1.0000	1.0001
Belt Shrub Height *Eriodyctyon crassifolium*	1	-0.9835	0.5142	3.659	0.0558	0.3740	0.1365	1.0246
October PHDI	1	0.0631	0.0337	3.5141	0.0608	1.0651	0.9971	1.1379
November PHDI	1	0.0647	0.0353	3.3674	0.0665	1.0668	0.9955	1.1433
Fall PHDI	1	0.06	0.033	3.3038	0.0691	1.0618	0.9953	1.1328
Shrub Height Eriodictyon crassifolium	1	-1.0754	0.6011	3.2006	0.0736	0.3412	0.1050	1.1082
December PHDI	1	0.0673	0.0377	3.1834	0.0744	1.0696	0.9934	1.1516
Forb Height Non-native	1	-0.5635	0.3188	3.1248	0.0771	0.5692	0.3047	1.0633
Pre and Post Helicopter	1	0.4799	0.2724	3.1046	0.0781	1.6159	0.9474	2.7561
September PHDI	1	0.0527	0.0303	3.0271	0.0819	1.0541	0.9933	1.1186
August PHDI	1	0.0486	0.0281	2.9941	0.0836	1.0498	0.9935	1.1092
July PHDI	1	0.0478	0.0282	2.8766	0.0899	1.0490	0.9926	1.1086
June PHDI	1	0.052	0.0312	2.769	0.0961	1.0534	0.9909	1.1198
Belt Shrub Cover Deadwood	1	-0.1388	0.084	2.7298	0.0985	0.8704	0.7383	1.0262
Belt Shrub Height Secondary Chaparral	1	-0.413	0.2517	2.6922	0.1008	0.6617	0.4040	1.0836
X Coordinate	1	0.000036	0.000022	2.679	0.1017	1.0000	1.0000	1.0001
May PHDI	1	0.0556	0.0343	2.6247	0.1052	1.0572	0.9884	1.1307
Belt Shrub Cover *Eriophylum confertiflorum*	1	-0.2295	0.143	2.575	0.1086	0.7949	0.6006	1.0521
Shrub Length *Quercus dumosa*	1	3.0404	1.9013	2.5571	0.1098	20.9136	0.5035	868.6567
Shrub Length Secondary Charparral	1	-0.2465	0.1543	2.5525	0.1101	0.7815	0.5776	1.0575
Circ Index	1	0.00574	0.00365	2.465	0.1164	1.0058	0.9986	1.0130
Shrub Height *Eriophyllum confertiflorum*	1	-4.4601	2.8496	2.4497	0.1176	0.0116	0.0000	3.0806
Shrub Length *Eriogonum fasciculatum*	1	0.1003	0.0641	2.4456	0.1179	1.1055	0.9750	1.2535
Transect Richness	1	-0.0797	0.0516	2.3868	0.1224	0.9234	0.8346	1.0217
Distance to Class 2 Roads	1	0.000049	0.000032	2.3696	0.1237	1.0000	1.0000	1.0001

Table 6(Continued)

Traffic Disturbances	1	-0.0295	0.0192	2.354	0.125	0.9709	0.9351	1.0082
Belt Shrub Height Secondary CSS	1	0.3021	0.2003	2.2746	0.1315	1.3527	0.9135	2.0031
Shrub Height *Rhus integrifolia*	1	-2.6751	1.8489	2.0933	0.1479	0.0689	0.0018	2.5825
Forb Height Grass	1	0.5842	0.4096	2.0348	0.1537	1.7936	0.8036	4.0029
Belt Shrub Cover *Eriodictyon crassifolium*	1	-0.1593	0.1132	1.9811	0.1593	0.8527	0.6831	1.0646
Shrub Length *Rhus integrifolia*	1	-2.7716	2.0112	1.8991	0.1682	0.0626	0.0012	3.2231
Shrub Height *Salix apiana*	1	-0.7076	0.5143	1.8928	0.1689	0.4928	0.1799	1.3504
Prop Plane Overflights	1	11.6155	8.571	1.8366	0.1754	1.1080E+05	0.0056	2.1894E+12
Shrub Height Primary Chaparral	1	-0.2196	0.1621	1.8365	0.1754	0.8028	0.5843	1.1031
Shrub Length *Eriodictyon crassifolium*	1	-0.5437	0.4058	1.7954	0.1803	0.5806	0.2621	1.2862
Belt Shrub Height *Malacothamnus fasciculatus*	1	4.3729	3.2754	1.7824	0.1819	79.2732	0.1291	48663.4737
Helicopter	1	-23.5341	17.7748	1.753	0.1855	0.0000	0.0000	81186.8039
Success	1	19.415	14.9158	1.6943	0.193	2.7029E+08	0.0001	1.3440E+21
Bush Shrub Height *Eriogonum fasciculatum*	1	0.3554	0.2812	1.5966	0.2064	1.4268	0.8222	2.4758
Other Disturbances	1	-0.635	0.5041	1.5867	0.2078	0.5299	0.1973	1.4234
Traffic Disturbances	1	-0.635	0.5041	1.5867	0.2078	0.5299	0.1973	1.4234
Belt Shrub Cover *Rhus intergrifolia*	1	-7.7472	6.3114	1.5067	0.2196	0.0004	0.0000	101.8136
Patch Area	1	4.28E-07	3.50E-07	1.4949	0.2215	1.0000	1.0000	1.0000
Shrub Height *Quercus dumosa*	1	2.7524	2.2594	1.484	0.2232	15.6802	0.1871	1313.9905
Belt Shrub Height *Salvia apiana*	1	-0.587	0.4821	1.4827	0.2234	0.5560	0.2161	1.4303
Belt Shrub Height *Eriophyllum confertiflorum*	1	-1.6413	1.3608	1.4549	0.2278	0.1937	0.0135	2.7895
Elevation	1	0.00486	0.00403	1.4521	0.2282	1.0049	0.9970	1.0128
Shrub Height *Rhamnus crocea*	1	0.7714	0.6415	1.446	0.2292	2.1628	0.6151	7.6045
January PHDI	1	-0.0471	0.0402	1.373	0.2413	0.9540	0.8817	1.0322
Belt Shrub Height *Isocoma menziesii*	1	1.0924	0.9339	1.3684	0.2421	2.9814	0.4780	18.5941
Belt Shrub Height *Rhus integrifolia*	1	-7.49	6.4139	1.3637	0.2429	0.0006	0.0000	160.9742
Shrub Length Deadwood	1	-0.1033	0.0896	1.3272	0.2493	0.9019	0.7566	1.0750
Belt Shrub Cover *Lotus scoparius*	1	0.0914	0.0794	1.3248	0.2497	1.0957	0.9378	1.2802
Belt Shrub Cover Secondary Chaparral	1	-0.3165	0.2761	1.3143	0.2516	0.7287	0.4242	1.2519
Belt Shrub Cover *Isocoma menziesii*	1	0.2125	0.1865	1.2977	0.2546	1.2368	0.8581	1.7825
Shrub Height *Hazardia squarrosa*	1	-5.4945	4.8314	1.2933	0.2554	0.0041	0.0000	53.2525
Distance to Fixed-Wing Flight Procedures	1	0.000132	0.000116	1.2912	0.2558	1.0001	0.9999	1.0004
Disturbances Aircraft	1	-0.9217	0.8139	1.2826	0.2574	0.3978	0.0807	1.9612
Belt Shrub Cover *Malosma laurina*	1	0.9489	0.8421	1.2698	0.2598	2.5829	0.4958	13.4559
Shrub Height Secondary CSS	1	0.2422	0.2153	1.2651	0.2607	1.2740	0.8354	1.9429
Shrub Height Primary Other	1	-0.3033	0.2712	1.2506	0.2634	0.7384	0.4339	1.2564
Belt Shrub Cover *Artemisia californica*	1	0.0416	0.0374	1.2395	0.2656	1.0425	0.9688	1.1218
Average L_5	1	-0.0185	0.0167	1.2376	0.2659	0.9817	0.9501	1.0143
Belt Shrub Cover *Toxicodendron diversilobum*	1	-5.6883	5.1152	1.2367	0.2661	0.0034	0.0000	76.5154
BSH *Hazardia squarrosa*	1	-3.1257	2.8464	1.2059	0.2722	0.0439	0.0002	11.6260
Average Total SEL dBA	1	-0.0119	0.0108	1.2045	0.2724	0.9882	0.9675	1.0093
Forb Length Non-vegetated areas	1	0.0804	0.0736	1.1923	0.2749	1.0837	0.9381	1.2519
Forb Length Grass	1	0.0528	0.0484	1.1913	0.2751	1.0542	0.9588	1.1591
Shrub Length *Toxicodendron diversilobum*	1	-8.9446	8.2784	1.1674	0.2799	0.0001	0.0000	1452.5327
Number of Raptors Observed	1	-13.9192	12.964	1.1528	0.283	0.0000	0.0000	97756.9915
Belt Shrub Cover *Quercus dumosa*	1	6.4026	6.0003	1.1386	0.286	603.4119	0.0047	77298723.5125
Shrub Height *Marrubium vulgare*	1	16.2761	15.4654	1.1076	0.2926	1.1712E+07	0.0000	1.7102E+20
Belt Shrub Cover *Salvia apiana*	1	-0.1421	0.1352	1.1058	0.293	0.8675	0.6656	1.1308
Shrub Length *Opuntia prolifera*	1	9.3215	8.8779	1.1024	0.2937	11175.7329	0.0003	4.0299E+11
Shrub Height *Malacothamnus fasciculatus*	1	3.8498	3.6756	1.097	0.2949	46.9837	0.0349	63194.7180
Forb Height Leaf Litter	1	-0.9042	0.8652	1.0921	0.296	0.4049	0.0743	2.2069
Shrub Height *Isocoma menziesii*	1	1.1529	1.1208	1.058	0.3037	3.1674	0.3521	28.4933
Belt Shrub Height *Encelia californica*	1	1.6714	1.6463	1.0308	0.31	5.3196	0.2111	134.0413
Shrub Length *Marrubium vulgare*	1	20.7609	20.5719	1.0185	0.3129	1.0384E+09	0.0000	3.3690E+26
Shrub Length *Quercus berberidifolia*	1	4.1788	4.1465	1.0157	0.3136	65.2875	0.0193	221004.8664
Belt Shrub Cover *Ferrocactus viridescens*	1	1.7431	1.7944	0.9437	0.3313	5.7150	0.1697	192.5054
Shrub Length *Gurierrezia californica*	1	2.2196	2.3444	0.8964	0.3438	9.2036	0.0930	911.0739
Shrub Height *Toxicodendron diversilobum*	1	-4.0862	4.3195	0.8949	0.3442	0.0168	0.0000	79.8396
Shrub Height *Eriogonum fasciculatum*	1	0.2871	0.3113	0.8504	0.3564	1.3326	0.7239	2.4528
Belt Shrub Height *Ferrocactus viridescens*	1	18.8892	20.5467	0.8452	0.3579	1.5976E+08	0.0000	4.9338E+25
Belt Shrub Height *Toxicodendron diversilobum*	1	-3.6792	4.0067	0.8432	0.3585	0.0252	0.0000	64.9704
Belt Shrub Height Unknown Shrub	1	3.2577	3.5553	0.8396	0.3595	25.9897	0.0245	27614.2715
Aspect	1	-0.1267	0.1385	0.8363	0.3604	0.8810	0.6716	1.1558
Shrub Length Primary Chaparral	1	-0.0622	0.0684	0.8264	0.3633	0.9397	0.8218	1.0745

Table 6(Continued)

Shrub Height *Opuntia prolifera*	1	9.596	10.6847	0.8066	0.3691	1.4706E+04	0.0000	1.8302E+13
Shrub Length *Salvia apiana*	1	-0.2051	0.2288	0.8041	0.3699	0.8146	0.5202	1.2755
Forb Length Native Forbs	1	0.0581	0.0662	0.7696	0.3803	1.0598	0.9309	1.2067
Shrub Length *Lonicera subspicata*	1	0.5411	0.6228	0.7549	0.3849	1.7179	0.5068	5.8228
Belt Shrub Height *Adenostoma fasciculatum*	1	-0.2436	0.2826	0.7425	0.3889	0.7838	0.4505	1.3638
Number of Large Plane Overflights	1	30.9593	36.0793	0.7363	0.3908	2.7890E+13	0.0000	1.4347E+44
Belt Shrub Cover *Encelia californica*	1	0.0987	0.1169	0.7131	0.3984	1.1037	0.8777	1.3879
Shrub Length *Baccharis salicifolia*	1	-1.4713	1.7464	0.7098	0.3995	0.2296	0.0075	7.0403
Shrub Height *Adenostoma fasciculatum*	1	-0.2293	0.2763	0.6889	0.4065	0.7951	0.4626	1.3665
Shrub Height Secondary Other	1	-0.1888	0.2355	0.6423	0.4229	0.8280	0.5218	1.3136
Belt Shrub Cover Secondary CSS	1	0.0548	0.0689	0.6345	0.4257	1.0563	0.9229	1.2091
Belt Shrub Height *Gutierrezia californica*	1	1.7663	2.2249	0.6302	0.4273	5.8492	0.0747	458.1076
Average Total L_{eq}dBA	1	-0.0089	0.0113	0.62	0.431	0.9911	0.9694	1.0133
Belt Shrub Cover *Gutierrezia californica*	1	0.3488	0.4452	0.614	0.4333	1.4174	0.5923	3.3919
Shrub Height *Prunus ilicifolia*	1	-7.0688	9.0773	0.6064	0.4361	0.0009	0.0000	4.5375E+04
Shrub Length *Artemisia californica*	1	0.0656	0.0857	0.5858	0.4441	1.0678	0.9027	1.2631
Shrub Length *Opuntia littoralis*	1	-3.9326	5.1474	0.5837	0.4449	0.0196	0.0000	471.6815
Number of Jet Overflights	1	-2.0402	2.7061	0.5684	0.4509	0.1300	0.0006	26.1476
Belt Shrub Height Primary Chaparral	1	-0.1099	0.1476	0.5536	0.4569	0.8959	0.6709	1.1965
Average Maximum Event SELdBA	1	-0.00894	0.0121	0.5478	0.4592	0.9911	0.9679	1.0149
Y Coordinate	1	-0.00006	0.000077	0.546	0.46	0.9999	0.9998	1.0001
Belt Shrub Cover *Opuntia prolifera*	1	1.2527	1.7023	0.5415	0.4618	3.4998	0.1245	98.4165
Shrub Height *Baccharis salicifolia*	1	-1.1544	1.5746	0.5375	0.4635	0.3152	0.0144	6.9020
Belt Shrub Height *Marribium vulgare*	1	7.5757	10.4918	0.5214	0.4703	1950.2249	0.0000	1.6630E+12
Shrub Length *Prunus ilicifolia*	1	-14.7546	21.5582	0.4684	0.4937	0.0000	0.0000	8.7674E+11
Shrub Height *Baccharis pilularis*	1	-3.2512	4.7643	0.4657	0.495	0.0387	0.0000	440.0234
Belt Shrub Height *Rhamnus crocea*	1	0.4723	0.6932	0.4642	0.4957	1.6037	0.4121	6.2399
Shrub Length *Yucca baccata*	1	-9.7907	14.37	0.4642	0.4957	0.0001	0.0000	9.5487E+07
Shrub Height *Encelia californica*	1	1.2803	1.8813	0.4631	0.4962	3.5977	0.0901	143.6885
Shrub Height *Xylococcus bicolor*	1	-2.1322	3.1574	0.456	0.4995	0.1186	0.0002	57.7604
Shrub Length *Adenostoma fasciculatum*	1	-0.0701	0.1083	0.4189	0.5175	0.9323	0.7540	1.1528
Belt Shrub Cover *Baccharis salicifolia*	1	-0.8228	1.2739	0.4172	0.5184	0.4392	0.0362	5.3337
Shrub Length *Hazardia squarrosa*	1	-1.6295	2.527	0.4158	0.519	0.1960	0.0014	27.7551
Forb Length Non-native Forbs	1	0.0325	0.052	0.3905	0.532	1.0330	0.9329	1.1439
April PHDI	1	0.0303	0.0486	0.3894	0.5326	1.0308	0.9371	1.1338
Distance to Class 1 Roads	1	-0.00005	0.000085	0.3836	0.5357	1.0000	0.9998	1.0001
Shrub Length Unknown Shrub	1	-2.9107	4.7079	0.3822	0.5364	0.0544	0.0000	553.7891
Shrub Height *Malosma laurina*	1	-0.3514	0.5698	0.3802	0.5375	0.7037	0.2303	2.1499
Shrub Length *Helianthemum scoparium*	1	-4.5471	7.4372	0.3738	0.5409	0.0106	0.0000	2.2693E+04
Belt Shrub Height *Quercus dumosa*	1	3.6281	5.9752	0.3687	0.5437	37.6412	0.0003	4.5905E+06
Shrub Length *Isocoma menziesii*	1	0.3691	0.6201	0.3543	0.5517	1.4464	0.4290	4.8768
Shrub Length *Enecelia californica*	1	0.1598	0.2726	0.3438	0.5576	1.1733	0.6876	2.0019
Belt Shrub Cover *Rhamnus ilicifolia*	1	2.7245	4.6484	0.3435	0.5578	15.2488	0.0017	1.3805E+05
Shrub Length *Baccharis pilularis*	1	-2.5851	4.4286	0.3407	0.5594	0.0754	0.0000	443.6145
March PHDI	1	0.027	0.0463	0.34	0.5599	1.0274	0.9382	1.1250
Shrub Length Secondary Other	1	-0.0875	0.153	0.3271	0.5674	0.9162	0.6788	1.2366
Shrub Height *Yucca baccata*	1	-4.9631	8.7182	0.3241	0.5692	0.0070	0.0000	1.8435E+05
Belt Shrub Cover *Ceanothus tomentosus*	1	-0.8783	1.5601	0.3169	0.5734	0.4155	0.0195	8.8418
Shrub Length *Rhamnus crocea*	1	0.1994	0.3546	0.3164	0.5738	1.2207	0.6092	2.4459
Belt Shrub Height *Salvia* hybrid	1	-8.0275	14.3793	0.3117	0.5767	0.0003	0.0000	5.6703E+08
Belt Shrub Cover *Helianthemum scoparium*	1	-1.114	2.0001	0.3102	0.5776	0.3282	0.0065	16.5469
Number of Predators	1	-17.3567	31.8782	0.2964	0.5861	0.0000	0.0000	3.9569E+19
Belt Shrub Height *Yucca baccata*	1	-4.1554	7.6572	0.2945	0.5873	0.0157	0.0000	5.1674E+04
Belt Shrub Height *Lessingia filaginifolia*	1	0.4996	0.922	0.2936	0.5879	1.6481	0.2705	10.0414
Shrub Length *Hetromeles arbutifolia*	1	-3.3946	6.3023	0.2901	0.5901	0.0336	0.0000	7769.0875
Forb Length Road	1	-0.025	0.0469	0.2834	0.5945	0.9753	0.8897	1.0692
Belt Shrub Cover *Baccharis pilularis*	1	1.3756	2.5956	0.2809	0.5961	3.9575	0.0244	640.9657
Belt Shrub Height *Baccharis pilularis*	1	-3.1719	6.0324	0.2765	0.599	0.0419	0.0000	5719.3132
Belt Shrub Height *Baccharis salicifolia*	1	-0.7783	1.5245	0.2606	0.6097	0.4592	0.0231	9.1132
Shrub Length *Mirabilis californica*	1	-2.4219	4.8842	0.2459	0.62	0.0888	0.0000	1275.5491
Shrub Height Unknown Shrub	1	4.1393	8.5394	0.235	0.6279	62.7589	0.0000	1.1656E+09
Shrub Length Secondary CSS	1	0.064	0.1339	0.2284	0.6327	1.0661	0.8200	1.3860
Shrub Height *Opuntia litorralis*	1	-3.1256	6.6555	0.2206	0.6386	0.0439	0.0000	2.0316E+04
Shrub Height *Helianthemum scoparium*	1	-5.6453	12.1151	0.2171	0.6412	0.0035	0.0000	7.2587E+07

Table 6(Continued)

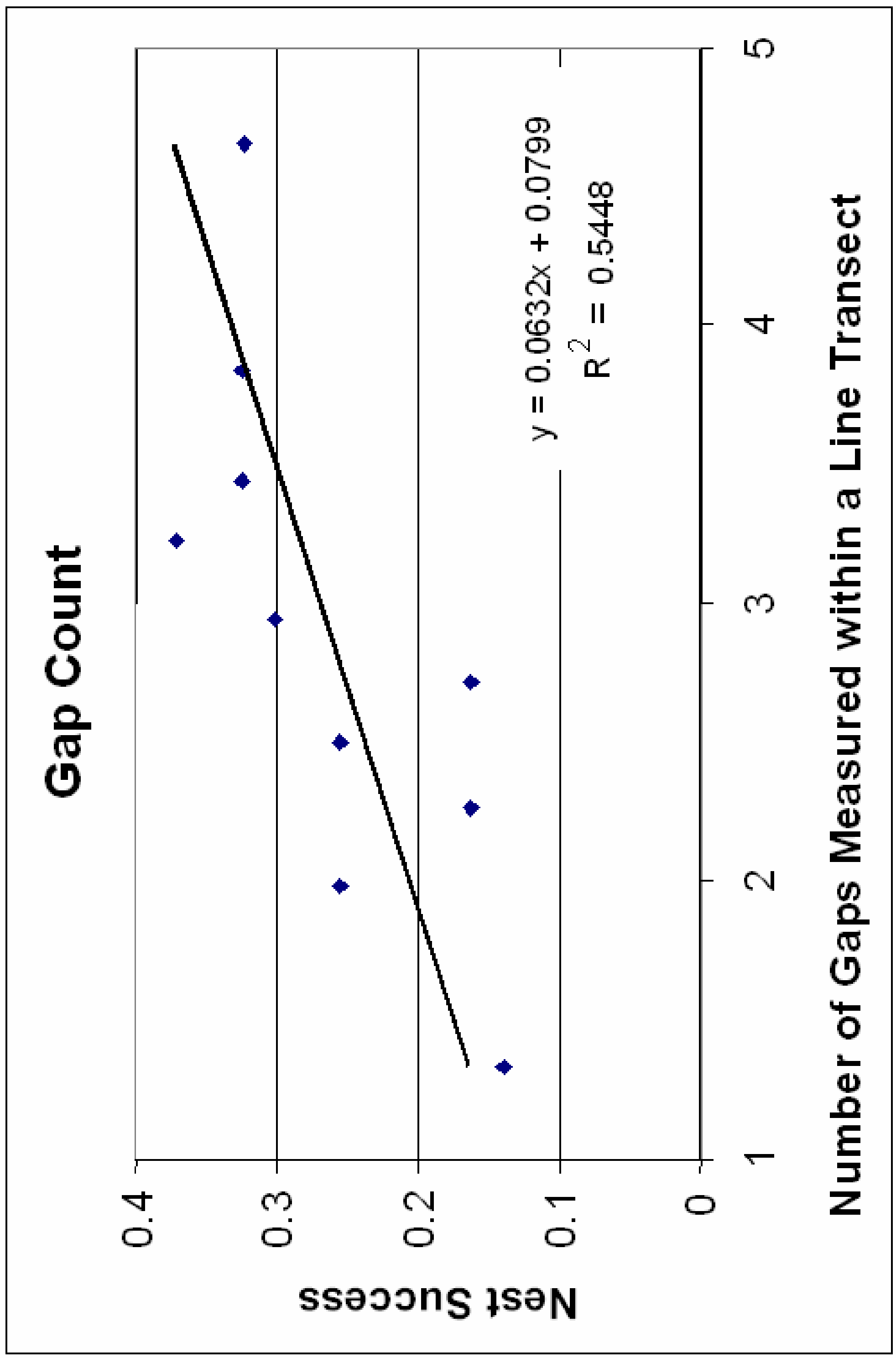
South Aspect	1	0.0946	0.2042	0.2148	0.643	**1.0992**	**0.7367**	**1.6402**
Shrub Height *Ceanothus tomentosus*	1	0.5104	1.1116	0.2108	0.6461	**1.6660**	**0.1886**	**14.7190**
Belt Shrub Height *Prunus ilicifolia*	1	-1.4874	3.2436	0.2103	0.6465	**0.2260**	**0.0004**	**130.3282**
Shrub Height *Gutierrezia californica*	1	1.3729	3.0751	0.1993	0.6553	**3.9468**	**0.0095**	**1636.1415**
Shrub Height *Artemisia californica*	1	0.1161	0.2744	0.1792	0.6721	**1.1231**	**0.6559**	**1.9231**
Belt Shrub Height *Helianthemum scoparium*	1	-5.1516	12.1806	0.1789	0.6723	**0.0058**	**0.0000**	**1.3521E+08**
February PHDI	1	0.0184	0.0437	0.1776	0.6734	**1.0186**	**0.9350**	**1.1097**
Belt Shrub Cover Unknown Shrub	1	-0.3674	0.8864	0.1718	0.6785	**0.6925**	**0.1219**	**3.9351**
Belt Shrub Cover *Lonicera subspicata*	1	0.2617	0.6405	0.167	0.6828	**1.2991**	**0.3702**	**4.5589**
Belt Shrub Height *Malosma laurina*	1	-0.3335	0.8208	0.1651	0.6845	**0.7164**	**0.1434**	**3.5797**
Belt Shrub Cover *Yucca bacatta*	1	-1.2189	3.039	0.1609	0.6884	**0.2956**	**0.0008**	**114.1530**
Belt Shrub Cover *Adenostoma fasciculatum*	1	-0.0255	0.068	0.1403	0.7079	**0.9748**	**0.8532**	**1.1138**
Number of Corvidae Observed	1	1.2813	3.4362	0.139	0.7092	**3.6013**	**0.0043**	**3.0298E+03**
Shrub Height *Cneoridium dumosum*	1	-0.8117	2.1872	0.1377	0.7105	**0.4441**	**0.0061**	**32.3047**
Shrub Length *Xylococcus bicolor*	1	-1.0756	2.9777	0.1305	0.7179	**0.3411**	**0.0010**	**116.8267**
Belt Shrub Height *Artemisia californica*	1	0.0907	0.2578	0.1238	0.725	**1.0949**	**0.6606**	**1.8148**
Man-made Items occurring in the Forb Layer	1	-0.0384	0.1095	0.1231	0.7257	**0.9623**	**0.7765**	**1.1927**
Shrub Length *Lessingia filaginifolia*	1	0.3312	0.9721	0.1161	0.7333	**1.3926**	**0.2072**	**9.3607**
Belt Shrub Cover *Malacothamnus fasciculatus*	1	-0.2185	0.6533	0.1119	0.738	**0.8037**	**0.2234**	**2.8921**
Belt Shrub Height *Xylococcus bicolor*	1	2.4867	7.4457	0.1115	0.7384	**12.0215**	**0.0000**	**2.6174E+07**
Shrub Length *Ceanothus tomentosus*	1	-0.2851	0.8739	0.1064	0.7443	**0.7519**	**0.1356**	**4.1693**
Shrub Height *Porophyllum gracile*	1	9.7567	30.9434	0.0994	0.7525	**17269.5480**	**0.0000**	**3.7743E+30**
Forb Height Native Forbs	1	-0.1097	0.3579	0.094	0.7591	**0.8961**	**0.4443**	**1.8072**
Average Percent > 60dBA	1	-0.00351	0.0118	0.0887	0.7658	**0.9965**	**0.9737**	**1.0198**
Nest Richness	1	-0.0245	0.0848	0.0834	0.7728	**0.9758**	**0.8264**	**1.1522**
Belt Shrub Height *Cneoridium dumosum*	1	-0.576	2.0074	0.0823	0.7742	**0.5621**	**0.0110**	**28.7462**
Belt Shrub Cover *Salvia* hybrid	1	2.0938	7.3787	0.0805	0.7766	**8.1157**	**0.0000**	**1.5495E+07**
Belt Shrub Cover *Harzardia squarrosa*	1	-0.0801	0.2975	0.0724	0.7879	**0.9230**	**0.5152**	**1.6537**
Belt Shrub Cover *Xylococcus bicolor*	1	-1.5169	5.7714	0.0691	0.7927	**0.2194**	**0.0000**	**1.7945E+04**
Shrub Length *Malosma laurina*	1	-0.1058	0.4253	0.0618	0.8036	**0.8996**	**0.3909**	**2.0705**
Patch Perimeter	1	-4.52E-06	0.000019	0.0587	0.8086	**1.0000**	**1.0000**	**1.0000**
Belt Shrub Height *Opuntia prolifera*	1	1.5377	6.4312	0.0572	0.811	**4.6539**	**0.0000**	**1.3873E+06**
Belt Shrub Height *Lonicera subspicata*	1	0.257	1.0767	0.057	0.8114	**1.2930**	**0.1567**	**10.6689**
Belt Shrub Cover *Rhamnus crocea*	1	-0.0866	0.4371	0.0392	0.843	**0.9170**	**0.3893**	**2.1600**
Belt Shrub Height *Mirabillis californica*	1	-1.5978	8.285	0.0372	0.8471	**0.2023**	**0.0000**	**2.2825E+06**
Shrub Length *Malacothamnus fasciculatus*	1	0.244	1.4292	0.0291	0.8645	**1.2763**	**0.0775**	**21.0149**
Shrub Height *Mirabillis californica*	1	-1.4846	8.9579	0.0275	0.8684	**0.2266**	**0.0000**	**9.5580E+06**
Belt Shrub Height Secondary Other	1	0.0336	0.2044	0.0271	0.8692	**1.0342**	**0.6928**	**1.5438**
Shrub Height *Lessingia filaginifolia*	1	0.1914	1.2672	0.0228	0.8799	**1.2109**	**0.1010**	**14.5140**
Average Percent > 80dBA	1	-0.0229	0.1521	0.0226	0.8805	**0.9774**	**0.7254**	**1.3168**
Shrub Height *Heteromeles arbutifolia*	1	0.222	1.6209	0.0188	0.8911	**1.2486**	**0.0521**	**29.9331**
Aspect	1	0.000155	0.00122	0.0161	0.8989	**1.0002**	**0.9978**	**1.0025**
Belt Shrub Cover Primary Chaparral	1	-0.00537	0.0426	0.0159	0.8995	**0.9946**	**0.9150**	**1.0813**
Belt Shrub Cover *Prunus ilicifolia*	1	0.4736	4.017	0.0139	0.9061	**1.6058**	**0.0006**	**4217.1718**
Belt Shrub Height *Rhamnus ilicifolia*	1	-0.8143	8.1883	0.0099	0.9208	**0.4429**	**0.0000**	**4.1340E+06**
Shrub Length *Cneoridium dumosum*	1	0.1595	1.6638	0.0092	0.9236	**1.1729**	**0.0450**	**30.5862**
Belt Shrub Height *Ceanothus tomemtosus*	1	-0.1168	1.2616	0.0086	0.9262	**0.8898**	**0.0751**	**10.5480**
Belt Shrub Cover *Mirabilis californica*	1	-0.0555	0.6119	0.0082	0.9278	**0.9460**	**0.2851**	**3.1387**
Belt Shrub Cover Primary CSS	1	-0.00179	0.0205	0.0077	0.9302	**0.9982**	**0.9589**	**1.0391**
Non-vegetated Items in the Forb Layer	1	0.0581	0.6884	0.0071	0.9327	**1.0598**	**0.2750**	**4.0852**
Shrub Length *Viguiera lacinata*	1	-166.5	2150.1	0.006	0.9383	**0.0000**	**0.0000**	**0.0000**
Belt Shrub Height *Heteromeles arbutifolia*	1	-200.4	2615.9	0.0059	0.9389	**0.0000**	**0.0000**	**0.0000**
Belt Shrub Cover *Lessingia filaginifolia*	1	0.01	0.1338	0.0056	0.9404	**1.0101**	**0.7771**	**1.3129**
Belt Shrub Cover Secondary Other	1	-0.00377	0.0507	0.0055	0.9407	**0.9962**	**0.9020**	**1.1003**
Belt Shrub Cover *Cneoridium dumosum*	1	-0.093	1.3231	0.0049	0.944	**0.9112**	**0.0681**	**12.1859**
Shrub Height *Quercus berberidifolia*	1	-0.2238	3.3815	0.0044	0.9472	**0.7995**	**0.0011**	**604.2210**
Percent Slope	1	-0.00067	0.0116	0.0033	0.9541	**0.9993**	**0.9769**	**1.0223**
Slope Degree	1	-0.00113	0.0208	0.003	0.9565	**0.9989**	**0.9590**	**1.0404**
Belt Shrub Height *Opuntia littoralis*	1	-290.9	6341.1	0.0021	0.9634	**0.0000**	**0.0000**	**0.0000**
Belt Shrub Cover *Opunia littoralis*	1	-70.9539	1646.6	0.0019	0.9656	**0.0000**	**0.0000**	**0.0000**
Belt Shrub Cover *Marribium vulgare*	1	-0.2353	5.6826	0.0017	0.967	**0.7903**	**0.0000**	**54317.1883**
Belt Shrub Cover *Cerrocarpus betuloides*	1	-69.2047	1846.5	0.0014	0.9701	**0.0000**	**0.0000**	**0.0000**
Shrub Length *Cerrocarpus betuloides*	1	-39.2039	1165	0.0011	0.9732	**0.0000**	**0.0000**	**0.0000**
Shrub Length *Porophyllum gracile*	1	-0.7041	21.9839	0.001	0.9744	**0.4946**	**0.0000**	**2.5544E+18**

Table 6(Continued)

Belt Shrub Cover *Viguiera laciniata*	1	-64.0871	2094.7	0.0009	0.9756	**0.0000**	**0.0000**	**INF**
Shrub Height *Viguiera laciniata*	1	-183.3	6017.6	0.0009	0.9757	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Cerrocarpus betuloides*	1	-32.5222	1130.5	0.0008	0.977	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Eriogonum cinerium*	1	-122	4908	0.0006	0.9802	**0.0000**	**0.0000**	**INF**
Shrub Height *Cerrocarpus betuloides*	1	-19.7798	909.4	0.0005	0.9826	**0.0000**	**0.0000**	**INF**
Shrub Length *Ceanothus verrucosus*	1	-36.6023	1740.1	0.0004	0.9832	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Ribes speciosum*	1	89.6433	4388	0.0004	0.9837	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Ceanothus verrucosus*	1	-41.3947	2083.5	0.0004	0.9841	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Ribes speciosum*	1	142.1	7182.4	0.0004	0.9842	**0.0000**	**0.0000**	**INF**
Shrub Height *Ceanothus verrucosus*	1	-44.1027	2249.7	0.0004	0.9844	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Dudleya* spp.	1	-118.4	6230.8	0.0004	0.9848	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Viguiera laciniata*	1	-110.8	6177.2	0.0003	0.9857	**0.0000**	**0.0000**	**INF**
Shrub Height *Eriogonum cinereum*	1	-63.5854	3873.8	0.0003	0.9869	**0.0000**	**0.0000**	**INF**
Frequency	1	2.7005	165.2	0.0003	0.987	**14.8872**	**0.0000**	**INF**
Belt Shrub Cover *Dudleya* Spp.	1	-37.3524	2535.7	0.0002	0.9882	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Eriogonum cinereum*	1	-37.3524	2535.7	0.0002	0.9882	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Brickellia californica*	1	-74.9771	5207.7	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Bouganvillea* spp.	1	29.8627	2068.5	0.0002	0.9885	$\mathbf{9.3*10^{12}}$	**0.0000**	**INF**
Belt Shrub Cover *Isomeris arborea*	1	-37.4885	2603.9	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Porophyllum gracile*	1	-37.4885	2603.9	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Belt Shrub *Quercus berberidifolia*	1	89.588	6205.6	0.0002	0.9885	$\mathbf{8.08*10^{38}}$	**0.0000**	**INF**
Belt Shrub Height *Brickellia californica*	1	-83.3078	5786.3	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Bouganvillea* Spp.	1	51.1931	3546	0.0002	0.9885	$\mathbf{1.7*10^{22}}$	**0.0000**	**INF**
Belt Shrub Height *Isomeris arborea*	1	-107.1	7439.6	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Porophyllum gracile*	1	-178.5	12399.3	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Quercus berberidifolia*	1	61.7848	4279.7	0.0002	0.9885	$\mathbf{6.8*10^{26}}$	**0.0000**	**INF**
Shrub Height *Brickellia californica*	1	-93.7213	6509.6	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Height *Ceanothus crassifolius*	1	-20.7693	1442.6	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Height *Dudleya lanceolata*	1	-1499.5	104154	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Height *Dudleya* Spp.	1	-93.7213	6509.6	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Height *Rhamnus ilicifolia*	1	-59.9816	4166.2	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Height *Ribes speciosum*	1	-53.555	3719.8	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Height *Salvia* hybrid	1	-59.9816	4166.2	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Brickellia californica*	1	-150	10415.4	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Ceanothus crassifolius*	1	-57.6747	4005.9	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Dudleya lanceolata*	1	-833.1	57863.4	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Dudleya* Spp.	1	-125	8679.5	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Rhamnus ilicifolia*	1	-44.1041	3063.4	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Ribes speciosum*	1	-83.3078	5786.3	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Salix* hybrid	1	-37.4885	2603.9	0.0002	0.9885	**0.0000**	**0.0000**	**INF**
Shrub Length *Eriogonum cinereum*	1	-30.064	2098	0.0002	0.9886	**0.0000**	**0.0000**	**INF**
Belt Shrub Height *Dudleya lanceolata*	1	-125.9	8942.1	0.0002	0.9888	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Ceanothus verrucosus*	1	-40.4982	3035.6	0.0002	0.9894	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Dudleya lanceolata*	1	-40.4982	3035.6	0.0002	0.9894	**0.0000**	**0.0000**	**INF**
Belt Shrub Cover *Heteromeles arbutifolia*	1	-80.9964	6071.3	0.0002	0.9894	**0.0000**	**0.0000**	**INF**
Shrub Height *Lonicera subspicata*	1	0	0.9344	0	1	**1.0000**	**0.1602**	**6.2428**
Number of Visits	1	-0.1075	0.0266	16.2882	<.0001	**0.8981**	**0.8525**	**0.9461**
Summary of Minutes	1	-0.00184	0.000451	16.7438	<.0001	**0.9982**	**0.9973**	**0.9990**
Belt Shrub Cover *Arctostaphylos glandulosa*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Cover *Clematis pauciflora*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Cover *Encelia farinosa*	0	0	NA	NA	NA	NA	NA	NA
Belt ShrubCover *Ribes indecorum*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Cover *Solanum parishii*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Cover *Trichostema lanatum*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Cover *Yucca whipplei*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Height *Arctostaphylos glandulosa*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Height *Clematis pauciflora*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Height *Encelia farinosa*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Height *Ribes indecorum*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Height *Solanum parishii*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Height *Trichostema lanatum*	0	0	NA	NA	NA	NA	NA	NA
Belt Shrub Height *Yucca whipplei*	0	0	NA	NA	NA	NA	NA	NA
Shrub Height *Arctostaphylos glandulosa*	0	0	NA	NA	NA	NA	NA	NA

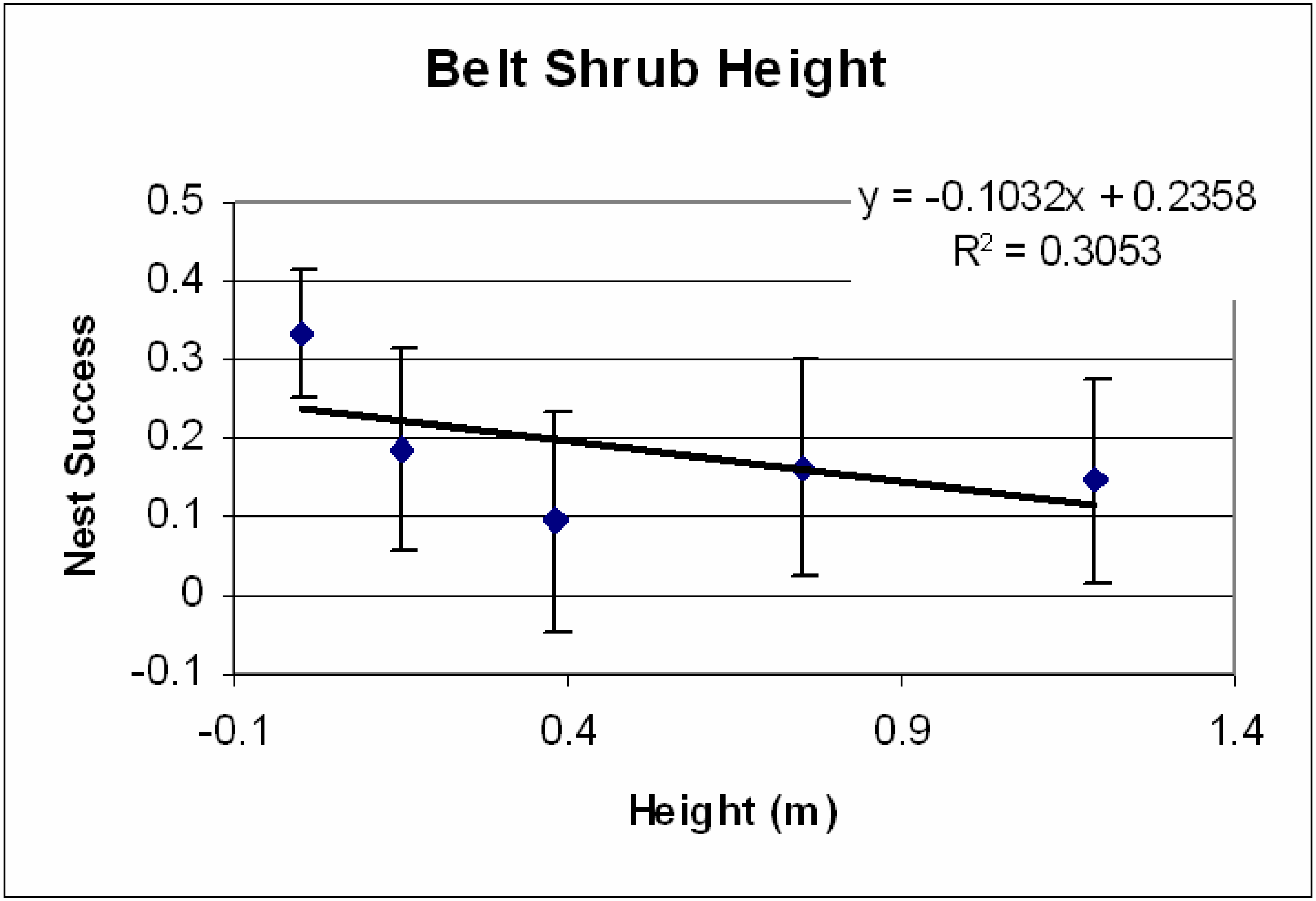
Table 6(Continued)

Shrub Height *Artemisia palmeri*	0	0	NA	NA	NA	NA	NA	NA
Shrub Height *Clematis pauciflora*	0	0	NA	NA	NA	NA	NA	NA
Shrub Height *Ferrocactus viridescens*	0	0	NA	NA	NA	NA	NA	NA
Shrub Height *Ribes indecorum*	0	0	NA	NA	NA	NA	NA	NA
Shrub Height *Solanum parishii*	0	0	NA	NA	NA	NA	NA	NA
Shrub Height *Trichostema lanatum*	0	0	NA	NA	NA	NA	NA	NA
Shrub Height *Yucca whipplei*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Arctostaphylos glandulosa*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Artemisia palmeri*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Clematis pauciflora*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Ferrocacuts viridescens*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Ribes indecorum*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Solanum parishii*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Trichostema lanatum*	0	0	NA	NA	NA	NA	NA	NA
Shrub Length *Yucca whipplei*	0	0	NA	NA	NA	NA	NA	NA

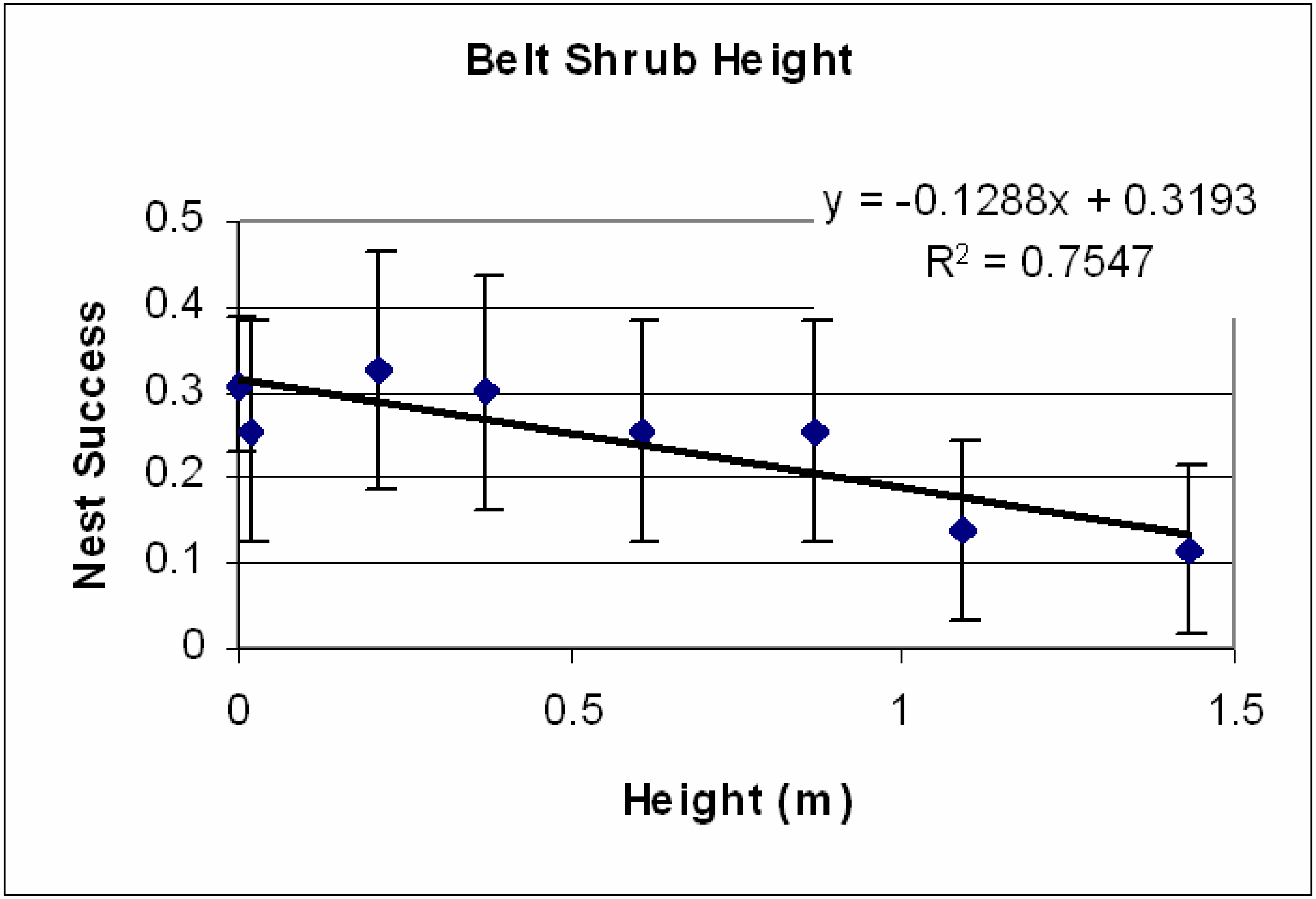


Gap Count

Figure 22



Black Sage (*Salvia Mellifera*) | Figure 23



Broom Baccharis (*Baccharis Sarothroides*)

Figure 24

Table 7

Spearman Rank Correlation Coefficients Among Statistically Signifficant ($p<0.10$) Predictors of Nesting Success
Pairs of Predictors With Correlation Coefficients Greater Than 0.4 Were Not Included in Multiple Variable Models

Variable	Belt Shrub Height Primary CSS	Shrub Height Primary CSS	Belt Shrub Height Deadwood	Shrub Height *Salvia mellifera*	Belt Shrub Height *Salvia Mellifera*	Curvature	Shrub Length *Salvia mellifera*	Shrub Height *Lotus scoparius*	Forb Length Leaf Litter	Belt Shrub Height *Baccharis sarothroides*	Gap Length	Shrub Height *Baccharis sarothroides*	Belt Shrub Height *Salvia mellifera*	Distance to Rotary-Wing Flight Procedures	Gap Count
Belt Shrub Height Primary CSS	1.00	0.79	0.29	0.29	0.28	-0.26	0.29	-0.12	0.40	0.46	-0.33	0.45	0.28	-0.14	-0.24
Shrub Height Primary CSS	0.79	1.00	0.31	0.33	0.30	-0.23	0.32	-0.12	0.45	0.37	-0.33	0.42	0.29	-0.14	-0.30
Belt Shrub Height Deadwood	**0.29**	**0.31**	**1.00**	**0.23**	**0.24**	**-0.01**	**0.24**	**-0.08**	**0.20**	**0.32**	**-0.12**	**0.32**	**0.24**	**-0.22**	**-0.15**
Shrub Height *Salvia mellifera*	**0.29**	**0.33**	**0.23**	**1.00**	**0.94**	**-0.03**	**0.99**	**-0.03**	**0.40**	**0.10**	**-0.30**	**0.12**	**0.93**	**-0.35**	**-0.17**
Belt Shrub Height *Salvia mellifera*	0.28	0.30	0.24	0.94	1.00	-0.02	0.94	-0.02	0.38	0.08	-0.29	0.10	0.99	-0.34	-0.13
Curvature	**-0.26**	**-0.23**	**-0.01**	**-0.03**	**-0.02**	**1.00**	**-0.03**	**0.04**	**-0.17**	**-0.09**	**0.02**	**-0.10**	**-0.03**	**0.06**	**0.11**
Shrub Length *Salvia mellifera*	0.29	0.32	0.24	0.99	0.94	-0.03	1.00	-0.04	0.41	0.10	-0.29	0.13	0.94	-0.34	-0.17
Shrub Height *Lotus scoparius*	**-0.12**	**-0.12**	**-0.08**	**-0.03**	**-0.02**	**0.04**	**-0.04**	**1.00**	**-0.05**	**-0.05**	**0.07**	**-0.05**	**-0.03**	**-0.10**	**0.28**
Forb Length Leaf Litter	0.40	0.45	0.20	0.40	0.38	-0.17	0.41	-0.05	1.00	0.30	-0.26	0.30	0.38	-0.21	-0.35
Belt Shrub Height *Baccharis sarothroides*	0.46	0.37	0.32	0.10	0.08	-0.09	0.10	-0.05	0.30	1.00	-0.10	0.95	0.08	-0.43	-0.13
Gap Length	**-0.33**	**-0.33**	**-0.12**	**-0.30**	**-0.29**	**0.02**	**-0.29**	**0.07**	**-0.26**	**-0.10**	**1.00**	**-0.11**	**-0.29**	**0.00**	**0.02**
Shrub height *Baccharis sarothroides*	**0.45**	**0.42**	**0.32**	**0.12**	**0.10**	**-0.10**	**0.13**	**-0.05**	**0.30**	**0.95**	**-0.11**	**1.00**	**0.11**	**-0.42**	**-0.14**
Belt shrub cover *Salvia mellifera*	0.28	0.29	0.24	0.93	0.99	-0.03	0.94	-0.03	0.38	0.08	-0.29	0.11	1.00	-0.35	-0.13
Gap Count	**-0.24**	**-0.30**	**-0.15**	**-0.17**	**-0.13**	**0.11**	**-0.17**	**0.28**	**-0.35**	**-0.13**	**0.02**	**-0.14**	**-0.13**	**0.06**	**1.00**
Belt Shrub Height Primary Other	0.18	0.16	0.02	0.10	0.09	-0.08	0.10	0.26	0.13	0.04	-0.15	0.03	0.09	-0.03	0.00
Shrub length *Lotus scoparius*	-0.13	-0.14	-0.10	-0.04	-0.03	0.04	-0.05	0.98	-0.04	-0.05	0.08	-0.05	-0.04	-0.11	0.28
Belt Shrub Cover *Baccharis sarathroides*	0.38	0.32	0.31	0.10	0.09	-0.09	0.10	-0.03	0.32	0.96	-0.05	0.93	0.09	-0.45	-0.09
Shrub Length *Baccharis sarathroides*	0.40	0.36	0.30	0.08	0.06	-0.09	0.09	-0.05	0.28	0.95	-0.07	0.98	0.07	-0.41	-0.14
Shrub Height Deadwood	**0.27**	**0.30**	**0.44**	**0.22**	**0.20**	**-0.01**	**0.21**	**-0.09**	**0.17**	**0.26**	**-0.13**	**0.27**	**0.19**	**-0.19**	**-0.17**
Shrub Length Primary CSS	0.46	0.49	0.09	0.23	0.20	-0.09	0.24	-0.11	0.52	0.27	-0.52	0.28	0.20	-0.03	-0.27
Belt Shrub Height *Lotus scoparius*	-0.18	-0.18	-0.11	-0.05	-0.04	0.04	-0.06	0.78	-0.09	-0.12	0.09	-0.13	-0.04	-0.07	0.27
Shrub Length Other	0.10	0.09	-0.04	0.07	0.10	-0.03	0.07	0.49	0.13	0.04	-0.13	0.04	0.10	-0.09	0.16
Belt Shrub Cover Primary Other	0.06	0.03	0.02	0.17	0.21	-0.07	0.16	0.42	0.12	0.07	-0.07	0.04	0.20	-0.25	0.20
Distance to Flight Line Center Point	**-0.17**	**-0.15**	**-0.26**	**-0.37**	**-0.37**	**0.01**	**-0.37**	**-0.04**	**-0.28**	**-0.48**	**-0.04**	**-0.46**	**-0.38**	**0.78**	**0.10**
Shrub Height Secondary Chaparral	**0.14**	**0.16**	**0.13**	**0.18**	**0.16**	**0.01**	**0.18**	**-0.03**	**0.07**	**0.14**	**-0.13**	**0.12**	**0.14**	**-0.06**	**-0.08**
Distance to Rotary-Wing Flight Procedures	**-0.15**	**-0.15**	**-0.28**	**-0.36**	**-0.37**	**0.00**	**-0.36**	**-0.06**	**-0.31**	**-0.47**	**-0.01**	**-0.47**	**-0.37**	**0.84**	**0.11**
October PHDI, (hydrology index)	-0.02	0.02	0.00	0.00	-0.02	-0.14	0.00	-0.03	-0.15	-0.06	0.06	-0.03	-0.01	-0.03	-0.04
November PHDI	-0.02	0.02	0.00	0.00	-0.02	-0.14	0.00	-0.03	-0.15	-0.06	0.06	-0.03	-0.01	-0.03	-0.04
Fall PHDI	**-0.02**	**0.02**	**0.00**	**0.00**	**-0.02**	**-0.14**	**0.00**	**-0.03**	**-0.15**	**-0.06**	**0.06**	**-0.03**	**-0.01**	**-0.03**	**-0.04**
December PHDI	-0.02	0.02	0.00	0.00	-0.02	-0.14	0.00	-0.03	-0.15	-0.06	0.06	-0.03	-0.01	-0.03	-0.04
Height Non-native Forbs	0.23	0.23	0.18	-0.04	-0.07	-0.05	-0.03	-0.18	0.11	0.39	0.04	0.39	-0.06	-0.04	-0.18
September PHDI	-0.02	0.02	0.00	0.00	-0.02	-0.14	0.00	-0.03	-0.15	-0.06	0.06	-0.03	-0.01	-0.03	-0.04
August PHDI	-0.02	0.02	0.00	0.00	-0.02	-0.14	0.00	-0.03	-0.15	-0.06	0.06	-0.03	-0.01	-0.03	-0.04
July PHDI	-0.04	-0.07	-0.06	0.01	0.02	-0.10	0.02	0.02	-0.11	-0.12	-0.06	-0.10	0.03	-0.02	-0.02
June PHDI	-0.04	-0.07	-0.06	0.01	0.02	-0.10	0.02	0.02	-0.11	-0.12	-0.06	-0.10	0.03	-0.02	-0.02
Belt Shrub Cover Deadwood	0.04	0.06	0.36	0.11	0.14	0.13	0.11	0.14	0.13	0.15	-0.07	0.15	0.15	-0.24	0.19

Table 7 (Continued)

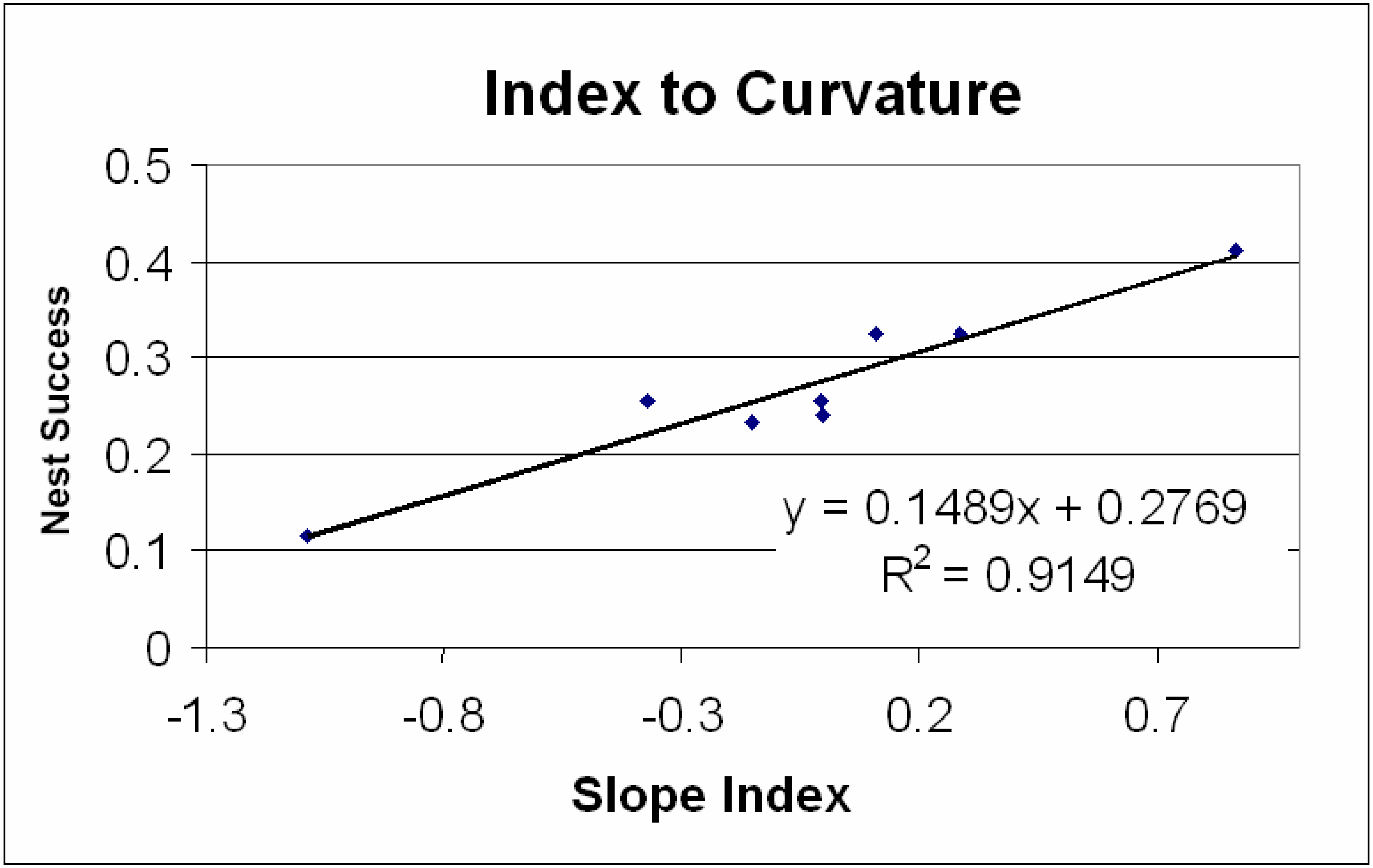
Spearman Rank Correlation Coefficients Among Statistically Significant (p<0.10) Predictors of Nesting Success
Pairs of Predictors With Correlation Coefficients Greater Than 0.4 Were Not Included in Multiple Variable Models

Variable	Belt Shrub Height Primary Other	Shrub Length *Lotus scoparius*	Belt Shrub Cover *Baccharis sarothroides*	Shrub Length *Baccharis sarothroides*	Shrub Height Deadwood	Shrub Length Primary CSS	Belt Shrub Height *Lotus scoparius*	Shrub Length Primary Other	Belt Shrub Cover Primary Other	Distance to Flight Line Center Point	Shrub Height Secondary Chaparral	Distance to Rotary-Wing Flight Procedures
Belt Shrub Height Primary CSS	0.18	-0.13	0.38	0.40	0.27	0.46	-0.18	0.10	0.06	-0.17	0.14	-0.15
Shrub Height Primary CSS	0.16	-0.14	0.32	0.36	0.30	0.49	-0.18	0.09	0.03	-0.15	0.16	-0.15
Belt Shrub Height Deadwood	**0.02**	**-0.10**	**0.31**	**0.30**	**0.44**	**0.09**	**-0.11**	**-0.04**	**0.02**	**-0.26**	**0.13**	**-0.28**
Shrub Height *Salvia mellifera*	**0.10**	**-0.04**	**0.10**	**0.08**	**0.22**	**0.23**	**-0.05**	**0.07**	**0.17**	**-0.37**	**0.18**	**-0.36**
Belt Shrub Height *Salvia mellifera*	0.09	-0.03	0.09	0.06	0.20	0.20	-0.04	0.10	0.21	-0.37	0.16	-0.37
Curvature	**-0.08**	**0.04**	**-0.09**	**-0.09**	**-0.01**	**-0.09**	**0.04**	**-0.03**	**-0.07**	**0.01**	**0.01**	**0.00**
Shrub Length *Salvia mellifera*	0.10	-0.05	0.10	0.09	0.21	0.24	-0.06	0.07	0.16	-0.37	0.18	-0.36
Shrub Height *Lotus scoparis*	**0.26**	**0.98**	**-0.03**	**-0.05**	**-0.09**	**-0.11**	**0.78**	**0.49**	**0.42**	**-0.04**	**-0.03**	**-0.06**
Forb Length Leaf Litter	0.13	-0.04	0.32	0.28	0.17	0.52	-0.09	0.13	0.12	-0.28	0.07	-0.31
Belt Shrub Height *Baccharis sarothroides*	0.04	-0.05	0.96	0.95	0.26	0.27	-0.12	0.04	0.07	-0.48	0.14	-0.47
Gap Length	**-0.15**	**0.08**	**-0.05**	**-0.07**	**-0.13**	**-0.52**	**0.09**	**-0.13**	**-0.07**	**-0.04**	**-0.13**	**-0.01**
Shrub Height *Baccharis sarothroides*	**0.03**	**-0.05**	**0.93**	**0.98**	**0.27**	**0.28**	**-0.13**	**0.04**	**0.04**	**-0.46**	**0.12**	**-0.47**
Belt Shrub Cover *Salvia mellifera*	0.09	-0.04	0.09	0.07	0.19	0.20	-0.04	0.10	0.20	-0.38	0.14	-0.37
Gap Count	**0.00**	**0.28**	**-0.09**	**-0.14**	**-0.17**	**-0.27**	**0.27**	**0.16**	**0.20**	**0.10**	**-0.08**	**0.11**
Belt Shrub Height Primary Other	1.00	0.25	0.03	0.02	0.05	0.12	0.35	0.62	0.62	0.05	0.13	0.03
Shrub Length *Lotus scoparius*	0.25	1.00	-0.02	-0.05	-0.10	-0.11	0.78	0.52	0.44	-0.05	-0.04	-0.07
Belt Shrub Cover *Baccharis sarothroides*	0.03	-0.02	1.00	0.94	0.25	0.23	-0.09	0.06	0.09	-0.51	0.13	-0.51
Shrub Length *Baccharis sarothroides*	0.02	-0.05	0.94	1.00	0.25	0.25	-0.12	0.04	0.04	-0.45	0.11	-0.45
Shrub Height Deadwood	**0.05**	**-0.10**	**0.25**	**0.25**	**1.00**	**-0.03**	**-0.12**	**-0.03**	**0.05**	**-0.24**	**0.12**	**-0.25**
Shrub Length Primary CSS	0.12	-0.11	0.23	0.25	-0.03	1.00	-0.17	0.06	-0.05	0.00	0.00	-0.03
Belt Shrub Height *Lotus scoparius*	0.35	0.78	-0.09	-0.12	-0.12	-0.17	1.00	0.37	0.48	-0.03	0.00	-0.05
Shrub Length Primary Other	0.62	0.52	0.06	0.04	-0.03	0.06	0.37	1.00	0.63	-0.03	0.03	-0.06
Belt Shrub Cover Primary Other	0.62	0.44	0.09	0.04	0.05	-0.05	0.48	0.63	1.00	-0.27	0.07	-0.26
Distance to Flight Line Center Point	**0.05**	**-0.05**	**-0.51**	**-0.45**	**-0.24**	**0.00**	**-0.03**	**-0.03**	**-0.27**	**1.00**	**-0.12**	**0.94**
Shrub Height Secondary Chaparral	**0.13**	**-0.04**	**0.13**	**0.11**	**0.12**	**0.00**	**0.00**	**0.03**	**0.07**	**-0.12**	**1.00**	**-0.09**
Distance to Rotary-Wing Flight Procedures	**0.03**	**-0.07**	**-0.51**	**-0.45**	**-0.25**	**-0.03**	**-0.05**	**-0.06**	**-0.26**	**0.94**	**-0.09**	**1.00**
October PHDI	-0.11	-0.03	-0.07	-0.04	-0.07	-0.04	-0.11	-0.05	-0.18	0.08	0.00	0.09
November PHDI	-0.11	-0.03	-0.07	-0.04	-0.07	-0.04	-0.11	-0.05	-0.18	0.08	0.00	0.09
Fall PHDI	**-0.11**	**-0.03**	**-0.07**	**-0.04**	**-0.07**	**-0.04**	**-0.11**	**-0.05**	**-0.18**	**0.08**	**0.00**	**0.09**
December PHDI	-0.11	-0.03	-0.07	-0.04	-0.07	-0.04	-0.11	-0.05	-0.18	0.08	0.00	0.09
Forb Height Non-native	-0.14	-0.18	0.36	0.42	0.12	0.20	-0.24	-0.17	-0.20	-0.13	0.03	-0.12
September PHDI	-0.11	-0.03	-0.07	-0.04	-0.07	-0.04	-0.11	-0.05	-0.18	0.08	0.00	0.09
August PHDI	-0.11	-0.03	-0.07	-0.04	-0.07	-0.04	-0.11	-0.05	-0.18	0.08	0.00	0.09
July PHDI	-0.08	0.01	-0.13	-0.10	-0.17	0.01	-0.04	-0.04	-0.15	0.10	0.01	0.10
June PHDI	-0.08	0.01	-0.13	-0.10	-0.17	0.01	-0.04	-0.04	-0.15	0.10	0.01	0.10
Belt Shrub Cover Deadwood	0.06	0.15	0.16	0.13	0.20	-0.02	0.21	0.10	0.25	-0.29	0.00	-0.30

Table 7 (Continued)

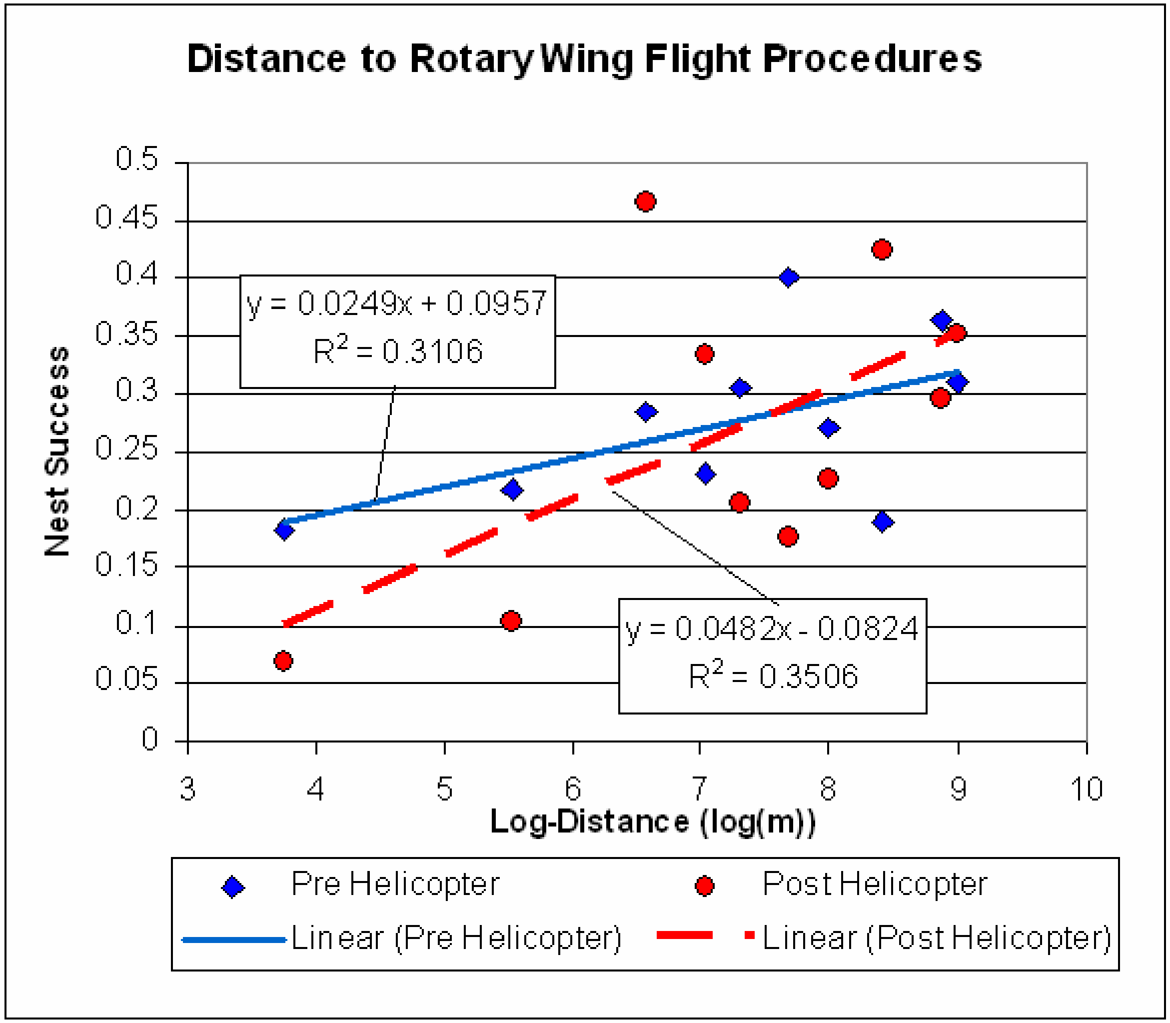
Spearman Rank Correlation Coefficients Among Statistically Signifficant (p<0.10) Predictors of Nesting Success
Pairs of Predictors With Correlation Coefficients Greater Than 0.4 Were Not Included in Multiple Variable Models

Variable	**October PHDI**	**November PDHI**	**Fall PHDI**	**December PHDI**	**Forb Height Non-native**	**September PHDI**	**August PHDI**	**July PHDI**	**June PHDI**	**Belt Shrub Cover Deadwood**
Belt Shrub Height Primary CSS	-0.02	-0.02	-0.02	-0.02	0.23	-0.02	-0.02	-0.04	-0.04	0.04
Shrub Height Primary CSS	0.02	0.02	0.02	0.02	0.23	0.02	0.02	-0.07	-0.07	0.06
Belt Shrub Deadwood	**0.00**	**0.00**	**0.00**	**0.00**	**0.18**	**0.00**	**0.00**	**-0.06**	**-0.06**	**0.36**
Shrub Height *Salvia mellifera*	**0.00**	**0.00**	**0.00**	**0.00**	**-0.04**	**0.00**	**0.00**	**0.01**	**0.01**	**0.11**
Belt Shrub Height *Salvia mellifera*	-0.02	-0.02	-0.02	-0.02	-0.07	-0.02	-0.02	0.02	0.02	0.14
Curvature	**-0.14**	**-0.14**	**-0.14**	**-0.14**	**-0.05**	**-0.14**	**-0.14**	**-0.10**	**-0.10**	**0.13**
Shrub Length *Salvia mellifera*	0.00	0.00	0.00	0.00	-0.03	0.00	0.00	0.02	0.02	0.11
Shrub Height *Lotus scoparius*	**-0.03**	**-0.03**	**-0.03**	**-0.03**	**-0.18**	**-0.03**	**-0.03**	**0.02**	**0.02**	**0.14**
Forb Length Leaf Litter	-0.15	-0.15	-0.15	-0.15	0.11	-0.15	-0.15	-0.11	-0.11	0.13
Belt Shrub Height *Baccharis sarothroides*	-0.06	-0.06	-0.06	-0.06	0.39	-0.06	-0.06	-0.12	-0.12	0.15
Gap Length	**0.06**	**0.06**	**0.06**	**0.06**	**0.04**	**0.06**	**0.06**	**-0.06**	**-0.06**	**-0.07**
Shrub Height *Baccharis sarothroides*	**-0.03**	**-0.03**	**-0.03**	**-0.03**	**0.39**	**-0.03**	**-0.03**	**-0.10**	**-0.10**	**0.15**
Belt Shrub Cover *Salvia mellifera*	-0.01	-0.01	-0.01	-0.01	-0.06	-0.01	-0.01	0.03	0.03	0.15
Gap Count	**-0.04**	**-0.04**	**-0.04**	**-0.04**	**-0.18**	**-0.04**	**-0.04**	**-0.02**	**-0.02**	**0.19**
Belt Shrub Height Primary Other	-0.11	-0.11	-0.11	-0.11	-0.14	-0.11	-0.11	-0.08	-0.08	0.06
Shrub Length *Lotus scoparius*	-0.03	-0.03	-0.03	-0.03	-0.18	-0.03	-0.03	0.01	0.01	0.15
Belt Shrub Cover *Baccharis sarothroides*	-0.07	-0.07	-0.07	-0.07	0.36	-0.07	-0.07	-0.13	-0.13	0.16
Shrub Length *Baccharis sarothroides*	-0.04	-0.04	-0.04	-0.04	0.42	-0.04	-0.04	-0.10	-0.10	0.13
Shrub Height Deadwood	**-0.07**	**-0.07**	**-0.07**	**-0.07**	**0.12**	**-0.07**	**-0.07**	**-0.17**	**-0.17**	**0.20**
Shrub Height Deadwood	-0.07	-0.07	-0.07	-0.07	0.12	-0.07	-0.07	-0.17	-0.17	0.20
Shrub Length Primary CSS	-0.04	-0.04	-0.04	-0.04	0.20	-0.04	-0.04	0.01	0.01	-0.02
Belt Shrub Height *Lotus scoparius*	-0.11	-0.11	-0.11	-0.11	-0.24	-0.11	-0.11	-0.04	-0.04	0.21
Shrub Length Primary Other	-0.05	-0.05	-0.05	-0.05	-0.17	-0.05	-0.05	-0.04	-0.04	0.10
Belt Shrub Cover Primary Other	-0.18	-0.18	-0.18	-0.18	-0.20	-0.18	-0.18	-0.15	-0.15	0.25
Distance to Flight Line Center Point	**0.08**	**0.08**	**0.08**	**0.08**	**-0.13**	**0.08**	**0.08**	**0.10**	**0.10**	**-0.29**
Shrub Height Secondary Chaparral	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**	**0.01**	**0.01**	**0.00**
Distance to Rotary-Wing Flight Procedures	**0.09**	**0.09**	**0.09**	**0.09**	**-0.12**	**0.09**	**0.09**	**0.10**	**0.10**	**-0.30**
October PHDI	1.00	1.00	1.00	1.00	0.04	1.00	1.00	0.77	0.77	-0.28
November PHDI	1.00	1.00	1.00	1.00	0.04	1.00	1.00	0.77	0.77	-0.28
Fall PHDI	**1.00**	**1.00**	**1.00**	**1.00**	**0.04**	**1.00**	**1.00**	**0.77**	**0.77**	**-0.28**
December PHDI	1.00	1.00	1.00	1.00	0.04	1.00	1.00	0.77	0.77	-0.28
Forb Height Non-native	0.04	0.04	0.04	0.04	1.00	0.04	0.04	0.08	0.08	-0.02
September PHDI	1.00	1.00	1.00	1.00	0.04	1.00	1.00	0.77	0.77	-0.28
August PHDI	1.00	1.00	1.00	1.00	0.04	1.00	1.00	0.77	0.77	-0.28
July PDHI	0.77	0.77	0.77	0.77	0.08	0.77	0.77	1.00	1.00	-0.25
June PDHI	0.77	0.77	0.77	0.77	0.08	0.77	0.77	1.00	1.00	-0.25
Belt Shrub Cover Deadwood	-0.28	-0.28	-0.28	-0.28	-0.02	-0.28	-0.28	-0.25	-0.25	1.00



Index to Curvature

Figure 25



Distance to Rotary Wing Flight Procedures

Figure 26

post-realignment data. Graphically it can be seen that the fitted lines are qualitatively similar. We tested for these effects statistically by looking for significant differences in intercepts for pre vs. post-realignment, or a significant interaction between Pre/Post realignment and distance to helicopter flight tracks (Figure 27 and Figure 28) in the following model:

$$\text{logit}(p) = \beta_0 + \beta_1(\text{Pre/Post}) + \beta_2 \times \log(\text{Distance}) + \beta_3 \times \left(Log(\text{Distance}) \times (\text{Pre/Post})\right)$$

Because this study was intended to test the helicopter noise effects due to Station realignment, the difference in effects due to distance from rotary-wing flight procedures, before and after Station realignment was tested. The effect of distance from rotary-wing flight procedures was similar before and after the addition of helicopters (N=760, p=0.26; See Figure 26).

3.4.1.4 Soil Moisture/Climate Patterns

The Palmer Hydrologic Drought Index (PHDI) and the Palmer Drought Severity Index (PDSI) are two models to measure the drought conditions based on several climate factors. The PDSI is a rather short term index of the severity of drought conditions, and the PHDI is a model of a value computed as a function of both meteorological and hydrologic data to measure soil moisture conditions at a regional scale. PHDI is the value (index) generated monthly that indicates the hydrological implications of a wet or dry spell. This index is based on the principles of a balance between moisture supply and demand. Man-made changes such as increased irrigation, new reservoirs, and added industrial water use were not included in the computation of this index. The index generally ranges from - 6 to +6, with negative values denoting dry spells, and positive values indicating wet spells. There are a few values in the magnitude of +7 or -7. PHDI values 0 to -0.5 = normal; -0.5 to -1.0 = incipient drought; -1.0 to - 2.0 = mild drought; -2.0 to -3.0 = moderate drought; -3.0 to -4.0 = severe drought; and greater than -4.0 = extreme drought. Similar adjectives are attached to positive values of wet spells. This is a hydrological drought index used to assess long-term moisture supply and the one that is used extensively in this study to determine the relationship between weather conditions and reproductive success of the gnatcatchers. The supply-and-demand concept of the water balance equation, takes into account more than just the precipitation deficit at specific locations. The objective of the PHDI is to provide measurements of

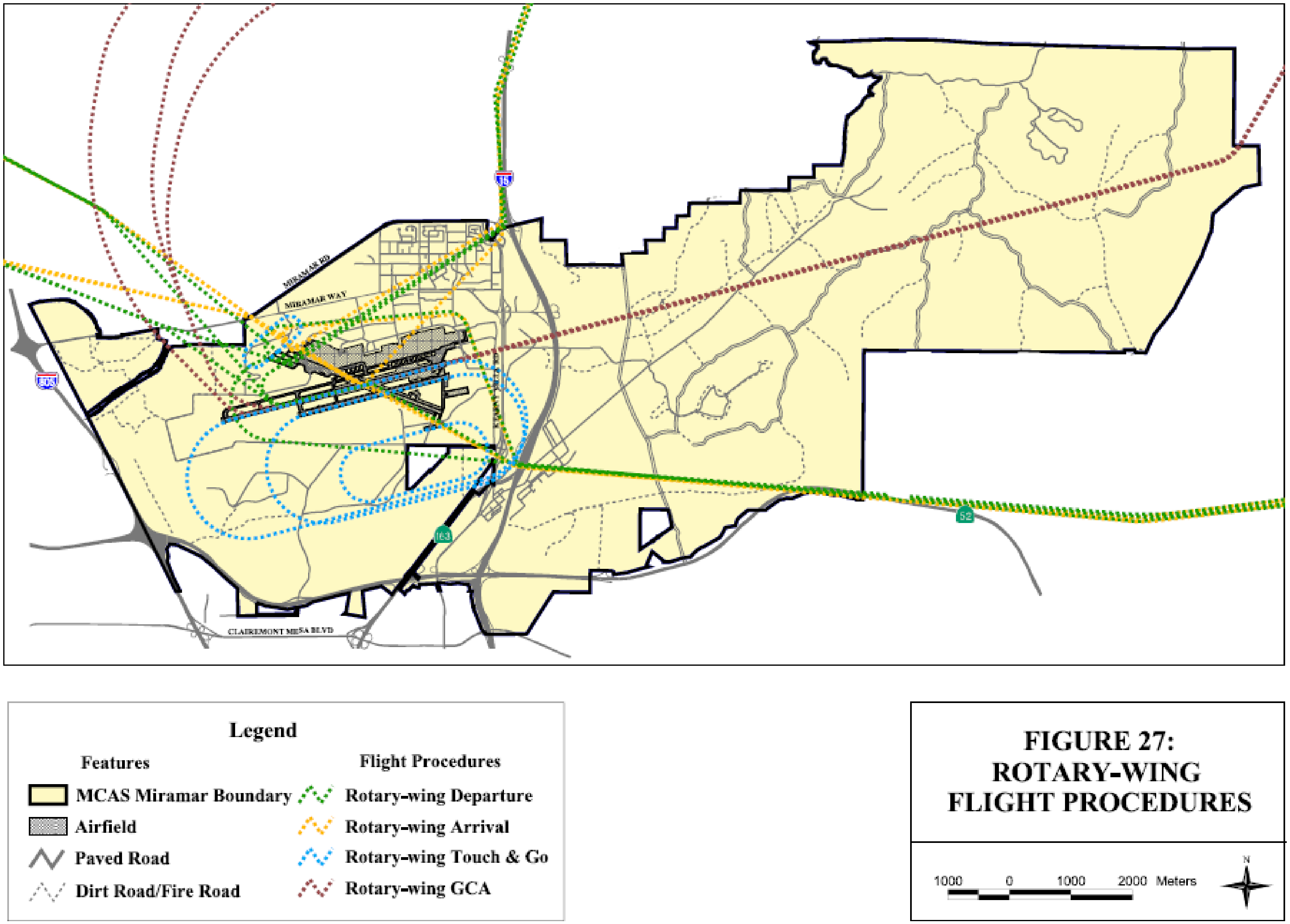


FIGURE 27: ROTARY-WING FLIGHT PROCEDURES

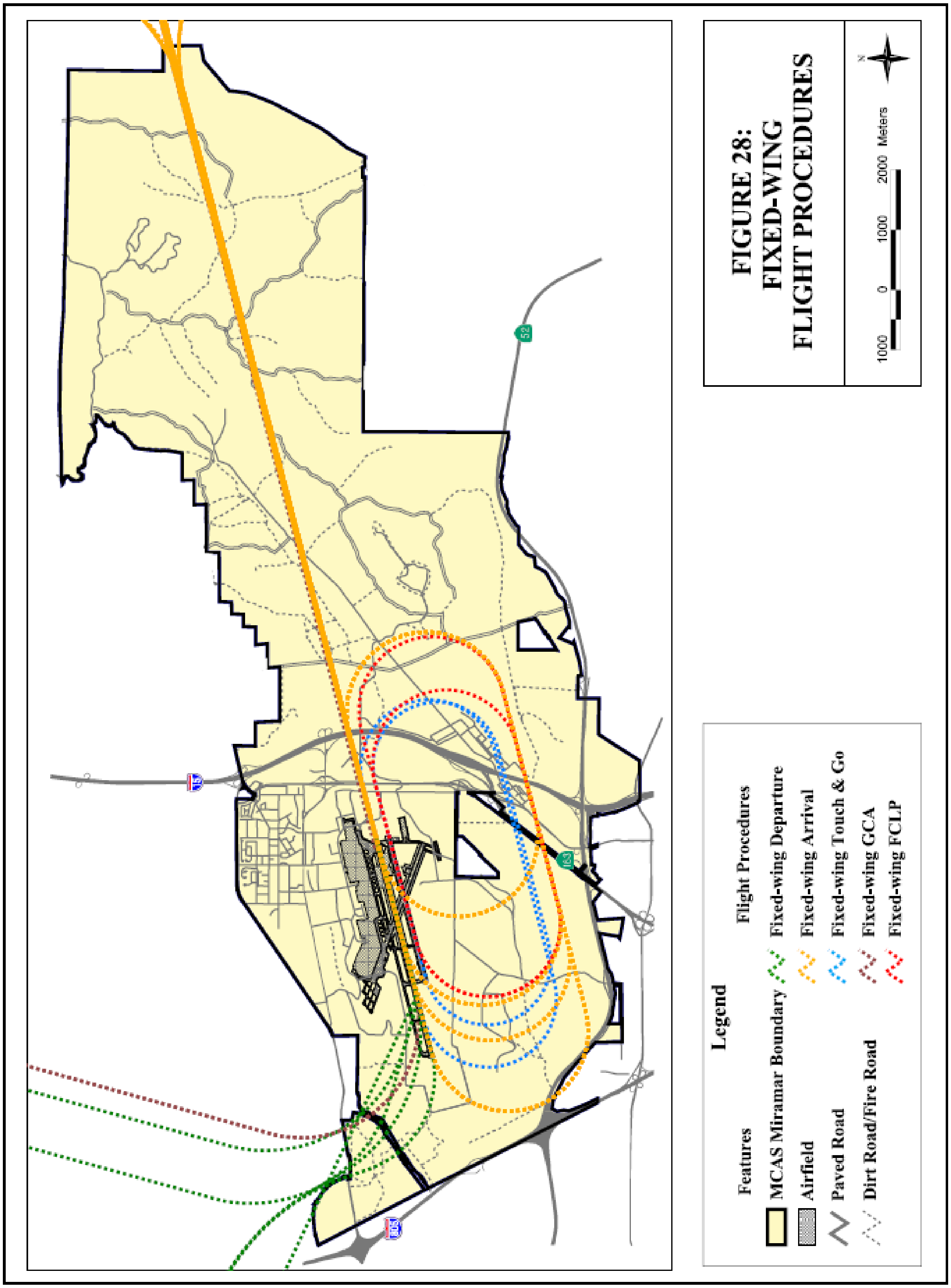


FIGURE 28:
FIXED-WING
FLIGHT PROCEDURES
1000
0
1000
2000
Meters
N
Legend
Features
MCAS Miramar Boundary
Airfield
Paved Road
Dirt Road/Fire Road
Flight Procedures
Fixed-wing Departure
Fixed-wing Arrival
Fixed-wing Touch & Go
Fixed-wing GCA
Fixed-wing FCLP
15
52
163
805

moisture conditions that are standardized so that comparisons using the index could be made between locations and months. The PDSI measures climatic conditions that can change rapidly, so it was not used in these calculations, only the PHDI, which we consider as a much better indicator of moisture conditions during seasonal periods of breeding and reproductive success of the target species, was used in our analysis and testing.

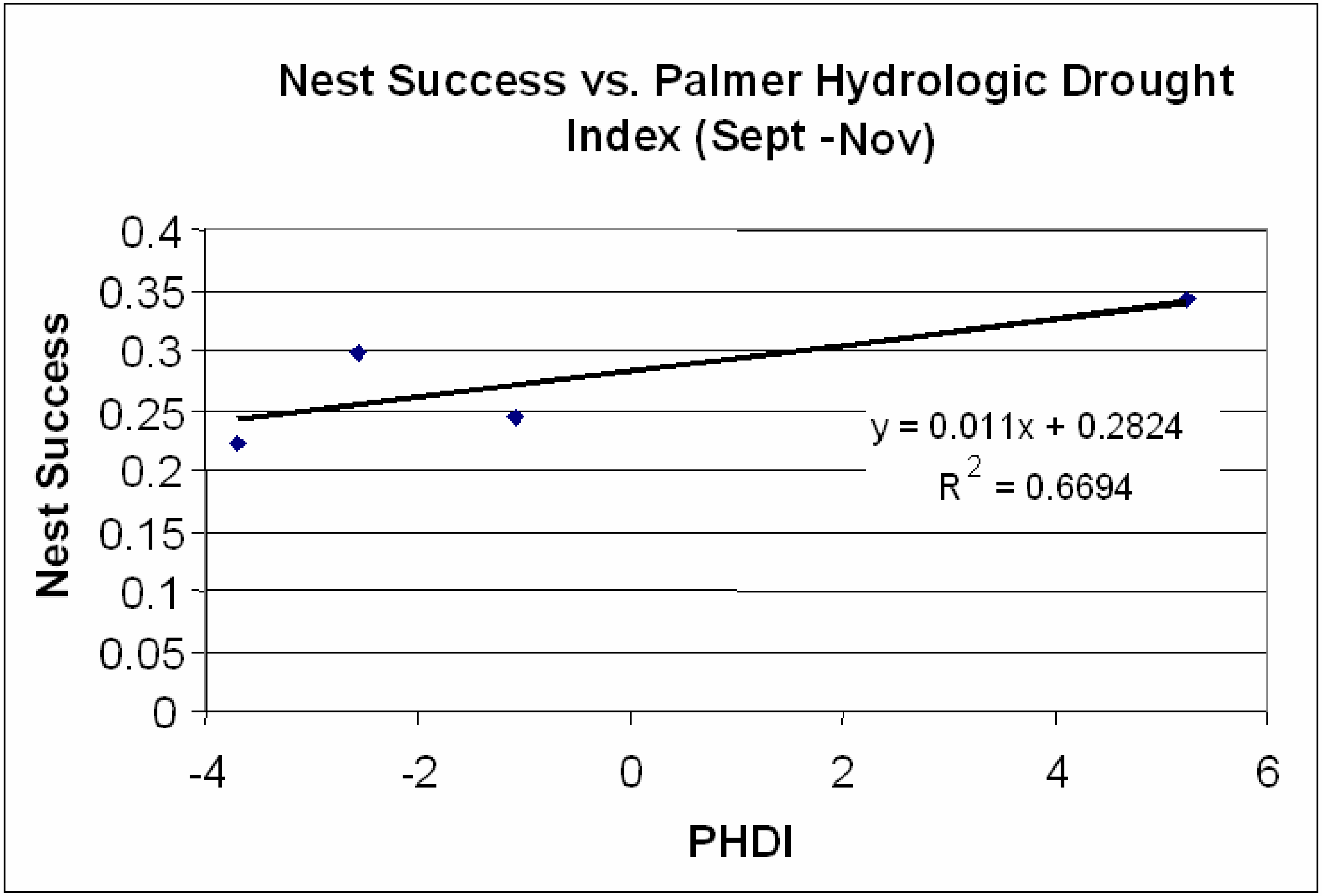
We tested for association between nesting success and the PHDI for each of the 12 months preceding the breeding season. We found that nesting success was positively associated with the PHDI for most fall months. We therefore averaged the PHDI over the months of September through November resulting in a fall season PHDI and found that nesting success was positively associated with this fall PHDI (See Figure 29, p=0.069). Because the PHDI is a regional index, it explains only temporal fluctuations in nesting success as opposed to spatial variation within the study area.

3.4.1.5 Disturbance Factors, Predator Counts and Aircraft Overflights

While nests were monitored for reproductive status of breeding pairs, the occurrence of miscellaneous events such as presence of predators, human disturbance factors and aircraft overflights were noted. These data were summarized into event counts of each type per unit time monitored, and tested for association with nesting success using logistic regression. None of these factors were found to be statistically significant and therefore were not included in the multiple regression models.

3.4.1.6 Multiple Variable Models

There were 40 factors associated with nesting success when tested at the 10% level of statistical significance (See Table 6). This set of factors was reduced to a total of 12 that were uncorrelated (r < 0.4) with other factors. When pairs of factors were correlated, the more interpretable factors were retained for modeling. The resulting set of factors considered for multiple variable modeling included: height of dead shrubs, count of dead shrubs, height of chaparral shrubs, height of *Salvia mellifera*, index to topographic curvature, height of *Lotus scoparius*, percent cover by leaf litter, length of



Nest Success vs. Palmer Hydrologic Drought Index (Sept-Nov)

Figure 29

gaps in shrub cover, number of gaps in shrub cover, PHDI, non-native forb height and height of *Baccharis sarothroides*. These factors were included in a multiple variable logistic regression analysis of nesting success. Best subsets regression was used to search for the subsets of factors that minimized that AIC criterion (Akaike, 1973). Model fit was also evaluated using the Hosmer and Lemeshow goodness of fit test (Hosmer and Lemeshow, 1989). All possible combinations of the 12 factors were tested and a set of 20 models (Table 8) were found to provide similar balance between model complexity and model fit. Nearly all models included height of each of the three species of coastal sage scrub (*Salvia mellifera, Lotus scoparius and Baccharis sarothroides*) as significant predictors of nesting success. Additionally, the index to curvature, gap length and fall PHDI were also included in nearly all models. Inclusion of additional factors did not improve model fit and increased AIC values. Inclusion of additional factors would be justified if the AIC were reduced substantially. A common rule of thumb for judging model improvement is a change of 3 AIC points for each additional variable included in a model.

The resulting model coefficients, tests and model diagnostics are summarized in Table 9 for the three best candidate models. Noise metrics and distance from rotary-wing flight procedures, fixed wing flight tracks and center line of the runways and helipads were also tested for association with nesting success after adjustment for the vegetation, physical and hydrologic metrics. As with the univariate analyses, the noise metrics were not associated with nesting success after adjusting for covariation with other potentially confounding factors.

In the basic model, distance to rotary-wing flight procedures was found to be correlated with height of *Baccharis sarothroides* (See Table 7). Therefore multiple logistic regression models that included *Baccharis sarothroides* height and distance to rotary-wing flight procedures, as reflected in the basic model (Model 1), could be subject to potential model sensitivity due to the effects of multi-collinearity (Neter, et al. 1996). To evaluate the significance of distance to rotary-wing flight procedures, two additional models were tested. Model 2 included the six factors discussed above (i.e. the three coastal sage scrub species, PHDI e.g. hydrological conditions, Curvature and gap length) plus distance to rotary-wing flight procedures; and similar Model 3, with two coastal sage species, excluding *Baccharis sarothroides* height, were developed. Model 2, evaluated the effect of distance to rotary-wing

Table 8 Variables Included in Best Multiple Variable Nest Success Models

AIC	Nest Success Predictors	ChiSq	DF	Significance
458 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Dead Shrub Height, Curvature, Gap Length, Fall PHDI, Non-native forb height	36.9	8	<.0001
458 Shrub Height	*Salvia melifera, Lotus scoparius* , Curvature, FallHdi, Non-native forb height	32.4	5	<.0001
458 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius,* Forb Layer LeafLitter, Gap Length, Gap Count, Fall PHDI	36.6	8	<.0001
458 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Curvature, Leaf litter, Gap Length, FallHdi Non-native forb height	36.7	8	<.0001
458 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Dead shrub height, Curvature, Fall PHDI	33.8	6	<.0001
459 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius,* Curvature, Leaf litter, Gap Length, Gap Count, Fall PHDI, Non-native forb height	37.7	9	<.0001
459 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius,* Dead shrub	37.8	9	<.0001
456 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Curvature, Gap Length, Fall PHDI	35.2	6	<.0001
456 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* ,Curvature Gap Length Gap Count Fall PHDI	36.5	7	<.0001
456 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Curvature GapLength FallHdi Forb Height Non_native	36.7	7	<.0001
456 Shrub Height	*Salvia mellifera, Lotus scoparius* , Curvature Gap Length, Non-native forb height	35.2	6	<.0001
456 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Curvature, Gap Length, Fall PHDI	33.4	5	<.0001
457 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Curvature, Gap Count, Fall PHDI	34.6	6	<.0001
457 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Curvature Gap Length Gap Count Fall PHDI, Non-native forb height	37.6	8	<.0001
457 Shrub Height	*Salvia mellifera, Lotus scoparius* , Curvature, Gap Length, Gap Count, Fall PHDI, Non-native forb height	36.2	7	<.0001
457 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius,* Curvature Fall PHDI, Non-native forb height	34.5	6	<.0001
458 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius* , Dead Shrub Height, Curvature, Gap Length, Fall PHDI	35.5	7	<.0001
458 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius,* Dead Shrub Height, Curvature, GapLength, Fall PDHI, Non-native forb height	35.7	7	<.0001
458 Shrub Height	*Baccharis sarothroides, Salvia mellifera, Lotus scoparius,* Dead Shrub Height, Curvature, Gap Length, Gap Count, Fall PHDI	36.7	8	<.0001
458 Shrub Height	*Salvia mellifera, Lotus scoparius* , Curvature, Gap Length, Fall PHDI	32.1	5	<.0001

Table 9

Final Models for CAGN Nest Success at MCAS Miramar, 1998-2001

								Goodness of Fit			
	Variable	DF	Estimate	Standard Error	Chi Square	Significance	Standardized Coefficient	Chi Square	DF	Prob Chi Square	AIC
Model 1	Intercept	1	-1.2015	0.4316	7.7483	0.0054		8.56	8	0.381	456
	Salvia mellifera	1	-1.0137	0.3870	6.8622	0.0088	-0.2179				
	Curvature	1	0.7608	0.2581	8.6885	0.0032	0.2066				
	Lotus scoparius	1	1.9990	0.9062	4.8664	0.0274	0.1318				
	Gap Length	1	0.1205	0.0780	2.3849	0.1225	0.1045				
	Baccharis sarothroides	1	-0.5787	0.2589	4.9943	0.0254	-0.1583				
	Fall Hydrologic Drought Index	1	0.0829	0.0354	5.4860	0.0192	0.1472				
Model 2	Intercept	1	-3.1411	0.9273	11.4738	0.0007		4.90	8	0.768	452
	Salvia mellifera	1	-0.6409	0.4089	2.4572	0.1170	-0.1378				
	Curvature	1	0.7853	0.2541	9.6	0.002	0.2132				
	Lotus scoparius	1	2.0282	0.9089	5.0	0.026	0.1338				
	Gap Length	1	0.1653	0.0812	4.1	0.042	0.1434				
	Baccharis sarothroides	1	-0.3186	0.2785	1.3	0.253	-0.0871				
	Fall Hydrologic Drought Index	1	0.0823	0.0356	5.4	0.021	0.1461				
	Log(Distance to RW Track)	1	0.2151	0.0903	5.7	0.017	0.2046				
Model 3	Intercept	1	-3.6476	0.8260	19.5	<.0001		7.81	8	0.452	451
	Salvia mellifera	1	-0.5828	0.4052	2.1	0.150	-0.1253				
	Curvature	1	0.8119	0.2552	10.1	0.002	0.2205				
	Lotus scoparius	1	2.0422	0.9052	5.1	0.024	0.1347				
	Gap Length	1	0.1825	0.0801	5.2	0.023	0.1583				
	Fall Hydrologic Drought Index	1	0.0828	0.0355	5.4	0.020	0.1469				
	Log(Distance to RW Track)	1	0.2539	0.0846	9.0	0.003	0.2415				

flight procedures with *Baccharis sarothroides* height in the model. Results were compared using statistical significance of effect size, standardized coefficients (Neter et al. 1996), AIC model selection criterion and the Hosmer and Lemeshow goodness of fit test. Because of the potential for multicolinearity, these tests do not provide a purely inferential evaluation of the importance of distance to rotary-wing flight procedures; however through a weight of evidence approach, reasonable deductive conclusions can be drawn. After adjustment for variation in habitat, physical and hydrologic factors described above, nest success was not associated with distance to rotary-wing flight procedures (p=0.33; Table 9).

In Model 3, the distance to rotary-wing flight procedures replaced height of *Baccharis sarothroides*. It was found that without adjusting for *Baccharis*-height, nesting success was positively associated with distance to rotary-wing flight procedures (p=0.07; Table 9). However, this substitution resulted in an increased AIC criterion indicating a greater distance between the selected model and the true set of factors controlling nesting success. This suggests that the model including height of *Baccharis* was more parsimonious with the observed nest success data than the model that included distance to rotary-wing flight procedures.

3.4.2 Nest Site Selection Model

The objective of this study is to evaluate the extent to which helicopter noise affects nest site selection. The results of these logistic regression analyses are summarized in Table 10. Of the 293 variables tested, 124 were found to be associated with nest site selection at the 10% level of statistical significance. These variables were considered for development of multiple logistic regression models. An assumption of the model (Equation 1) is that the predictors, x_1, x_2,…., x_n are statistically independent. However, many of the 124 variables associated with nest site selection were also inter-correlated (multicollinear) so a subset of 35 uncorrelated (r < 0.4) variables were selected for inclusion in the multiple variable model. Best subsets regression was used to find the subset of these 35 variables that best predicted CAGN nest site selection. Best model fit was judged by the AIC (Akaike, 1973).

Table 10

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

Variable List	Estimate	Standard Error	Wald Chi Squared	Probability Chi Sq	Odds Ratio **Estimate**	Odds Ratio Lower 95% Limit	Odds Ratio Upper 95% Limit	Effect Size	
Elevation 30	-0.0353	0.00408	74.7842	<.0001	0.7026	0.6486	0.7611	10	ft
Distance to Class 2 Roads	-0.00078	0.000096	64.6936	<.0001	0.6771	0.6163	0.7438	500	m
Shrub Length Priamary CSS	0.6927	0.0911	57.7987	<.0001	1.9991	1.6722	2.3899	1	(m-Count)/(10 m)
Belt Shrub Height Primary CSS	2.8832	0.3894	54.82	<.0001	4.2275	2.8863	6.1917	0.5	m
Shrub Height Primary CSS	2.787	0.3958	49.5946	<.0001	4.0289	2.7336	5.9381	0.5	m
Belt Shrub Count Primary CSS	0.2878	0.045	40.9593	<.0001	1.3335	1.2209	1.4564	1	Shrubs
Distance to Rotary-Wing Flight Procedures	-0.00019	0.000035	29.3127	<.0001	0.9094	0.8787	0.9411	500	m
Shrub Height Chaparral	-2.1271	0.3936	29.1982	<.0001	0.3452	0.2347	0.5077	0.5	m
Shrub Height *Eriogonum fasciculatum*	2.9548	0.5533	28.5203	<.0001	4.3815	2.5476	7.5356	0.5	m
Shrub Length Secondary Chaparral	-1.5432	0.2896	28.385	<.0001	0.2137	0.1211	0.3770	1	(m-Count)/(10 m)
Slope Percent	-0.0613	0.0119	26.6119	<.0001	0.7360	0.6550	0.8271	5	%
Distance to Flight line center point	-0.00017	0.000034	25.9277	<.0001	0.9185	0.8884	0.9496	500	m
Belt Shrub Height *Eriogonum fasciculatum*	2.5159	0.4952	25.8138	<.0001	3.5182	2.1655	5.7159	0.5	m
Shrub Height *Ceanothus tomentosus*	-3.963	0.7842	25.5375	<.0001	0.1379	0.0639	0.2973	0.5	m
Belt Shrub Height Primary Chaparral	-1.1774	0.2349	25.1129	<.0001	0.5550	0.4409	0.6987	0.5	m
Forb Height Non-native	3.6859	0.7362	25.0703	<.0001	1.4457	1.2514	1.6701	0.1	m
Belt Shrub Height *Artemisia californica*	2.8307	0.5695	24.7062	<.0001	4.1179	2.3566	7.1955	0.5	m
Belt Shrub Height *Ceanothus tomentosus*	-4.0265	0.8107	24.6676	<.0001	0.1336	0.0603	0.2956	0.5	m
Shrub Height *Artemisia californica*	3.0685	0.6226	24.29	<.0001	4.6378	2.5196	8.5369	0.5	m
Belt Shrub Height Secondary Chaparral	-2.4773	0.5145	23.1826	<.0001	0.2898	0.1750	0.4798	0.5	m
Belt Shrub Count Primary Chaprarral	-0.2103	0.0438	23.0493	<.0001	0.8103	0.7437	0.8830	1	Shrubs
Shrub Height Primary Other	-2.4995	0.5359	21.7553	<.0001	0.2866	0.1695	0.4845	0.5	m
Shrub Height Primary Chaparral	-1.0905	0.2339	21.7448	<.0001	0.5797	0.4609	0.7290	0.5	m
Shrub Length Primary Other	-0.9755	0.2104	21.491	<.0001	0.3770	0.2496	0.5694	1	(m-Count)/(10 m)
Belt Shrub Count Secondary Chaparral	-2.9472	0.6377	21.3584	<.0001	0.0525	0.0150	0.1832	1	Shrubs
Belt Shrub Height Primary Other	-2.1294	0.4645	21.0154	<.0001	0.3448	0.2187	0.5436	0.5	m
Shrub Length *Artemisia californica*	1.4009	0.3118	20.1798	<.0001	4.0589	2.2029	7.4785	1	(m-Count)/(10 m)
Shrub Length *Baccharis sarathroides*	2.8807	0.6475	19.7903	<.0001	4.2222	2.2385	7.9638	0.5	m
Belt Shrub Height *Baccharis sarathroides*	2.4323	0.5534	19.316	<.0001	3.3742	1.9617	5.8036	0.5	m
Belt Shrub Count *Artemisia californica*	0.7697	0.1776	18.779	<.0001	2.1591	1.5244	3.0581	1	Shrubs
Shrub Length *Eriogonum fasciculatum*	0.6593	0.1533	18.4897	<.0001	1.9334	1.4317	2.6111	1	(m-Count)/(10 m)
Shrub Length Primary Chaparral	-0.3648	0.0853	18.2854	<.0001	0.6943	0.5874	0.8207	1	(m-Count)/(10 m)
Belt Shrub Count *Adenostoma fasciculatum*	-0.2001	0.0472	17.9479	<.0001	0.8186	0.7463	0.8980	1	Shrubs
Shrub Length *Lotus scoparius*	-1.5432	0.3661	17.7722	<.0001	0.2137	0.1043	0.4380	1	(m-Count)/(10 m)
Belt Shrub Height *Adenostoma fasciculatum*	-0.9913	0.2462	16.2103	<.0001	0.6092	0.4786	0.7754	0.5	m
Shrub Height *Adnostoma fasciculatum*	-0.9639	0.2452	15.4513	<.0001	0.6176	0.4857	0.7853	0.5	m
Shrub Height *Xylococcus bicolor*	-5.2509	1.3421	15.308	<.0001	0.0724	0.0194	0.2698	0.5	m

Table 10 (Continued)

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

					Odds Ratio				
Variable List	Estimate	StdErr	WaldChiSq	ProbChiSq	**Estimate**	Lower 95% Limit	Upper 95% Limit	Effect Size	
Belt Shrub Count *Lotus scoparius*	-0.2302	0.0591	15.1947	<.0001	0.7944	0.7075	0.8919	1	Shrubs
Belt Shrub Height *Mimulus aurantiacus*	-1.8864	0.4994	14.2691	0.0002	0.3894	0.2387	0.6352	0.5	m
Shrub Height *Mimulus aurantiacus*	-2.3489	0.6239	14.1741	0.0002	0.3090	0.1677	0.5695	0.5	m
Belt Shrub Height *Helianthemum scoparium*	-15.5859	4.1417	14.1614	0.0002	0.0004	0.0000	0.0239	0.5	m
Shrub Length *Ceanothus tomentosus*	-2.556	0.6795	14.151	0.0002	0.0776	0.0205	0.2940	1	(m-Count)/(10 m)
Belt Shrub Count Deadwood	-0.2399	0.0647	13.7591	0.0002	0.7867	0.6930	0.8931	1	Shrubs
Shrub Length *Baccharis sarathroides*	1.5129	0.4125	13.4513	0.0002	4.5399	2.0226	10.1899	1	(m-Count)/(10 m)
Belt Shrub Height *Xylococcus bicolor*	-11.2267	3.0623	13.4405	0.0002	0.0036	0.0002	0.0734	0.5	m
Average of L_5	0.0804	0.0222	13.1652	0.0003	1.2728	1.1170	1.4503	3	dB(A)
Shrub Height *Lotus scoparius*	-2.9324	0.8086	13.1521	0.0003	0.2308	0.1045	0.5098	0.5	m
Shrub Height *Helianthemum scoparium*	-16.8727	4.6852	12.9691	0.0003	0.0002	0.0000	0.0214	0.5	m
Belt Shrub Count *Mimulus aurantiacus*	-0.3961	0.1116	12.6016	0.0004	0.6729	0.5407	0.8375	1	Shrubs
Belt Shrub Height *Lotus scoparius*	-2.4828	0.7042	12.4308	0.0004	0.2890	0.1449	0.5762	0.5	m
Shrub Length *Adnostoma fasciculatum*	-0.3203	0.0939	11.6401	0.0006	0.7259	0.6039	0.8726	1	(m-Count)/(10 m)
Shrub Length *Xylococcus bicolor*	-5.3801	1.5965	11.356	0.0008	0.0046	0.0002	0.1053	1	(m-Count)/(10 m)
Belt Shrub Count *Xylococcus bicolor*	-8.7118	2.6036	11.1964	0.0008	0.0002	0.0000	0.0271	1	Shrubs
Belt Shrub Count *Baccharis sarathroides*	0.6591	0.1976	11.1209	0.0009	1.9331	1.3123	2.8474	1	Shrubs
Shrub Length *Mimulus aruantiacus*	-0.8648	0.2669	10.5016	0.0012	0.4211	0.2496	0.7106	1	(m-Count)/(10 m)
Belt Shrub Count *Eriogonum fasciculatum*	0.1853	0.0587	9.964	0.0016	1.2036	1.0728	1.3503	1	Shrubs
Belt Shrub Count *Ceanothus tomentosus*	-1.5333	0.4919	9.7157	0.0018	0.2158	0.0823	0.5660	1	Shrubs
Gap Length	-0.249	0.0799	9.7143	0.0018	0.7796	0.6666	0.9117	1	(m-Count)/(m)
Non-vegetated	-0.3221	0.1038	9.6266	0.0019	0.7246	0.5912	0.8881	1	(m-Count)/(m)
Shrub Length *Yucca whipplei*	-36.6935	11.8651	9.5639	0.002	0.0000	0.0000	0.0000	1	(m-Count)/(10 m)
Belt Shrub Count *Quercus dumosa*	-9.6445	3.1702	9.2553	0.0023	0.0001	0.0000	0.0324	1	Shrubs
Gap Count	-0.4057	0.1337	9.2155	0.0024	0.6665	0.5129	0.8662	1	Gaps
Shrub Length *Rhus integrifolia*	-1.5424	0.512	9.0734	0.0026	0.2139	0.0784	0.5834	1	(m-Count)/(10 m)
Belt Shrub Count Primary Other	-0.1071	0.0363	8.6939	0.0032	0.8984	0.8367	0.9647	1	Shrubs
Sine of aspect	0.7305	0.2517	8.4245	0.0037	1.4409	1.1259	1.8440	0.5	unitless
Shrub Height *Heteromeles arbutifolia*	-3.172	1.1063	8.2203	0.0041	0.2047	0.0692	0.6054	0.5	m
Shrub Height *Rhus integrifolia*	-1.8738	0.661	8.0358	0.0046	0.3918	0.2050	0.7489	0.5	m
Belt Shrub Count *Yucca whipplei*	-23.064	8.2401	7.8344	0.0051	0.0000	0.0000	0.0010	1	Shrubs
Shrub Height *Quercus berberidifolia*	-4.6356	1.7052	7.3904	0.0066	0.0985	0.0185	0.5238	0.5	m
Shrub Length *Quercus berberidifolia*	-3.1559	1.163	7.3638	0.0067	0.0426	0.0044	0.4163	1	(m-Count)/(10 m)
Length Non-native Forbs	0.25	0.0943	7.0299	0.008	1.2840	1.0673	1.5447	1	(m-Count)/(m)
Shrub Height *Quercus dumosa*	-4.3198	1.647	6.879	0.0087	0.1153	0.0230	0.5794	0.5	m
Belt Shrub Height *Yucca whipplei*	-40.1615	15.5215	6.695	0.0097	0.0000	0.0000	0.0077	0.5	m
Belt Shrub Height *Baccharis salicifolia*	-2.2419	0.8826	6.4516	0.0111	0.3260	0.1373	0.7741	0.5	m

Table 10 (Continued)

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

					Odds Ratio				
Variable List	Estimate	StdErr	WaldChiSq	ProbChiSq	**Estimate**	Lower 95% Limit	Upper 95% Limit	Effect Size	
Average of Percent > 80dBA	0.8739	0.3458	6.387	0.0115	2.3962	1.2167	4.7193	1	% Time
Shrub Height *Porophyllum gracile*	-38.655	15.3478	6.3434	0.0118	0.0000	0.0000	0.0138	0.5	m
Belt Shrub Height *Quercus dumosa*	-6.0749	2.5906	5.4988	0.019	0.0480	0.0038	0.6073	0.5	m
Shrub Length Deadwood	0.3652	0.1581	5.3336	0.0209	1.4408	1.0569	1.9642	1	(m-Count)/(10 m)
Shrub Length *Heteromeles arbutifolia*	-3.4375	1.4956	5.2826	0.0215	0.0321	0.0017	0.6028	1	(m-Count)/(10 m)
Shrub Height *Yucca whipplei*	-29.2339	12.7303	5.2735	0.0217	0.0000	0.0000	0.1175	0.5	m
Shrub Length *Helianthemum scoparium*	-2.1329	0.94	5.1482	0.0233	0.1185	0.0188	0.7479	1	(m-Count)/(10 m)
Average Total SELdBA	0.0308	0.0137	5.0764	0.0243	1.0968	1.0119	1.1888	3	dB(A)
Belt Shrub Count *Helianthemum scoparium*	-0.1475	0.0659	5.0047	0.0253	0.8629	0.7583	0.9818	1	Shrubs
Belt Shrub Height *Quercus berberidifolia*	-6.8368	3.0649	4.9759	0.0257	0.0328	0.0016	0.6605	0.5	m
Belt Shrub Count *Porophyllum gracile*	-7.7858	3.4988	4.9517	0.0261	0.0004	0.0000	0.3953	1	Shrubs
Shrub Length *Quercus dumosa*	-2.3803	1.0742	4.9101	0.0267	0.0925	0.0113	0.7597	1	(m-Count)/(10 m)
Distance to Class 2 Roads	-0.00009	0.000039	4.8372	0.0279	0.9560	0.9201	0.9932	500	m
Shrub Height *Toxicodendron diversilobum*	-4.4699	2.0331	4.8337	0.0279	0.1070	0.0146	0.7847	0.5	m
Average Total L_{eq}dba	0.0311	0.0142	4.7592	0.0291	1.0978	1.0099	1.1934	3	dB(A)
Cosine of Aspect	-0.3747	0.1726	4.714	0.0299	0.8292	0.7001	0.9820	0.5	unitless
Height of Native Forbs	1.5443	0.7236	4.5551	0.0328	1.1670	1.0127	1.3448	0.1	m
Belt Shrub Height *Porophyllum gracile*	-28.3786	13.4095	4.4787	0.0343	0.0000	0.0000	0.3506	0.5	m
Belt Shrub Count *Quercus berberidifolia*	-12.8204	6.063	4.4713	0.0345	0.0000	0.0000	0.3918	1	Shrubs
Belt Shrub Count Secondary CSS	-0.2366	0.1135	4.3433	0.0372	0.7893	0.6319	0.9860	1	Shrubs
Belt Shrub Height *Malacothamnus fasciculatus*	-2.6101	1.2565	4.315	0.0378	0.2712	0.0791	0.9290	0.5	m
Shrub Height *Rhamnus ilicifolia*	-14.2652	6.8789	4.3005	0.0381	0.0008	0.0000	0.6762	0.5	m
Belt Shrub Height *Baccharis pilularis*	-5.9031	2.9219	4.0816	0.0434	0.0523	0.0030	0.9157	0.5	m
Shrub Height *Baccharis salicifolia*	-1.6645	0.8264	4.0569	0.044	0.4351	0.1936	0.9779	0.5	m
Shrub Height *Baccharis pilularis*	-5.0906	2.5437	4.0048	0.0454	0.0784	0.0065	0.9489	0.5	m
Shrub Length *Porophyllum gracile*	-18.8994	9.6387	3.8447	0.0499	0.0000	0.0000	0.9925	1	(m-Count)/(10 m)
Belt Shrub Count *Baccharis salicifolia*	-0.8931	0.4686	3.6333	0.0566	0.4094	0.1634	1.0257	1	Shrubs
Belt Shrub Height *Malosma laurina*	-1.4848	0.7872	3.5576	0.0593	0.4760	0.2201	1.0295	0.5	m
Shrub Length *Cneoridium dumosum*	-2.387	1.2734	3.5138	0.0609	0.0919	0.0076	1.1150	1	(m-Count)/(10 m)
Belt Shrub Count *Isocoma menziesii*	-0.2194	0.1173	3.4987	0.0614	0.8030	0.6381	1.0106	1	Shrubs
Shrub Height *Malacothamnus fasciculatus*	-3.0006	1.6078	3.483	0.062	0.2231	0.0461	1.0783	0.5	m
Shrub Height *Cneoridium dumosum*	-3.4023	1.834	3.4415	0.0636	0.1825	0.0302	1.1009	0.5	m
Shrub Length *Salvia apiana*	1.5502	0.849	3.3344	0.0678	4.7124	0.8924	24.8844	1	(m-Count)/(10 m)
Shrub Height *Salvia apiana*	2.0889	1.1659	3.2101	0.0732	2.8418	0.9065	8.9087	0.5	m
Shrub Length *Baccharis salicifolia*	-1.1237	0.6281	3.201	0.0736	0.3251	0.0949	1.1134	1	(m-Count)/(10 m)
Belt Shrub Count *Salvia apiana*	0.6459	0.3651	3.1307	0.0768	1.9077	0.9327	3.9020	1	Shrubs
Belt Shrub Count *Cneoridium dumosum*	-1.3834	0.7843	3.1114	0.0777	0.2507	0.0539	1.1663	1	Shrubs

Table 10 (Continued)

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

					Odds Ratio				
						Lower 95%	Upper 95%		
Variable List	Estimate	StdErr	WaldChiSq	ProbChiSq	**Estimate**	Limit	Limit	Effect Size	
Belt Shrub Height Deadwood	-0.763	0.4388	3.0232	0.0821	0.6828	0.4442	1.0497	0.5	m
Belt Shrub Count *Malosma laurina*	-1.2189	0.7045	2.9935	0.0836	0.2956	0.0743	1.1758	1	Shrubs
Belt Shrub Count *Toxicodendron diversilobum*	-2.2975	1.3296	2.9859	0.084	0.1005	0.0074	1.3614	1	Shrubs
Average Percent > 60dBA	0.0439	0.0258	2.8907	0.0891	1.0449	0.9934	1.0991	1	% Time
Belt Shrub Height *Salvia apiana*	1.7084	1.0176	2.8187	0.0932	2.3495	0.8667	6.3690	0.5	m
Shrub Length *Baccharis pilularis*	-2.1558	1.3365	2.6018	0.1067	0.1158	0.0084	1.5900	1	(m-Count)/(10 m)
Shrub Length *Ribes speciosum*	-10.0192	6.4028	2.4486	0.1176	0.0000	0.0000	12.5571	1	(m-Count)/(10 m)
Belt Shrub Height *Toxicodendron diversilobum*	-3.4185	2.1934	2.4291	0.1191	0.1810	0.0211	1.5531	0.5	
Shrub Length *Viguiera laciniata*	-2.504	1.6123	2.4119	0.1204	0.0818	0.0035	1.9273	1	(m-Count)/(10 m)
Belt Shrub Count *Viguiera laciniata*	-1.6002	1.054	2.3052	0.1289	0.2019	0.0256	1.5930	1	Shrubs
Shrub Height *Viguiera laciniata*	-4.2817	2.8259	2.2957	0.1297	0.1176	0.0074	1.8749	0.5	m
Belt Shrub Height Secondary Other	-0.9283	0.6156	2.2741	0.1315	0.6287	0.3439	1.1493	0.5	
Shrub Height *Ribes speciosum*	-6.7971	4.548	2.2336	0.135	0.0334	0.0004	2.8820	0.5	m
Richness Nest Belt Transect	0.1602	0.1075	2.222	0.1361	1.1737	0.9508	1.4490	1	Number of Species
Richness All Line Transects	-0.0821	0.0554	2.1978	0.1382	0.9212	0.8264	1.0268	1	Number of Species
Belt Shrub Height *Viguiera laciniata*	-4.2307	2.9961	1.9939	0.1579	0.1206	0.0064	2.2724	0.5	
Belt Shrub Height *Lessingia filaginifolia*	2.3516	1.6881	1.9407	0.1636	3.2407	0.6197	16.9478	0.5	
Grass Height Forb Layer	0.8144	0.6038	1.8195	0.1774	1.5026	0.8315	2.7154	0.5	
Shrub Length *Toxicodendron diversilobum*	-3.0436	2.2774	1.7861	0.1814	0.0477	0.0005	4.1376	1	(m-Count)/(10 m)
Man Made Fprb Layer	4.3639	3.2752	1.7753	0.1827	78.5629	0.1280	4.8209E+04	1	(m-Count)/(m)
Belt Shrub Count *Heteromeles arbutifolia*	-8.5901	6.6405	1.6734	0.1958	0.0002	0.0000	83.5362	1	Shrubs
Shrub Length *Mirabilis californica*	-4.3127	3.3491	1.6582	0.1978	0.0134	0.0000	9.5023	1	(m-Count)/(10 m)
Belt Shrub Height *Cneoridium dumosum*	-2.1281	1.6593	1.645	0.1996	0.3451	0.0679	1.7543	0.5	
Belt Shrub Count *Salvia mellifera*	-0.0656	0.0512	1.6365	0.2008	0.9365	0.8471	1.0354	1	Shrubs
Belt Shrub Count *Baccharis pilularis*	-1.9651	1.5584	1.59	0.2073	0.1401	0.0066	2.9724	1	Shrubs
Shrub Height *Lonicera subspicata*	7.9513	6.3323	1.5767	0.2092	53.2847	0.1075	2.6405E+04	0.5	m
Richness Nest Line Transect	0.1405	0.1128	1.5504	0.2131	1.1508	0.9226	1.4356	1	Number of Species
Belt Shrub Height *Rhus integrifolia*	-1.3196	1.0654	1.5341	0.2155	0.5170	0.1820	1.4686	0.5	
Shrub Length *Rhamnus ilicifolia*	-8.0844	6.5417	1.5273	0.2165	0.0003	0.0000	114.1293	1	(m-Count)/(10 m)
Shrub length *Lessingia filaginifolia*	2.6543	2.1759	1.488	0.2225	14.2150	0.1998	1011.3729	1	(m-Count)/(10 m)
Belt Shrub Count *Rhus integrifolia*	-2.1468	1.7608	1.4865	0.2228	0.1169	0.0037	3.6854	1	Shrubs
Belt Shrub Count *Eriophyllum confertiflorum*	0.2857	0.2416	1.3985	0.237	1.3307	0.8288	2.1366	1	Shrubs
Shrub Length *Isocoma menziesii*	-0.6651	0.5809	1.3111	0.2522	0.5142	0.1647	1.6055	1	(m-Count)/(10 m)
Belt Shrub Height *Lonicera subspicata*	7.6953	6.7808	1.2879	0.2564	46.8828	0.0610	3.6056E+04	0.5	
Belt Shrub Count *Lonicera subspicata*	5.1419	4.8435	1.127	0.2884	171.0404	0.0129	2.2697E+06	1	Shrubs
Shrub Height *Mirabilis californica*	-8.5982	8.1032	1.1259	0.2887	0.0136	0.0000	38.1695	0.5	m
Average Max Event SELdBA	0.0159	0.015	1.1183	0.2903	1.0489	0.9603	1.1456	3	dB(A)

Table 10 (Continued)

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

Variable List	Estimate	StdErr	WaldChiSq	ProbChiSq	Odds Ratio **Estimate**	Odds Ratio Lower 95% Limit	Odds Ratio Upper 95% Limit	Effect Size	
Belt Shrub Count *Hazardia squarrosa*	3.5996	3.4358	1.0976	0.2948	36.5836	0.0435	3.0754E+04	1	Shrubs
Belt Shrub Height *Hazardia squarrosa*	5.9311	5.712	1.0782	0.2991	19.4054	0.0719	5235.9836	0.5	
Shrub Height *Dudleya* spp.	-14.5458	14.0454	1.0725	0.3004	0.0007	0.0000	659.5726	0.5	m
Shrub Length *Lonicera subspicata*	8.4709	8.2581	1.0522	0.305	4773.8100	0.0004	5.1086E+10	1	(m-Count)/(10 m)
Shrub Length *Dudleya* spp.	-19.2405	19.258	0.9982	0.3178	0.0000	0.0000	1.0882E+08	1	(m-Count)/(10 m)
Belt Shrub Height *Heteromeles arbutifolia*	-2.2259	2.2332	0.9935	0.3189	0.3286	0.0368	2.9317	0.5	
Belt Shrub Count *Malacothamnus fasciculatus*	-0.2498	0.2561	0.951	0.3295	0.7790	0.4715	1.2868	1	Shrubs
Shrub Height Secondary Other	-0.5593	0.5851	0.9139	0.3391	0.7560	0.4261	1.3414	0.5	m
Shrub Height *Eriodyctyon crassifolium*	-0.4759	0.5041	0.8912	0.3451	0.7882	0.4810	1.2918	0.5	m
Shrub Length Secondary CSS	-0.3071	0.3279	0.877	0.349	0.7356	0.3868	1.3988	1	(m-Count)/(10 m)
Belt Shrub Height *Isocoma menziesii*	1.5042	1.63	0.8516	0.3561	2.1215	0.4294	10.4803	0.5	
Shrub Height *Hazardia squarrosa*	19.7864	23.0566	0.7364	0.3908	19795.3037	0.0000	1.2872E+14	0.5	m
Belt Shrub Count *Prunus ilicifolia*	-3.3703	3.9333	0.7342	0.3915	0.0344	0.0000	76.6284	1	Shrubs
Belt Shrub Height Unknown Shrub	10.3636	12.2494	0.7158	0.3975	178.0029	0.0011	2.9099E+07	0.5	
Belt Shrub Height *Mirabilis californica*	-6.2289	7.3772	0.7129	0.3985	0.0444	0.0000	61.2648	0.5	
Shrub Length *Malacothamnus fasciculatus*	-1.0132	1.2022	0.7103	0.3993	0.3631	0.0344	3.8309	1	(m-Count)/(10 m)
Shrub Height Deadwood	0.3018	0.4105	0.5406	0.4622	1.1629	0.7777	1.7388	0.5	m
Shrub Length *Eriophyllum confertiflorum*	2.3817	3.309	0.5181	0.4717	10.8233	0.0165	7096.3795	1	(m-Count)/(10 m)
Shrub Length *Hazardia squarrosa*	19.1712	26.6794	0.5164	0.4724	211809956.7124	0.0000	1.0862E+31	1	(m-Count)/(10 m)
Shrub Height Secondary CSS	-0.4739	0.6601	0.5154	0.4728	0.7890	0.4132	1.5067	0.5	m
Richness All Belt Transects	-0.0412	0.0584	0.4981	0.4803	0.9596	0.8558	1.0760	1	Number of Species
Shrub Height *Malosma laurina*	-0.4038	0.5838	0.4785	0.4891	0.8172	0.4612	1.4481	0.5	m
Belt Shrub Height *Opuntia littoralis*	23.4254	36.3329	0.4157	0.5191	122112.7406	0.0000	3.5510E+20	0.5	
Shrub Length *Malosma laurina*	-0.2802	0.4431	0.3999	0.5271	0.7556	0.3171	1.8009	1	(m-Count)/(10 m)
Belt Shrub Count Unknown Shrub	3.6237	6.0985	0.3531	0.5524	37.4760	0.0002	5.8197E+06	1	Shrubs
Length Native Forbs	0.0741	0.1248	0.3526	0.5526	1.0769	0.8432	1.3753	1	(m-Count)/(m)
Shrub Height *Prunus ilicifolia*	3.3511	5.6711	0.3492	0.5546	5.3417	0.0206	1384.6851	0.5	m
Belt Shrub Count *Opunita littoralis*	5.2744	9.0366	0.3407	0.5594	195.2733	0.0000	9.6106E+09	1	Shrubs
Belt Shrub Count *Mirabilis californica*	-0.3286	0.5842	0.3163	0.5738	0.7199	0.2291	2.2624	1	Shrubs
Shrub Length Unknown Shrub	6.6162	12.233	0.2925	0.5886	747.1007	0.0000	1.9334E+13	1	(m-Count)/(10 m)
Shrub Length *Cercocarpus betuloides*	-0.7912	1.4674	0.2907	0.5898	0.4533	0.0255	8.0438	1	(m-Count)/(10 m)
Distance to Fixed-Wing Flight Procedures	0.000086	0.000163	0.2778	0.5982	1.0000	0.9999	1.0002	0.5	
Belt Shrub Height *Cercocarpus betuloides*	4.1447	7.9296	0.2732	0.6012	7.9435	0.0034	18832.8507	0.5	
Belt Shrub Count *Dudleya* spp.	-1.944	3.7911	0.2629	0.6081	0.1431	0.0001	241.4243	1	Shrubs
Shrub Length *Rhamnus crocea*	0.2933	0.584	0.2522	0.6156	1.3408	0.4268	4.2120	1	(m-Count)/(10 m)
Shrub Length *Prunus ilicifolia*	2.4426	4.9154	0.2469	0.6192	11.5029	0.0008	1.7574E+05	1	(m-Count)/(10 m)
Shrub Height *Cercocarpus betuloides*	-0.7395	1.4951	0.2447	0.6209	0.6909	0.1596	2.9905	0.5	m

Table 10 (Continued)

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

					Odds Ratio				
Variable List	Estimate	StdErr	WaldChiSq	ProbChiSq	**Estimate**	Lower 95% Limit	Upper 95% Limit	Effect Size	
Length Leaf Litter- Forb Layer	0.0322	0.0679	0.2242	0.6359	1.0327	0.9040	1.1797	1	(m-Count)/(m)
Belt Shrub Count *Ferocactus viridescens*	2.4115	5.1728	0.2173	0.6411	11.1507	0.0004	2.8215E+05	1	Shrubs
Shrub Length Secondary Other	-0.1838	0.4063	0.2047	0.651	0.8321	0.3753	1.8451	1	(m-Count)/(10 m)
Belt Shrub Height *Salvia mellifera*	-0.1511	0.3352	0.2031	0.6522	0.9272	0.6676	1.2878	0.5	
Shrub Length *Eriodyctyon crassifolium*	-0.1675	0.3725	0.2022	0.653	0.8458	0.4075	1.7552	1	(m-Count)/(10 m)
Shrub Height *Salvia mellifera*	-0.149	0.3488	0.1825	0.6693	0.9282	0.6595	1.3065	0.5	m
Height Leaf Litter- Forb Layer	1.5581	3.6491	0.1823	0.6694	2.1794	0.0610	77.8799	0.5	
Belt Shrub Height *Eriodyctyon crassifolium*	-0.1934	0.4558	0.18	0.6714	0.9078	0.5808	1.4190	0.5	
Belt Shrub Height *Eriophyllum confertiflorum*	0.7236	1.7172	0.1776	0.6735	1.4359	0.2669	7.7265	0.5	
Belt Shrub Count *Cercocarpus betuloides*	3.3779	8.5232	0.1571	0.6919	29.3092	0.0000	5.2735E+08	1	Shrubs
Belt Shrub Count Secondary Other	-0.0698	0.1841	0.1437	0.7047	0.9326	0.6501	1.3378	1	Shrubs
Curvurvature 30	-0.097	0.2592	0.14	0.7082	0.9527	0.7390	1.2282	0.5	
Belt Shrub Count *Lessingia filaginifolia*	0.086	0.2394	0.1292	0.7193	1.0898	0.6817	1.7423	1	Shrubs
Height Non-vegetated Forb Layer	9.1445	25.5795	0.1278	0.7207	2.4954	0.0166	375.4150	0.1	m
Belt Shrub Height Secondary CSS	-0.2304	0.6782	0.1154	0.7341	0.8912	0.4585	1.7323	0.5	
Belt Shrub Height *Encelia californica*	5.9708	17.9689	0.1104	0.7397	19.7944	0.0000	8.7955E+08	0.5	
Belt Shrub Count *Eriodyctyon crassifolium*	0.0375	0.1186	0.0997	0.7521	1.0382	0.8229	1.3099	1	Shrubs
Length Road Forb Layer	-0.047	0.1507	0.0973	0.7551	0.9541	0.7101	1.2819	1	(m-Count)/(m)
Belt Shrub Count *Rhamnus crocea*	0.1886	0.6525	0.0836	0.7725	1.2076	0.3361	4.3384	1	Shrubs
Belt Shrub Height *Ferocactus viridescens*	10.0596	36.7653	0.0749	0.7844	152.9024	0.0000	6.7927E+17	0.5	
Belt Shrub Height *Rhamnus ilicifolia*	-2.5157	9.3974	0.0717	0.7889	0.2843	0.0000	2.8401E+03	0.5	
Shrub Height *Isocoma menziesii*	0.4367	1.6686	0.0685	0.7936	1.2440	0.2425	6.3826	0.5	m
Shrub Height *Rhamnus crocea*	0.2268	0.9217	0.0605	0.8056	1.1201	0.4539	2.7640	0.5	m
Belt Shrub Height *Prunus ilicifolia*	0.7768	3.4582	0.0505	0.8223	1.4746	0.0498	43.7038	0.5	
Belt Shrub Height *Encelia californica*	1.5736	7.0547	0.0498	0.8235	4.8240	0.0000	4.8808E+06	1	Shrubs
Shrub Height Unknown Shrub	2.1941	10.4182	0.0444	0.8332	2.9953	0.0001	8.1380E+04	0.5	m
Shrub Length *Salvia mellifera*	-0.021	0.1031	0.0415	0.8385	0.9792	0.8001	1.1985	1	(m-Count)/(10 m)
Length Grass Forb Layer	0.0119	0.0591	0.0404	0.8407	1.0120	0.9013	1.1363	1	(m-Count)/(m)
Shrub Height *Eriophylllum confertiflorum*	0.5248	3.0698	0.0292	0.8643	1.3000	0.0642	26.3325	0.5	m
Shrub Length *Ceanothus crassifolius*	-1.7851	11.1992	0.0254	0.8734	0.1678	0.0000	5.7239E+08	1	(m-Count)/(10 m)
Belt Shrub Height *Dudleya* Spp.	-1.3914	10.0273	0.0193	0.8896	0.4987	0.0000	9.2378E+03	0.5	
Belt Shrub Height *Rhamnus crocea*	-0.112	0.8546	0.0172	0.8957	0.9455	0.4092	2.1848	0.5	
Shrub Height *Ceanothus crassifolius*	0.6963	5.6451	0.0152	0.9018	1.4164	0.0056	357.9338	0.5	m
Betl Shrub Count *Gutierrezia californica*	48.3992	471.9	0.0105	0.9183	1.0459E+21	0.0000	Inf	1	Shrubs
Shrub Length *Opuntia littoralis*	414.3	4165.8	0.0099	0.9208	8.4763E+179	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Gutierrezia californica*	204.7	2444.9	0.007	0.9333	7.9448E+88	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Height *Opuntia littoralis*	306.1	4769.9	0.0041	0.9488	2.9429E+66	0.0000	Inf	0.5	m

Table 10 (Continued)

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

					Odds Ratio				
						Lower 95%	Upper 95%		
Variable List	Estimate	StdErr	WaldChiSq	ProbChiSq	**Estimate**	Limit	Limit	Effect Size	
Belt Shrub Height *Gutierrezia californica*	117.5	1859.7	0.004	0.9496	3.2719E+25	0.0000	Inf	0.5	
Belt Shrub Count *Rhamnus ilicifolia*	-0.3364	6.9235	0.0024	0.9612	0.7143	0.0000	5.5886E+05	1	Shrubs
Shrub Length *Yucca baccata*	247.1	5209.9	0.0022	0.9622	2.0614E+107	0.0000	Inf	1	(m-Count)/(10 m)
Belt Shrub Height *Salvia* hybrid (*apiana* X *mellifera*)	264.6	6980.6	0.0014	0.9698	2.8652E+57	0.0000	Inf	0.5	
Belt Shrub Count *Yucca baccata*	59.3924	1693	0.0012	0.972	6.2200E+25	0.0000	Inf	1	Shrubs
Belt Shrub Height *Yucca baccata*	135.1	3836	0.0012	0.9719	2.1707E+29	0.0000	Inf	0.5	
Shrub Height *Gutierrezia californica*	122.9	3643.2	0.0011	0.9731	4.8685E+26	0.0000	Inf	0.5	m
Belt Shrub Height *Marrubium vulgare*	281.1	9195.7	0.0009	0.9756	1.0967E+61	0.0000	Inf	0.5	
Shrub Length *Solanum parishii*	-660.3	23680	0.0008	0.9778	1.7193E-287	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Marrubium vulgare*	291.2	10882.1	0.0007	0.9787	2.9279E+126	0.0000	Inf	1	(m-Count)/(10 m)
Belt Shrub Count *Solanum parishii*	-134.4	5388.8	0.0006	0.9801	4.2739E-59	0.0000	Inf	1	Shrubs
Belt Shrub Height *Eriogonum cinereum*	107.8	4317.7	0.0006	0.9801	2.5614E+23	0.0000	Inf	0.5	
Belt Shrub Height *Solanum parishii*	-544.6	23284.3	0.0005	0.9813	5.5159E-119	0.0000	Inf	0.5	
Shrub Length *Ceanothus verrucosus*	32.4875	1532.4	0.0004	0.9831	1.2857E+14	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Height *Solanum parishii*	-561.7	34209.4	0.0003	0.9869	1.0676E-122	0.0000	Inf	0.5	m
Shrub Height *Yucca baccata*	128	7004.2	0.0003	0.9854	6.2351E+27	0.0000	Inf	0.5	m
Belt Shrub Count *Marrubium vulgare*	73.737	5595.1	0.0002	0.9895	1.0558E+32	0.0000	Inf	1	Shrubs
Shrub Height *Ceanothus verrucosus*	42.9667	3266.5	0.0002	0.9895	2.1385E+09	0.0000	Inf	0.5	m
Belt Shrub Height *Ceanothus verrucosus*	40.3256	3025.3	0.0002	0.9894	5.7094E+08	0.0000	Inf	0.5	
Belt Shrub Count *Ceanothus verrucosus*	36.5741	2666.6	0.0002	0.9891	7.6547E+15	0.0000	Inf	1	Shrubs
Belt Shrub Count *Dudleya lanceolata*	36.5741	2666.6	0.0002	0.9891	7.6547E+15	0.0000	Inf	1	Shrubs
Belt Shrub Count *Opuntia prolifera*	14.6296	1066.6	0.0002	0.9891	2.2571E+06	0.0000	Inf	1	Shrubs
Shrub Height *Encelia californica*	16.2749	1182.9	0.0002	0.989	3420.1853	0.0000	Inf	0.5	m
Shrub Length *Encelia californica*	2.4433	174	0.0002	0.9888	11.5110	0.0000	1.4890E+149	1	(m-Count)/(10 m)
Shrub Height *Opuntia prolifera*	97.2417	6838.9	0.0002	0.9887	1.3055E+21	0.0000	Inf	0.5	m
Belt Shrub Height *Dudleya lanceolata*	112.9	7852.5	0.0002	0.9885	3.2804E+24	0.0000	Inf	0.5	
Belt Shrub Count *Brickellia californica*	67.1349	4574.6	0.0002	0.9883	1.4332E+29	0.0000	Inf	1	Shrubs
Belt Shrub Count *Isomeris arborea*	33.5674	2287.3	0.0002	0.9883	3.7856E+14	0.0000	Inf	1	Shrubs
Belt Shrub Height *Brickellia californica*	74.5943	5082.9	0.0002	0.9883	1.5774E+16	0.0000	Inf	0.5	
Belt Shrub Height *Isomeris arborea*	95.907	6535.2	0.0002	0.9883	6.6979E+20	0.0000	Inf	0.5	
Shrub Height *Brickellia californica*	83.9186	5718.3	0.0002	0.9883	1.6699E+18	0.0000	Inf	0.5	m
Shrub Height *Dudleya lanceolata*	1342.7	91492.7	0.0002	0.9883	3.6610E+291	0.0000	Inf	0.5	m
Shrub Height *Salvia* hybrid (*apiana* X *mellifera*)	53.7079	3659.7	0.0002	0.9883	4.5975E+11	0.0000	Inf	0.5	m
Shrub Length *Brickellia californica*	134.3	9149.3	0.0002	0.9883	2.1171E+58	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Dudleya lanceolata*	745.9	50829.3	0.0002	0.9883	#NUM!	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Eriogonum cinereum*	26.946	1843.1	0.0002	0.9883	5.0408E+11	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Salvia* hybrid (*apiana* X *mellifera*)	33.5674	2287.3	0.0002	0.9883	3.7856E+14	0.0000	Inf	1	(m-Count)/(10 m)

Table 10 (Continued)

Univariate Logistic Regression for CAGN Nest Site Selection
Statistically Significant Variables Were Considered Candidates for Multiple Variable Models

					Odds Ratio				
Variable List	Estimate	StdErr	WaldChiSq	ProbChiSq	**Estimate**	Lower 95% Limit	Upper 95% Limit	Effect Size	
Belt Shrub Count *Arctostaphylos glandulosa*	-96.4385	6478.4	0.0002	0.9881	0.0000	0.0000	Inf	1	Shrubs
Belt Shrub Count *Encelia farinosa*	-289.3	19435.3	0.0002	0.9881	0.0000	0.0000	Inf	1	Shrubs
Belt Shrub Count *Ribes indecorum*	-96.4385	6478.4	0.0002	0.9881	0.0000	0.0000	Inf	1	Shrubs
Belt Shrub Count *Trichostema lanatum*	-19.2877	1295.7	0.0002	0.9881	0.0000	0.0000	Inf	1	Shrubs
Belt Shrub Height *Arctostaphylos glandulosa*	-122.1	8200.5	0.0002	0.9881	0.0000	0.0000	Inf	0.5	
Belt Shrub Height *Encelia farinosa*	-642.9	43189.5	0.0002	0.9881	0.0000	0.0000	Inf	0.5	
Belt Shrub Height *Ribes indecorum*	-63.5858	4271.5	0.0002	0.9881	0.0000	0.0000	Inf	0.5	
Belt Shrub Height *Trichostema lanatum*	-50.4913	3391.8	0.0002	0.9881	0.0000	0.0000	Inf	0.5	
Shrub Height *Arctostaphylos glandulosa*	-413.3	27764.7	0.0002	0.9881	0.0000	0.0000	Inf	0.5	m
Shrub Height *Artemisia palmeri*	-241.1	16196.1	0.0002	0.9881	0.0000	0.0000	Inf	0.5	m
Shrub Height *Ferocactus viridescens*	-723.3	48588.2	0.0002	0.9881	0.0000	0.0000	Inf	0.5	m
Shrub Height *Ribes indecorum*	-247.3	16611.3	0.0002	0.9881	0.0000	0.0000	Inf	0.5	m
Shrub Height *Trichostema lanatum*	-54.2806	3646.4	0.0002	0.9881	0.0000	0.0000	Inf	0.5	m
Shrub Length *Arctostaphylos glandulosa*	-413.3	27764.7	0.0002	0.9881	0.0000	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Artemisia palmeri*	-1446.6	97176.3	0.0002	0.9881	0.0000	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Ferocactus viridescens*	-964.4	64784.2	0.0002	0.9881	0.0000	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Ribes indecorum*	-2893.2	194353	0.0002	0.9881	0.0000	0.0000	Inf	1	(m-Count)/(10 m)
Shrub Length *Trichostema lanatum*	-64.2923	4318.9	0.0002	0.9881	0.0000	0.0000	Inf	1	(m-Count)/(10 m)
Belt Shrub Height *Ribes speciosum*	110.4	7053.2	0.0002	0.9875	9.3984E+23	0.0000	Inf	0.5	
Belt Shrub Count *Eriogonum cinereum*	36.4355	3675.5	0.0001	0.9921	6.6640E+15	0.0000	Inf	1	Shrubs
Shrub Height *Marrubium vulgare*	178.6	16339.8	0.0001	0.9913	6.0603E+38	0.0000	Inf	0.5	m
Shrub Length *Opuntia prolifera*	102.1	9386.5	0.0001	0.9913	2.1952E+44	0.0000	Inf	1	(m-Count)/(10 m)
Belt Shrub Count *Ribes speciosum*	79.1616	7179.4	0.0001	0.9912	2.3958E+34	0.0000	Inf	1	Shrubs
Belt Shrub Count *Salvia* hybrid (*apiana* X *mellifera*)	79.1616	7179.4	0.0001	0.9912	2.3958E+34	0.0000	Inf	1	Shrubs
Shrub Height *Eriogonum cinereum*	61.9969	5620.4	0.0001	0.9912	2.9004E+13	0.0000	Inf	0.5	m
Belt Shrub Height *Opuntia prolifera*	79.0969	7116.7	0.0001	0.9911	1.4986E+17	0.0000	Inf	0.5	

3.4.2.1 Noise Metrics

The noise metrics that we considered can be separated into two basic types, those directly measuring sound levels (Total L_{Aeq}, Total ASEL, Maximum Event ASEL, L_5) and those representing time above specified thresholds (Percent time exceeding 60 dBA and Percent time exceeding 80 dBA. Gnatcatchers selected nesting sites that were noisier than average noise levels within available nesting habitat (Table 11; Total L_{Aeq}, p=0.03; Total ASEL, p=0.02; L_5, p < 0.01). Percent time exceeding 60 dBA, and 80 dBA, was also greater at nesting sites than at available sites (p=0.09 and p=0.01, respectively). See Appendix A, the glossary of technical terms, for explanation of terms.

3.4.2.2 Vegetation Metrics

The gnatcatcher pairs selected shrub stands dominated by *Artemisia californica* (p<0.01), *Baccharis sarothroides* (p=0.01) and *Eriogonum fasciculatum* (p=0.02) and avoided habitats dominated by *Isocoma menziesii* (p=0.06), *Malosma laurina* (p=0.05), *Baccharis salicifolia* (p<0.01), *Lotus scoparius* (p=0.06) and *Rhus integrifolia* (p<0.01).

3.4.2.3 Physical Variables

Aspect was transformed into its north/south and east/west components by transforming to cosine and sine of aspect respectively. Probability of nest site selection was negatively associated with cosine of aspect (p=0.01) and positively associated with sine of aspect (p=0.04) indicating that gnatcatchers preferred nesting sites on slopes with southeastern exposures. Gnatcatchers also selected areas with lower elevation than is generally available throughout the Station (p<0.01).

3.4.2.4 Multiple Variable Models

Nest site selection was found to be associated with 124 of the variables that were measured. Due to multicollinearity these variables were reduced to a subset of 35 variables for inclusion in the model. When pairs of factors were

Table 11

Variables Included in Best Multpile Variable Nest Success Models

147.564	Shrub Height:	*Artemisia californica, Baccharis salicifolia, Baccharis sarothroides, Cneoridium dumosum, Eriogonum fasciculatum, Lotus scoparius, Malosma laurina, Quercus berberidifolia, Rhus integrifolia* sin(aspect), cos(aspect), Elevation, Belt- Shrub-Count:*Isocoma menziesii* , Non-Native-Forb-Cover, Gap-Length	57.6	11	0.061
149.546	Shrub Height:	*Artemisia californica, Baccharis salicifolia, Baccharis sarothroides, Cneoridium dumosum, Eriogonum fasciculatum, Lotus scoparius, Malacothamnus fasciculatus, Quercus berberidifolia, Rhus integrifolia* sin(aspect), cos(aspect), Elevation, Belt-Shrub-Count:*Isocoma menziesii* , Non-Native-Forb-Cover, Gap Length	57.6	13	0.0605
149.967	Shrub Height:	*Artemisia californica, Baccharis salicifolia, Baccharis sarothroides, Cneoridium dumosum, Eriogonum fasciculatum, Lotus scoparius, Malosma laurina, Quercus berberidifolia, Rhus integrifolia* sin(aspect), cos(aspect), Elevation, Non-Native-Forb-Height, Non-Native-Forb-Cover, Gap Length	56.7	14	0.056
150.126	Shrub Height:	*Artemisia californica, Baccharis salicifolia, Baccharis sarothroides, Cneoridium dumosum, Eriogonum fasciculatum, Lotus scoparius, Quercus berberidifolia, Rhus integrifolia* cos(aspect), Elevation, Belt-Shrub-Count:*Isocoma menziesii* , Non-Native-Forb-Cover, Gap Length	60.3	12	0.025
150.619	Shrub Height:	*Artemisia californica, Baccharis salicifolia, Baccharis sarothroides, Cneoridium dumosum, Eriogonum fasciculatum, Lotus scoparius, Malacothamnus fasciculatus, Malosma laurina, Quercus berberidifolia, Rhus integrifolia* sin(aspect) cos(aspect), Elevation, Belt-Shrub-Count:*Isocoma menziesii* ,Native-gorb-height, Non-Native-Forb-Cover, Gap Length	57.9		0.0768

correlated the more interpretable factors were maintained for modeling. The resulting set of factors considered for multiple variable modeling included shrub height of several species (See Table 10), percent slope, sine and cosine of aspect, elevation, number and average length of gaps in the vegetation layer, distance to airfield, distance to rotary-wing flight procedures (Figure 27), distance to class-one roads, height and cover of native and non-native forbs, and proportion of cover composed of dead wood. All possible combinations of the 35 variables were evaluated and a set of 11 models (See Table 11) were found to provide a similar balance between model complexity and model fit. Inclusion of additional factors would be justified if the AIC were reduced substantially. A common rule of thumb for judging model improvement is a change of 3 AIC points for each additional variable included in a model. In this study additional variables were included in multiple variable models when AIC was reduced by at least 3 points. Additionally, candidate models within 3 AIC points of the best fitting model were inspected to determine if primary components of the models were of substantive importance. Models that thought to be biologically and substantively different were discussed separately.

The resulting model coefficients tests and model diagnostic tests are summarized in Table 12. Standardized coefficients were estimated and used to evaluate the relative importance of each factor within each model. Noise metrics and distance from rotary-wing flight procedures were also tested for association with nesting success after adjusting for vegetation and physical metrics.

There were 11 models within 3 AIC points of the best model (Table 11). These models were very similar in composition with indices to primary coastal sage species, aspect and elevation, and average length of gaps present in all of the 11 models. Differences among models were very minor, so further discussion and results are restricted to the best model.
In general, gnatcatchers selected low elevation southeast facing slopes, densely vegetated (low percent gaps) with *Artemisia californica*, *Baccharis sarothroides*, and *Eriogonum fasciculatum* and a well developed forb understory. CAGN avoided areas dominated by *Lotus scoparius*, *Rhus integrifolia*, *Baccharis salicifolia* and *Malosma laurina*. The three most important factors controlling the distribution of gnatcatcher nest site

Table 12

Best Multivariable Model and Tests for Noise Effects After Adjustment for Habitat and Other Non-noise Effects

				Wald		Standardized	Goodness of Fit			
Variable	DF	Estimate	Standard Error	Chi-Square	Significance	Coefficient	ChiSq	DF	Significance	AIC
Sine of Aspect	1	0.865	0.420	4.2	0.039	0.27	12.9	8	0.110	148
Cosine of Aspect	1	-0.960	0.371	6.7	0.010	-0.43				
Elevation 30	1	-0.045	0.007	35.5	<0.001	-0.97				
Belt Shrub Count *Isocoma menziesii*	1	-0.529	0.279	3.6	0.058	-0.24				
Malosma laurina	1	-3.462	1.777	3.8	0.051	-0.28				
Cover Non-native forb	1	0.487	0.189	6.6	0.010	0.51				
Artemisia californica	1	2.668	0.920	8.4	0.004	0.59				
Baccharis salicifolia	1	-5.376	1.689	10.1	0.002	-0.34				
Baccharis sarothroides	1	2.657	1.009	6.9	0.008	0.71				
Eriogonum fasciculatum	1	2.347	0.994	5.6	0.018	0.46				
Lotus scoparius	1	-3.245	1.752	3.4	0.064	-0.25				
Rhus integrifolia	1	-4.225	1.177	12.9	<0.001	-0.35				
Gap Length	1	-0.507	0.146	12.0	0.001	-0.49				
Univariate Noise Effects										
Total L_{eq} dB(A)	1	0.0311	0.0142	4.7592	0.0291	0.1657	NA	NA	NA	NA
Total SEL dB(A)	1	0.0308	0.0137	5.0764	0.0243	0.1698	NA	NA	NA	NA
Maximum Event SEL dB(A)	1	0.0159	0.015	1.1183	0.2903	0.0812	NA	NA	NA	NA
L_5 dB(A)	1	0.0804	0.0222	13.1652	0.0003	0.3103	NA	NA	NA	NA
Percent Time > 60 dB(A)	1	0.0439	0.0258	2.8907	0.0891	0.2599	NA	NA	NA	NA
Percent Time > 80 dB(A)	1	0.8739	0.3458	6.387	0.0115	2.1335	NA	NA	NA	NA
Adjusted Noise Effects:										
Total L_{eq} dB(A)	1	-0.033	0.038	0.7	0.385	-0.17	15.6	8	0.049	149
Total SEL dB(A)	1	-0.022	0.036	0.4	0.547	-0.12	15.3	8	0.054	149
Maximum Event SEL dB(A)	1	-0.034	0.039	0.8	0.380	-0.18	16.7	8	0.033	149
L_5 dB(A)	1	0.016	0.049	0.1	0.752	0.06	11.8	8	0.161	150
Percent Time > 60 dB(A)	1	0.002	0.033	0.0	0.948	0.01	13.6	8	0.094	150
Percent Time > 80 dB(A)	1	0.108	0.447	0.1	0.808	0.26	13.3	8	0.103	150

selection were elevation, distribution of *Artemisia californica* and distribution of *Baccharis sarothroides.*

Univariate tests showed that gnatcatchers preferred nesting in noisy areas close to the developed areas of the Station and helicopter procedures of flight paths (See Figure 9 and 27). However, after adjusting for the effects of habitat and physical factors on gnatcatcher nest site selection, these associations were not apparent (Table 12; Total L_{Aeq}, p=0.39; Total ASEL, p=0.55; L_5, p < 0.75; Percent time exceeding 60 dBA, p=0.95; Percent time exceeding 80 dBA, p=0.81). Additionally, the adjusted effects were positive in 3 of the 6 noise metrics and negative in the other 3 (Table 12) indicating a general indifference to the noise environment. The standardized coefficients indicated that most of the noise metrics were nearly an order of magnitude less important than the most important habitat and physical variables included in the models.

3.4.3 Fledges Per Pair Analysis

Nesting success rates were found to be associated with a combination of 6 factors; height of Salvia mellifera, Lotus scoparius, and Baccharis sarothroides; topographic curvature, percent cover of gaps and fall hydrologic drought index (See Table 10). Because CAGN commonly renest after failed nesting attempts, differential nesting success rates may be compensated by multiple nesting attempts. To evaluate the effects of variation in habitat and the noise environment on fledge production, the factors determined to be associated with nest success were tested to determine the association with the number of chicks fledged per pair.

We found that the number of chicks fledged per pair was negatively associated with the height of *Salvia mellifera* (Table 13; p=0.01) but unassociated with the other factors that predicted nesting success (*Lotus scoparius*, p=0.33; *Baccharis sarothroides*, p=0.92; topographic curvature, p=0.25; percent cover of gaps, p=0.37; and fall hydrologic drought index, p=0.98)

Each noise metric was then tested individually for an association with the number of chicks fledged per pair using Poisson regression (McCullough and Nelder 1989). We found that gnatcatcher pairs successfully fledged similar

Table 13

Coefficients and Tests for Poisson Regression Models of Number of Chicks Fledged per Pair

Model	Parameter	DF	Estimate	Standard Error	Chi-Square	Significance
Multiple Regression	Intercept	1	0.580	0.357	2.64	0.10
	Salvia mellifera height	1	-0.870	0.346	6.32	0.01
	Curvature	1	0.217	0.190	1.30	0.25
	Lotus scoparius	1	0.706	0.728	0.94	0.33
	Percent Gaps	1	0.062	0.069	0.80	0.37
	Baccharis sarothroides	1	-0.021	0.211	0.01	0.92
	Fall Hydrologic Drought Index	1	0.000	0.024	0.00	0.99
	Scale[1]	0	1.531	NA	NA	NA
Best Model	Intercept	1	0.919	0.093	97.60	<0.01
	Salvia mellifera height	1	-0.955	0.330	8.35	<0.01
	Scale[1]	0	1.522	NA	NA	NA
Univariate Noise Metrics	L5	1	0.007	0.013	0.26	0.61
	Maximum Event ASEL	1	0.004	0.010	0.18	0.67
	Percent Time Greater than 60 dBA	1	0.009	0.009	0.96	0.33
	Percent Time Greater than 80 dBA	1	0.172	0.123	1.96	0.16
	Total Leq	1	0.005	0.009	0.33	0.57
	Total ASEL	1	0.003	0.008	0.11	0.74
	Distance to Rotary-Wing Flight Procedures	1	0.047	0.062	0.58	0.45
Noise Metrics Adjusted for *Salvia mellifera*	L5	1	0.013	0.013	0.95	0.33
	Maximum Event ASEL	1	0.008	0.009	0.85	0.36
	Percent Time Greater than 60 dBA	1	0.009	0.009	1.09	0.30
	Percent Time Greater than 80 dBA	1	0.176	0.116	2.33	0.13
	Total Leq	1	0.009	0.008	1.28	0.26
	Total ASEL	1	0.007	0.008	0.86	0.35
	Distance to Rotary-Wing Flight Procedures	1	-0.025	0.065	0.15	0.70

Notes:

1) The scale parameter is an estimate of over dispersion for the Poisson Model. A value of 1.0 would be expected under the Poisson hypothesis. The reported significance of tests was adjusted to account for this overdispersion.

numbers of chicks in both noisy and quiet areas (Total Leq dBA, p=0.57; Total ASEL, p=0.74; L5, p=0.61; Maximum event ASEL, p=0.67; Percent time greater than 60 dBA, p=0.33; and Percent time greater than 80 dBA, p=0.16). Although, when tested individually, the six noise metrics were not associated with number of chicks fledged per pair, it is possible that an effect could have been masked by spatial variations in *Salvia mellifera*. To evaluate this possibility, multiple Poisson regression was used to test for an association between number of chicks fledged and the six noise metrics after adjusting for covariation with the distribution of *Salvia mellifera*.

After adjusting for covariation with *Salvia mellifera* distributions, gnatcatcher pairs fledged similar numbers of chicks in quiet and noisy areas (Total Leq dBA, p=0.26; Total ASEL, p=0.35; L5, p=0.33; Maximum event ASEL, p=0.35; Percent time greater than 60 dBA, p=0.29; and Percent time greater than 80 dBA, p=0.13).

While the effects of noise metrics on the number of chicks fledged per pair were not statistically significant, it is interesting to note that the estimated Poisson regression coefficients were positive, indicating that gnatcatcher pairs fledged more chicks in noisy than in quiet areas.

4.0 DISCUSSION

To date, factors affecting nesting success of the coastal California gnatcatcher have not been described quantitatively in the literature. The 760 nests studied from 1995 through 2001 provide one of the largest databases from which to infer conditions necessary for coastal California gnatcatcher reproductive success. The coastal California gnatcatcher pairs for this study were monitored from 1998 through 2001. Only nest's that had acoustic data, number of chicks and fledges were used in the final statistical models resulting in 421 nests available for analysis. The majority or over 75% of the statistical analyses were conducted on these nests because vegetation metrics were sampled using different methodology prior to 1998. Information collected on gnatcatcher pairs monitored during 1995-1997 was used in statistical analyses where habitat metrics were not required.

This study was conducted to evaluate the potential effects of helicopter noise on coastal California gnatcatcher reproductive success (nesting success, nest site selection, and number of fledges per pair). Based on the important factors controlling these reproductive endpoints, these modeled productivity endpoints were calculated and overlaid on sound contours based on average noise levels from 1999, 2000 and 2001 (See Figure 14). These maps show that the coastal California gnatcatcher will find and inhabit suitable nesting habitat, in spite of the noise environment. This combined with the fact that nest success is equally likely in quiet and noisy areas within the Station indicates that gnatcatchers find and utilize available, suitable habitats and that nesting success is unaffected by noise associated with helicopter over-flights. So if suitable habitat conditions exist, nest success rates are equal in both noisy and quiet areas.

Additionally, the map showing predicted probability of nest site selection indicates that gnatcatcher pairs select suitable habitat conditions regardless of noise. Finally, although there are habitat fluctuations on the western portion of the Station that do not exist on the eastern part of the Station, the number of fledges per pair was similar. CAGN pairs compensated for lower nest success rates by re-nesting.

4.1 REPRODUCTIVE SUCCESS

Statistical models describing habitat composition and structure, geographic and climatic conditions necessary to promote coastal California gnatcatcher nest success at MCAS Miramar were developed. These models were evaluated to determine if after adjusting for variation in these biological mechanisms, gnatcatcher success was also associated with the effects of noise related to helicopter operations. Additionally, any potential changes in these effects due to the addition of helicopters were tested.

When the models were evaluated, it was found that reproductive success was associated with spatial variation in habitat, topography and rainfall. Nesting success was not associated with any of the noise metrics tested suggesting that noise from helicopters was not detrimental to coastal California gnatcatcher reproductive success. This study provides a strong basis for understanding processes associated with reproductive success. The study design had adequate power to detect and model biologically meaningful relationships between CAGN reproductive success and spatial variation in environmental and ecological mechanisms. After adjusting for variation in these mechanisms it was further found that nesting success was not associated with environmental noise levels including rotary-wing aircraft sources.

Part of the study involved the analysis of multiple variables, two at a time to determine if there was an effect on one variable, i.e. nesting success, by the other, i.e. noise levels, plant species, etc**.** The calculation of R^2 is computed by looking at these two sources of variation, and provides us with the proportion of explained variation. We found that nesting success was best in areas with relatively tall stands of *Lotus scoparius*, a low growing (less than 0.5m) drought-resistant plant with malacophyllous, summer-deciduous leaves. Nest success in these areas was improved with interspersed gaps in shrub cover vegetated with forbs and grasses suitable for CAGN prey production. Nesting coastal California gnatcatchers were less successful in tall stands of *Baccharis sarothroides* and *Salvia mellifera* with an understory dominated by dead leaf litter. These areas were typical of either disturbed or late-successional-stage coastal sage scrub communities dominating the western and central parts of the Station.

Nests found in areas that were concave up such as drainage bottoms were more successful than those where the surrounding topography was concave down, such as ridge tops. Areas that were concave up represent localized areas where soil moisture may have been higher than in surrounding areas, providing additional resources to support prey species necessary for successful fledge production. Similarly, nesting success was highest in years in which the Palmer Hydrological Drought Index was high in the fall prior to the nesting season. This also suggests that adequate soil moisture to produce grasses and forbs necessary to support prey species may be an important factor controlling nesting success. Nesting success was lowest in years that conditions were either generally dry as indexed by the PHDI, or in years such as 1999 when storm events and cold weather coincided with the nesting season. One potential explanation for this decline could be that the limited rainfall occurring during the nesting season and the previous winter resulted in a decline in the food supply. Moisture, while necessary to support prey species, may be detrimental to reproductive success when present during any periods of cold temperatures during the nesting season. Cold, wet windy periods are the most significant factor of mortality during the nesting period.

Distance to rotary-wing flight procedures was apparently negatively associated with nesting success, however, based on 760 nests spanning 1995 through 2001, the pre-realignment effect was found to be similar to the post realignment effect. Additionally, nesting success was not associated with any of the noise metrics measured suggesting that noise from helicopters was not detrimental to coastal California gnatcatcher reproductive success. This suggests that the apparent effect of distance to helicopter procedures is not due to the introduction of helicopter noise. Further, regardless of the cause of the apparent effect, the nature and extent of this apparent effect did not change with the addition of helicopters.

The correlation between *Baccharis sarothroides* height and distance to rotary-wing flight procedure patterns suggests a biological mechanism, independent of noise that may explain the spatial gradient in nesting success that appeared to be associated with distance to rotary-wing flight procedures. The western part of the Station is composed of taller older stands of *Baccharis sarothroides* often dominated by standing-dead woody stems not suitable for nesting success. The eastern part of the Station, which had been more recently disturbed by fires, tends to be dominated by younger stands of *Lotus scoparius* interspersed with other coastal sage species and gaps in the shrub layer. These conditions were more suitable for nesting success resulting in an east-west gradient in nesting success. As a result nests in the eastern part of the Station (away from the majority of the rotary-wing flight procedures) were more successful than those in the older overgrown stands of coastal sage found in the western portion of the Station closer to rotary-wing flight procedures and the flight lines.

4.2 NEST SITE SELECTION

Univariate tests showed that CAGN preferred nesting in noisy areas close to the developed areas of the Station and helicopter training routes when the habitat characteristics were favorable for nesting. However, after adjusting for the effects of habitat and physical factors on gnatcatcher nest site selection, this association with noise was not apparent.

The initial univariate analysis showed that gnatcatchers preferred noisy areas close to developed areas of the Station and the helicopter training routes. In spite of this apparent association between nest site selection and the noise environment, the analysis indicates that the primary factors influencing coastal California gnatcatcher nest site selection continues to be habitat and physical factors necessary for successful reproduction. The primary factors controlling nest site selection were vegetation stands dominated by coastal sage species with ready access to areas with a dense forb understory. These factors apparently provide gnatcatchers with the cover and forage necessary for nests to fledge. The apparent positive association between CAGN and noise metrics is not plausible from a physiological perspective, and in fact was explained through the spatial distribution of habitat and physical features that we measured.

After adjusting for variation in habitat and other factors, gnatcatchers were equally likely to select quiet and noisy areas for nesting. This indicates that gnatcatchers find and inhabit suitable nesting habitats in spite of the noise environment. This, combined with the fact that nest success is equally likely in quiet and noisy areas within the Station, indicates that CAGN find and utilize available suitable habitats and that when those habitats are occupied, nesting success is unaffected by noise associated with helicopter over-flights.

In general, CAGN selected low elevation southeast facing slopes, densely vegetated (low percent of gaps in the vegetation) with *Artemisia californica*, *Baccharis sarothroide*s, and *Eriogonum fasciculatum* and a well developed forb understory. Coastal California gnatcatchers avoided areas dominated by *Lotus scoparius*, *Rhus integrifolia*, *Baccharis salicifolia* and *Malosma laurina*. The three most important factors controlling the distribution of CAGN nest site selection were elevation, and distribution of *Artemisia californica* and *Baccharis sarothroides*.

It is interesting that gnatcatchers select for *Baccharis sarothroides* in spite of the negative association between the height of *Baccharis sarothroides* and nest success rates. We believe that this apparent selection for less productive habitats may be due to interactions between habitat types and successional stage (i.e. CAGN prefer and select coastal sage species in general, but when these stands are at later successional stages with a high proportion of standing dead wood and a paucity of grasses and forbs, production may be reduced.)

4.3 FLEDGES PER PAIR

Statistical models describing the variation in habitat and the noise environment on fledge production were developed to determine if differential success rates were compensated by multiple nesting attempts. Because nesting success was determined to be associated with a combination of six factors; height of *Salvia mellifera*, *Lotus scoparius*, and *Baccharis sarothroides*; topographic curvature, percent cover of gaps and fall hydrologic drought index, these factors were tested to evaluate the effects of variation in habitat and the noise environment on fledge production.

We found that only the height of *Salvia mellifera* was negatively associated with the number of fledges per pair. When the noise metrics were tested, the number of chicks fledged per pair was similar in both high and low noise environments. In fact, coastal California gnatcatchers fledged slightly more chicks in noisy than in quiet areas.

5.0 CONCLUSION

The objective this study was to evaluate the existence and magnitude of the effects of helicopter noise on California gnatcatcher reproduction. In order to accomplish this, several years of gnatcatcher monitoring data, acoustic monitoring data and vegetation monitoring data were collected throughout MCAS Miramar. These data were used in the statistical analysis to evaluate any potential effects on nesting success, nest site selection and fledges per pair. The majority of the pairs were monitored from 1998 through 2001 but when possible the statistical analysis included data collected on 760 nests studied from 1995 through 2001.

When these data were analyzed, we determined that the noise levels on the Station did not affect the reproductive success of the GAGN population. It was found that coastal California gnatcatchers find and inhabit suitable nesting habitats in spite of the noise environment and that nest success is equally likely in quiet and noisy areas within the Station. This indicates that if suitable habitat is there, gnatcatchers occupy and successfully fledge young in these areas.

The factors affecting nest success and nest site selection were habitat, topography and rainfall. Habitat was the only factor affecting the number of fledges per pair. So noise, specifically noise produced by the CH-46 and CH-53 helicopters stationed at MCAS Miramar did not affect nest success, nest site selection or number of fledges per pair.

Specifically, nest success was highest in areas that were concave up such as drainage bottoms with relatively tall stands of *Lotus scoparius* and interspersed gaps in shrub cover vegetated with forbs and grasses suitable for CAGN prey production and when the Palmer Hydrological Drought Index was high during the fall prior to the breeding season. Gnatcatchers were less successful in tall (older) stands of *Baccharis sarothroides* and *Salvia mellifera* with an understory dominated by dead leaf litter

Gnatcatchers tended to select areas to nest in that are dominated by shrub stands of *Artemisia californica*, *Baccharis sarothroides* and *Eriogonum fasciculatum* and avoided habitats dominated by *Isocoma menziesii*, *Malosma laurina*, *Baccharis salicifolia*, *Lotus scoparius* and *Rhus integrifolia*. It is interesting that gnatcatcher pairs would select for areas dominated by shrub stands of *Baccharis sarothroides*, which was negatively associated with nest success and avoid areas dominated by *Lotus scoparius* which was positively associated with nest success. We believe that the successional stage of coastal sage species may be an important factor in determining success rates.

This study provides important information regarding the management of the coastal California gnatcatcher because, for the first time, the ecological habitat requirements and noise environment factors important to nesting success have been quantified. Gnatcatchers are successful in large expanses of early successional, low growing, quality coastal sage scrub habitat with a well-developed forb understory. If the coastal sage scrub habitat is low quality, late successional, with dead leaf litter overtaking the forb layer with few gaps and a high proportion of *Baccharis sarothroides* and *Salvia mellifera* the chances for successful nesting decreases.

Noise levels on the Station were cyclical, with much of the high levels of noise from highways almost constant during the mornings and afternoons. Flight operations contributed noise cyclically during the day. The total time of exposure to high levels of noise was small, in excess of 60 dBA for less than 5% of the monitored time and in excess of 80 dBA for less than 0.5% of the monitoring period.

Sound meters collected data on all the sources of noise at each location, with a portion contributed by helicopters. The study showed the gnatcatchers adapted to the total of noise sources and that habitat was the determining factor in nest selection and nest success. These data suggest that environmental noise and specifically helicopter noise did not affect nest site selection, nesting success rates nor pair productivity on the Station.

Management strategies for the coastal California gnatcatcher that focus on increasing habitat quality that favors the reproduction of the CAGN would be more effective than attempting to modify the noise environment.

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APPENDICES

APPENDIX A

Glossary of Acoustic, Ecological and Statistical Terms

The following glossary of terms is for the convenience of the reader and should not be interpreted as a set of technical definitions. The following glossary can be used for aid in conceptual understanding of acoustical, ecological and statistical methods. For technical definitions and further detail, the reader is referred to the references associated with these terms in the text.

$\hat{z}_i$	Predicted value at location i.
|h|	The distance between points without considering direction.
"Flagged in the field"	When a point of interest is marked by a piece of plastic tape for future reference.
24HL	Time-averaged A-weighted sound level during a 24 hour period.
7DAV or 7DEQ	Time-averaged A-weighted sound level during a 7 day period. The letter symbol is LA1Wk or LAeq, T= 7 days.
a	Effective width of smoothing in kernel smoothing
Active nest	A nest in which at least one egg is laid or one chick is alive.
Adaptive kernel plot	A method for determining home range sizes.
Adult bird	A bird that has the ability to breed.
AIC model	Akaike Information Criterion (AIC; Akaike, 1973) is a popular method for comparing the adequacy of multiple, possibly nonnested models. Akaike weights can greatly facilitate the interpretation of the results of AIC model comparison procedures.
Areal	Of or pertaining to an area.
Aspect	The direction a slope faces. Aspect compass direction north is 0.

A-weighting	An electronic filter applied to sound pressure level measurements. It discriminates against low frequencies so that the sound measurements correspond more closely the response of human hearing to many types of noise. All sound level meters must be able to measure A weighted sound pressure levels.
B	symbolic representation of rectangular area where average noise is predicted.
Banding	The placement of one or more small plastic or metal rings around a bird's leg in order to identify individuals from a distance or from year to year.
Belt Shrub Height	The height of shrubs measured in a Belt Transect vegetation analysis.
Block Kriging	A kriging algorithm where predictions are of the average over a specified spatial domain as opposed to prediction of the value at a single point. Block kriging is used in these analyses where the block is selected to represent a small area within which nesting birds are likely to spend the majority of their time.
Block Transect	A transect that has width as well as length and height, as opposed to a line transect that has only length and height.
Breeding season	The time when California gnatcatchers are participating in actual nesting activities, i.e. nest building, egg laying, etc.
Brooding	The act of sitting on or hatching the eggs by the parents.
c	Covariance estimates.
C	Covariance matrix for the data locations.
c_0	measurement error.
California gnatcatcher	Polioptila californica californica. A small, rare bird that is a year round, resident of the

	coastal sage scrub of southern California and northern Baja California Mexico.
Canopy cover	The area of ground directly beneath a plant which is covered (shaded) by the plant above. See individual overlap foliar cover.
C$_{ji}$	A vector containing the covariance between the j^{th} data location and the i^{th} location at which a prediction is to be made.
CESAR lab	The Center for Earth Systems Analysis Research at San Diego State University. Vegetation maps and other plots are generated in this lab.
Chaparral	A biome or vegetation community that is mostly comprised of woody shrubs which are adapted to periodic fires. Common in southern California.
Class 1 roads	Major roads and primary highways that have 4 or more lanes.
Clutch (size)	The number of eggs produced or incubated at one time. A bird attains a full clutch when it stops laying eggs in any given nest. For gnatcatchers, full clutches are 4 eggs, although nests with 3 or 5 eggs are not uncommon.
Clutch start	The date at which the first egg in a clutch is laid.
CNEL	Community noise equivalent level. Twenty-four hour average A-weighted sound level for a given day, after addition of five decibels to sound levels from 1900 to 2200, and after addition of ten decibels to sound levels from 0000 to 0700 and from 2200 to 2400. DNL is preferred.
Coastal sage scrub	A threatened community of aromatic, mostly deciduous subshrubs that is indigenous to southern California.
Color codes	The specific colors on the bands of any one bird that identify that bird. USFWS has

	assigned a red and yellow split color band to designate Miramar.
Composition	When referring to vegetation, the numbers and types of plant species that exist in a given area.
Contingency table	A statistical method by which two similar groups are compared for differences between them.
Contour (line)	An imaginary line, or its representation on a contour map, joining points of equal elevation.
Correlation Coefficient	The correlation coefficient (rR) is a number that varies between –1 and +1. A correlation of –1 indicates there is a perfect negative relationship between the two variables, with one always decreasing as the other increases. A correlation of +1 indicates there is a perfect positive relationship between the two variables, with both always increasing together. A correlation of 0 indicates no relationship between the two variables.
Corvidae	Avian family that includes crows and ravens.
Cosine	A trigonometric function of an angle, used among other things in modeling periodic phenomena. Abbreviated cos.
Curvature	As used in GIS, curvature is the second derivative of the elevation surface, or the slope of the slope. The curvature of the surface is calculated on a cell-by-cell basis at each cell center, as fitted through that cell and its eight surrounding neighbors. A positive curvature indicates the surface is upwardly convex at that cell. A negative curvature indicates the surface is upwardly concave at that cell. A value of zero indicates the surface is flat.
Curvature 30	This variable is the topographic curvature of the land derived on a digital curvature model. A digital curvature model is a cell based system of storing curvature values

	over an area. The cell size in this case is 30 meters.
Decibel	For sound pressure, this is a dimensionless unit that denotes the ratio between a measured sound pressure and a reference sound pressure. The number of decibels is 20 times the logarithm to the base 10 of this ratio. The unit symbol is dBA. In air, a sound pressure of 1 Pascal equals 94 dBA. See "sound pressure level."
Deciduous	Leaves that drop off before winter.
Depredation	To prey upon; to plunder. When a nest is destroyed by a predator in search of eggs or young birds.
Descriptive Statistics	Basic statistical calculations such as number of observations, mean, standard deviation, standard error, maximum value, minimum value and median.
Deterministic Noise Modeling	Methods for predicting the spatial distribution of noise based predominantly on theoretical properties based on the physics of noise propagation.
Diegan Coastal Sage Scrub	The wide-spread coastal sage scrub in coastal southern California from Los Angeles into Baja California, Mexico. Low, soft-woody subshrubs (to ca. 1m high) that is most active in winter and early spring. Dominated by California sage (*Artemisia californica*) and flat top buckwheat (*Eriogonum fasciculatum*).
Dispersal	The distance and direction away from the nest (or the last known site) that a fledgling moves after it leaves its parents.
E	Statistical expectation.
Elevation 30	This variable is the elevation of the nest derived on a digital elevation model. A digital elevation model is a cell based system of storing elevation values over an area. The cell size in this case is 30 meters.

Empirical Noise Modeling	Methods for predicting the spatial distribution of noise based predominantly on field measurements of noise.
Fast Fourier Transform (FFT)	A mathematical algorithm that is used to transform real-time data into a frequency spectrum. The FFT is performed over a defined number of samples, known as the sampling window (2048 pts., 4096 pts. , 8192 pts., 16384 pts., etc.).
Fast sound level	All sound levels are actually the average level during a finite time. When the time interval is 125 ms and the measurement is exponentially weighted to favor the most recent pressure fluctuations, the meter has a fast response. For rapidly fluctuating signals, fast response and slow response (1 sec exponential averaging time) give different numbers, so the time response should always be stated. Otherwise, fast response is assumed.
FFT Weighting	FFT weighting serves to smooth the transitions on either side of a sample window in the time domain. There are numerous types of FFT weightings, including Flattop, Rectangular, and Hanning.
Fledge	When a nestling bird leaves the nest.
Fledgling period	The amount of time required for a parent to feed fledglings before they disperse (or the time between fledging and dispersal).
Fledgling	A young bird that has recently acquired its flight feathers. A fledgling has left the nest but remains with the parents.
Floristic Composition	Species of plants that occupy a specific area or habitat.
Flush	To frighten a bird from cover (such as a nest).
Forbs	A flowering plant with a non-woody stem that is not a grass.

Gain	The amount of energy applied to an incoming signal in order to increase that signal's amplitude.
Gap Count	The number of gaps or spaces between plants in a transect.
Gap Length	The measured length between plants in a transect.
Generalized Linear Models	An extension of regression modeling where the observed values may take on discrete values, and maximum likelihood methods are used to estimate parameters.
GIS	Geographic Information System. A computerized software system that can store, retrieve, and manipulate geographic information (digitized maps/database files).
GLS	Generalized least squares.
GPS	Global Positioning System. A satellite based electronic system used to locate a position upon the face of the earth.
H	A statistical term computed by ranking all observations from smallest to largest without regard for the treatment group. The average value of the ranks for each treatment group are computed and compared. If H is small, the average ranks observed in each treatment group are approximately the same. There is no statistical difference. If H is a large number, the variability among the average ranks is larger than expected from random variability and you can conclude that the differences are statistically significant.
h_0	Zone of influence is the distance at which sampled data are considered uncorrelated.
Habitat Structure	The description of a habitat with vegetative species and the physical forms and characteristics of a given vegetational area.

Habitat Composition	The various species of plants that are present in a habitat.
Habitat	The area or type of environment in which an organism or biological population normally lives or occurs.
Harmonic mean	The average of all of the data for a particular trait used for determination of the home range.
Hectare	A metric spatial measure 0.404686 hectares = 1 acre.
Herb	An annual, non-woody plant.
Home range	The area used by a particular set of birds for a given period of time.
Homoscedastcity	Statistical term. All samples are from populations with identical variances.
Hydrologic Drought Index	Water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff) to determine the extent of drought condition in an area.
Incubation period	The amount of time required for a parent to sit on the eggs before they hatch (or the time between the egg-laying and the egg-hatching).
Independent (Independence)	Not dependent on other variables. The condition whereby one action or event does not affect another.
Individual overlap foliar cover	The total cover values for the canopy of a given area (individual plant). The sum can be greater than 100% when two or more plants overlap in canopy cover.
Juvenile	A young animal (bird) that has not reached sexual maturity. A sub-adult. A fledgling that has left the parents.

k	1,2,3...
Kernel Smoothing Technique	An interpolation method which relies on weighted averaging with weights proportional to a specified function, the kernel. For work performed here a Gaussian kernel is used.
Kriging Models	A statistical interpolation method which incorporates spatial correlation in sample data to predict values at unsampled locations and to quantify the uncertainty in predicted values.
Leq	Equivalent continuous sound level. The average time-weighted sound pressure level (usually 1-hour).
Line transect	A method for data collection in the field where a line is followed a given distance and all appropriate data are recorded along that line. A large area can be sampled quickly by dividing it transversely with line-transects.
Linear Averaging	A method of sampling wherein all samples contribute equally to the calculated levels. This is different than exponential averaging in which the most recent samples contribute more than earlier samples to the calculated levels.
Line-Transect Transect	A two dimensional line that intersects plants in a survey. It is two dimensional only, length and height.
Lmax	Maximum level. The highest fast time-weighted, A-weighted sound level within a measurement period. The letter symbol can be L_{AFmx} and the abbreviation is MXFA.
Lmin	Minimum level. The lowest fast time-weighted, A-weighted sound level within a measurement period. In truly quiet conditions, this number may be the noise floor of the measuring instrument. The abbreviation is LMIN.

Ln	The n-percentile or statistical level. The fast A-weighted sound pressure level that is equaled or exceeded N% of the time. For example, L50 is the A-weighted sound pressure level exceeded 50% of the time. The abbreviation is LN. This measure is not defined in ANSI S1.4, but is in common use.
Logistic Regression Models	A particular generalized linear model where the residual errors are assumed to be distributed as binomial random variables.
Masking Threshold	The sound level over a defined frequency bandwidth that just prevents detection of another sound within that same bandwidth.
Mean	The average value for a column of measurements.
Median	The "middle" observation. All values are listed, from smallest to largest, and the largest value of the smallest half is the median. There are an equal number of values greater than and less than the value.
Minimum convex polygon plot	A method in which the outermost points where a bird (or other animal) was spotted are connected to determine a minimum home range. This method tends to fill more non-used habitat than other methods.
Minimum mapping unit	A minimum mapping unit is the smallest amount of space that can be used to clearly classify an area. For the scrubland vegetation in this study, the minimum mapping unit was assigned to be 1 acre.
Mist net	A fine-threaded net used to capture flying creatures, birds, bats, etc. It is virtually invisible when set up.
Modal (Mode)	The value or item occurring most frequently in a series of observations or statistical data (e.g. the most frequently measured length).
Moore Penrose Generalized Inverse	Matrices which are theoretically positive definite are often close to singular up to

	numerical precision. To handle matrix inversion in these situations the generalized inverse is used to improve computational stability. The generalized inverse is not unique, and the Moore Penrose generalized inverse is a particular generalized inverse.
Mortality rates	The frequency in the number of deaths in proportion to a population: death rate.
mse	Mean squared prediction error
N	Statistical term for the number of observations
Nest Based	Transects and sound level meters placed in close association to a nest in the study area.
Nestling period	The amount time required for a parent to feed nestlings before they fledge (or the time between the egg-hatching and fledging).
Non-breeding season	The time of year when California gnatcatchers are involved in post-nesting, non-breeding and pre-nesting behavior.
Nonlinear Least Squares	An estimation technique used for models where the observed data are a non-linear function of the model parameters. As with ordinary least squares the sum of squared errors is minimized to estimate parameters.
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Nonlinear Least Squares	An estimation technique used for models where the observed data are a non-linear function of the model parameters. As with ordinary least squares the sum of squared errors is minimized to estimate parameters.
Normalcy	Statistical term. Normality.
OLS	Ordinary least squares regression residuals.

Ordinary Least Squares Regression
Regression functions where parameters are estimated using minimization of the sum of squared errors. Each data value receives equal weight in the minimization.

Orthophoto
A type of aerial photo that has been corrected for distortion.

P value
The probability of being wrong in concluding that there is a true difference in the groups (i.e., the probability of falsely rejecting the null hypothesis, or committing a Type I error, based on H). The smaller the P value, the greater the probability that the samples are significantly different. Traditionally, you can conclude there are significant differences when $P < 0.05$.

PDSI
Palmer Drought Severity Index. Or the *Palmer Drought Index (PDI)* measures the duration and intensity of the cumulative drought-inducing factors of supply (precipitation), demand (evapotranspiration) and loss (runoff). It basically measures precipitation factors that can change rapidly in the short term.

PHDI
Palmer Hydrologic Drought Index. A method to determine the amount of precipitation required to bring a drought condition back to normal. These factors change slowly, so it is a longer term analysis than the PDSI. It is a very useful index of drought condition because it accounts not only for precipitation totals, but also for temperature, evapotranspiration, soil runoff and soil recharge.

Peak A-Wt
Peak sound level. The level of the maximum instantaneous A-weighted peak sound pressure within a measurement period. The letter symbol is L_{Apk} and the abbreviation can be PKA.

Peak Flat	Peak sound pressure level. The level of the maximum instantaneous unweighted peak sound pressure within a measurement period. The abbreviation is PKT and the letter symbol is L_{uwpk}.
Plumage	The feathers of a bird . California gnatcatchers have different plumage depending on whether the bird is a juvenile, non-breeding or breeding male.
Points (mapping)	A data point. A place on a map where a bird, or other animal was observed, sound level meter location, real-time monitoring site location, etc.
Poisson Regression Model	A particular generalized linear model where the residual errors are assumed to be distributed as Poisson random variables.
Polytomous Regression Models	A particular generalized linear model where the residual errors are assumed to be distributed as multinomial random variation.
Positive Definite Functions	A positive definite covariance function guarantees that estimates of the kriging prediction error are positive and that mathematical solution of kriging equations are well conditioned.
Power	The strength of a statistical test. The higher the power of the test, the stronger the conclusion. Generally, the less assumptions and more data, the higher the power.
Primary Community	The primary plant community, like coastal sage scrub (css), is understood to be the most dominant and important community in the area of the study area or polygon referred to.
Pcss	Abbreviation for Primary Coastal Sage Scrub.
r, R	Regression residuals.
R^2	The proportion of variation in the dependent variable (nest success) on the Y or vertical

	axis, accounted for by the independent variable displayed on the X or horizontal axis.
Random Function	In space which exhibit spatial patterns at various scales.
Random sample	Of or designating a sample drawn from a population so that each member of the population has an equal chance to be drawn.
Raw data	Un-analyzed data.
Regression Functions	Statistical models where the sum squared differences between observed data and theoretical models minimized to estimate model parameters.
Renests	The act of building another nest after fledging or a previous one was destroyed or abandoned. As long as conditions are favorable, many birds will renest in the same year.
Resident adults	Those birds that live in and guard a particular territory.
Residual	The difference between observed data and theoretical models.
Sample (size)	A set of elements drawn from and analyzed to estimate the characteristics of a population (the number of such elements).
Sampling Frequency	The range of frequencies that is able to be recorded. This is dictated by the sampling rate. One-half the sampling rate determines the highest frequency that can be evaluated at that sampling rate (e.g.: 44100Hz sampling rate = 22050Hz highest frequency).
Sampling Rate	Number of samples collected per second (one sample per second is 1 Hz).
Sclerophyllous	Having hard and stiff leaves, as in manzanita.

Shrub	Any large, woody plant, generally between 1-4 m tall that has multiple trunks.
Significant (Significance)	When a perceived pattern or difference is statistically meaningful. An observation must be significant in order to be concluded.
Slope	A measure of how steep the land is, varies from 0 for flat land to 90 degrees vertical cliffs.
Slope angle	The measured angle from the horizontal of a given slope.
Slope aspect	The direction of a slope-face (e.g. north by northeast, etc.).
Smell	In this use, it is an abbreviation for *Salvia mellifera*, used in tables where space is not available to spell out. Other words will also be abbreviated in tables and figures when necessary. Other definitions include the olfactory response of the sense of smell.
Sound Exposure Level (ASEL)	A measure of the total sound energy in a transient event. The squared, frequency-weighted instantaneous sound pressure during an event is integrated to give the sound exposure, which is then converted to sound exposure level. Abbreviated SEL or ASEL if A-weighted.
Sound level	A-weighted sound pressure level. Standard practice in community noise measurement assumes that sound pressure levels are A-weighted unless otherwise stated. The letter symbol is L_A and the abbreviation is SL.
Sound Pressure Level (SPL)	The difference between static pressure and the pressure generated by a sound source, measured in Pascals and expressed as: 20 $\log_{10} (p_1/p_0)$. Where p_1 is the measured sound pressure and p_0 is the standard reference pressure 20 µPa in air and 1 µPa in water). The abbreviation is SPL and the letter symbol is Lp.

Spatially Auto-Correlated	Collection of random variables indexed to locations.
Splines	Mathematical method of interpolation of unknowns between known data samples. The methods do not allow easy introduction of covariates into the interpolation scheme.
Standard Deviation	The measure of data variability about the mean.
Standard Error	A measure of how closely the sample mean approximates the true population mean.
Structural	When referring to vegetation, the physical forms and characteristics of a given vegetational habitat (i.e. heights and widths of trees, bushes, etc.).
Student's t-test	A variety of statistical test used to detect the degree of difference between two sets of comparable values.
Subshrub	A plant with the lower stems woody, the upper stems and twigs not woody (or less so) and it dies back seasonally.
Substrate	The foundation or groundwork for something. The type of vegetation or the surface upon which a nest is attached.
Success (nest)	A nest is considered successful if at least one nestling fledges.
superscript +	Generalized inverse of a matrix.
Survivorship	Similar to mortality rate. The percentage of birds that survive from year to year (usually broken down by age).
^{T}	Matrix transpose operator (rows are interchanged with columns).
Time-weighted Average Sound Level	Also called the equivalent continuous sound level, it is not the arithmetic average of individual levels, but is the time-mean-square sound pressure over a stipulated

	time, usually one hour or 24 hours, expressed in decibels referred to a standard pressure. This average is equivalent to the sound level that would be produced by a lower level steady sound in the same period. Unlike fast or slow sound levels, this measurement is not exponentially weighted to favor the most recent pressure fluctuations. Measurement requires either an integrating sound level meter or a spectrum analyzer. A weighting is assumed unless otherwise stated. The abbreviation is TL, where T is the time period; e.g., 24HL for 24 hour average sound level.
Tone or tonal	A sound that has pitch. It may have harmonics or be a pure tone with only the fundamental frequency. We hear tonal sounds as a whistle, or squeal.
Topographic Curvature	The curvature of the terrain in a study area, a hillside is convex, a valley with upward sloping sides is concave.
Transect	A path along which a researcher moves, counts and records his observations.
u_i	A vector of covariates measured at the i^{th} location at which a prediction is to be made.
Universal Kriging Model	A kriging model which incorporates spatial correlation and large scale trend models for prediction at unsampled locations.
Un-paired adults	Birds that can breed but have no mates.
V	Covariance stationary.
Vegetation Gap	A space or distance between plants in a vegetation transect.
Vegetative cover	The (percent) area of the ground which is covered or shaded by living vegetation.
w	Smoothing weights used in kernel smoothing algorithm.
W	Sum of all kernel smoothing weights.

Wide-band noise	A non-tonal sound with its power spread over a range of frequencies. White noise has equal sound power at all frequencies in the band. Other kinds of wide-band noise, such as jet engine noise, generally have more energy in some parts of the band than at others. Wide-band noise does not have pitch; we hear it as a roar or rushing sound. However, it may combine with tonal noise, such as jet engine whine.
X	Data matrix of regression covariates (predictors).
Z	The vector of sound meter readings (noise levels).
β	Regression coefficients.
μ	Constant mean ($E\{R\} = \mu = 0$)
σ^2	Theoretical variance.

APPENDIX B

Summary Table of Noise Metrics for Sound Monitoring Systems

Field Name	Field Type / Units	Contents	Constraints*	Use During Analysis
Location Number	Alphanumeric	Meter site identification code	Must be verified at HSWRI	Used on maps, etc.
Run Number	Alphanumeric	Sampling period at that site (1st, 2nd, etc)	< 5	For estimate of site variability
Meter Number	Alphanumeric	Last four digits of meter serial number	Must be verified at HSWRI; 4 digits	Troubleshooting for bad meters
Latitude		Site latitude		
Longitude		Site longitude		
Start Date	Date		Within breeding season	
End Date	Date		Within breeding season	
Start Month	Integer	Month that sampling began	Feb-August	Search for seasonal variation in data
Run Time (Days)	Decimal days	Days in operation (decimal #)	Flag if > 15	Estimate of effort
Run Time (Hours)	Decimal hours	Hours in operation (decimal #)	Flag if > 15*24	Estimate of effort
Event Time (Hours)	Decimal hours	Total time above meter threshold (70 dBA)		Estimate of total time of exposure to aircraft overflights
Background Time (Hours)	Decimal hours	Total time below meter threshold	**Must be < Run Time (Hours)**	Estimate of ambient sound pressure level (without aircraft)
Total Leq (dBA)	A-weighted Leq/dBA	Leq, all samples included	Flag if < Background Leq or > Event Leq	Estimate of average sound pressure level (all sources combined)
Total ASEL (dBA)	A-weighted sound exposure level/dBA	Integrated sound exposure level of all events		Estimate of sound exposure in units proportional to energy
Lmax (dBA)	A-weighted maximum sound pressure level/dBA	Maximum sound pressure level (125 ms integration time; sampling interval 32 ms)	Flag if > 135	Maximum exposure in units of sound pressure
Max Event ASEL (dBA)	A-weighted maximum sound exposure level/dBA	Maximum sound exposure level (integrated over duration of event)	Flag if > 130	Maximum exposure in units proportional to energy
Unweighted peak (dBA)	dBA	Sample with highest magnitude (collected before weighting)	Flag if > upper limit for meter or if UwPk < Peak	Worst-case exposure
Peak duration (s)	Duration of peak event/s	Duration of event with the peak duration	Flag ANY event > 300 s; automatically eliminate records with event durations = 3600 s or <= 5 s	Used to eliminate peak events that probably aren't generated by aircraft (wind, croaking frogs, shotguns, meter malfunction, etc.)
Max Event Leq (dBA)	A-weighted maximum event Leq/dBA	Highest event Leq recorded during sampling period	Flag if > 100 or if > Background Leq	Maximum exposure in units of sound pressure; this measure correlates well with annoyance
Event Leq (dBA)	A-weighted Leq of all events/dBA	Leq of all events recorded during sampling period	Flag if > 135	Estimate of average event level
Background Leq (dBA)	A-weighted Leq of non-events/dBA	Leq calculated using all samples not collected during events	Flag if < L_{99}; eliminate if L_{99} is missing	Estimate of background levels in the absence of noisy sources
Signal to Noise Ratio	Event Leq –	Crude estimate of signal to noise	Flag if < 10 or > 45	Estimate of signal to noise ratio

	Background Leq/dBA	ratio		of noisy sources
Field Name	**Field Type / Units**	**Contents**	**Constraints***	**Use During Analysis**
L_{50}	dBA	Level exceeded by 50% of samples	Flag if absolute value of L50 – Background Leq > 200 or if doesn't follow the relation: $L_5 > L_{50} > L_{99}$	Second estimate of background levels; this one should be used preferentially
L_5	dBA	Level exceeded by 5% of samples	Flag if < 40 or > 80 or if doesn't follow the relation: $L_5 > L_{50} > L_{99}$	Estimate of worst-case exposures
A-weighted % of time > 60 dBA	Percentage	Measured by % of samples exceeding 60 dBA	Flag if > 50 or if %60 < %80	For USFWS
Time > 60 dBA (Hours)	Hours	Cumulative time at > 60 dBA	Flag if > 100 hr or if > Time80	For USFWS
A-weighted % of time > 65 dBA	Percentage	Measured by % of samples exceeding 65 dBA	Flag if > 50 or if %65 < %80	For USFWS
Time > 65 dBA (Hours)	Hours	Cumulative time at > 65 dBA	Flag if > 100 hr or if > Time 80	For USFWS
A-weighted % of time > 80 dBA	Percentage	Measured by % of samples exceeding 80 dBA	Flag if > 25	Estimate of potentially injurious exposure
Time > 80 dBA	Hours	Duration of samples exceeding 80 dBA	Flag if > 50 hr	Estimate of potentially injurious exposure
RMS Excd Threshold (dBA)	Event threshold/dBA	RMS exceedence threshold; calculated by exponential time average of A-weighted samples	Flag if <> 70	Needed in case we have to change the value at one site or the other
Duration Threshold (s)	Seconds	Minimum duration of events	Flag if <> 5 s	In case it changes
RMS Excd Count	Integer	Total number of times threshold exceeded	Flag if > 4000	High numbers of exceedence counts indicate possible wind noise problem
Event Count	Integer	Number of A-weighted events > threshold	Flag if > 1500	Estimate of number of noise disturbances
% Event Counts	Percentage	RMS Excd Count-Event Count/RMS Excd Count	Flag if > 50%	Index of wind noise in data
Number of Events > 80 dBA	Integer	Number of worst-case exposures	Flag if > 400	Estimate of worst-case exposure
Event Duration >3000 s	Integer	Event duration	Flag if >3000	If durations=3600, the meter was malfunctioning

Flags: When we checked the data, we flagged values that weren't totally impossible, but were unreasonable enough to warrant a close look. The criteria we used are indicated as follows: "flag if X".
Sampling: The meter collects 32 samples/second, for a sampling interval of 31.35 ms.
Integration times: There are two conventional integration times, slow and fast. Slow means samples were integrated over a 1 s period (32 samples). Fast means samples were integrated over a 125 ms period (4 samples). L_{max} is a fast-weighted value. Peak values are based on single samples. There are also values with variable integration time (e.g., event duration).
Exceedence threshold: The meters collected an exceedence when the exponential time-averaged, weighted SPL exceeds the threshold value (70 dBA).

APPENDIX C

Real-time monitoring of aircraft and other noise sources at MCAS Miramar

1.0 REAL-TIME MONITORING

This section describes the analysis of the noise contributed by aircraft and other sources to the total noise levels of MCAS Miramar. As described, noise metrics collected by the sound level meters (LD 720) do not identify noise sources or the individual sources in the ensemble of noises that produce the background levels recorded in each area of the Station. To estimate the contribution of each source to the overall exposure reported by the LD 720s, a set of representative sites was chosen and real-time recordings were made by observers who remained on site throughout the recording periods.

2.0 METHODS

A total of ten days of real-time recording in conjunction with LD 720 monitoring was completed at ten sites (Figure 1) on the Station between 8 June and 6 July 1999 and 23 May and 10 August 2000. Sites were chosen to monitor a representative sample of noise exposure across the Station. Each recording day was divided into five one-hour recording blocks (0800-900, 1000-1100, 1200-1300, 1400-1500, 1600-1700) interspersed with four non-recording sessions (observational note-taking only).

Real-time recordings were made using a two-channel Sony TCD-10 Pro II DAT recorder (16-bit stereo, 44.1 kHz sampling frequency, 20 Hz - 22.5 kHz bandwidth) and a matched pair of ACO Pacific Inc. Type 7013 pressure microphones with Type 4012 preamplifiers. The microphones were covered with 20 cm open-pore foam windscreens. The two preamplifiers were set at different gain settings in order to maximize the dynamic range of the recording system. At the start of each recording, a signal from a B&K 4230 calibrator (1 kHz, 94 dBA RMS SPL) was recorded to ensure that calibrated levels could be obtained during analysis. An LD 720 was deployed for nine hours with the settings normally used for nest site monitoring. Three galvanized poles arranged in a triangle were used to mount the ACO and Larson-Davis microphones at a height of 1.3 meters. The microphones were separated by 1.5 meters.

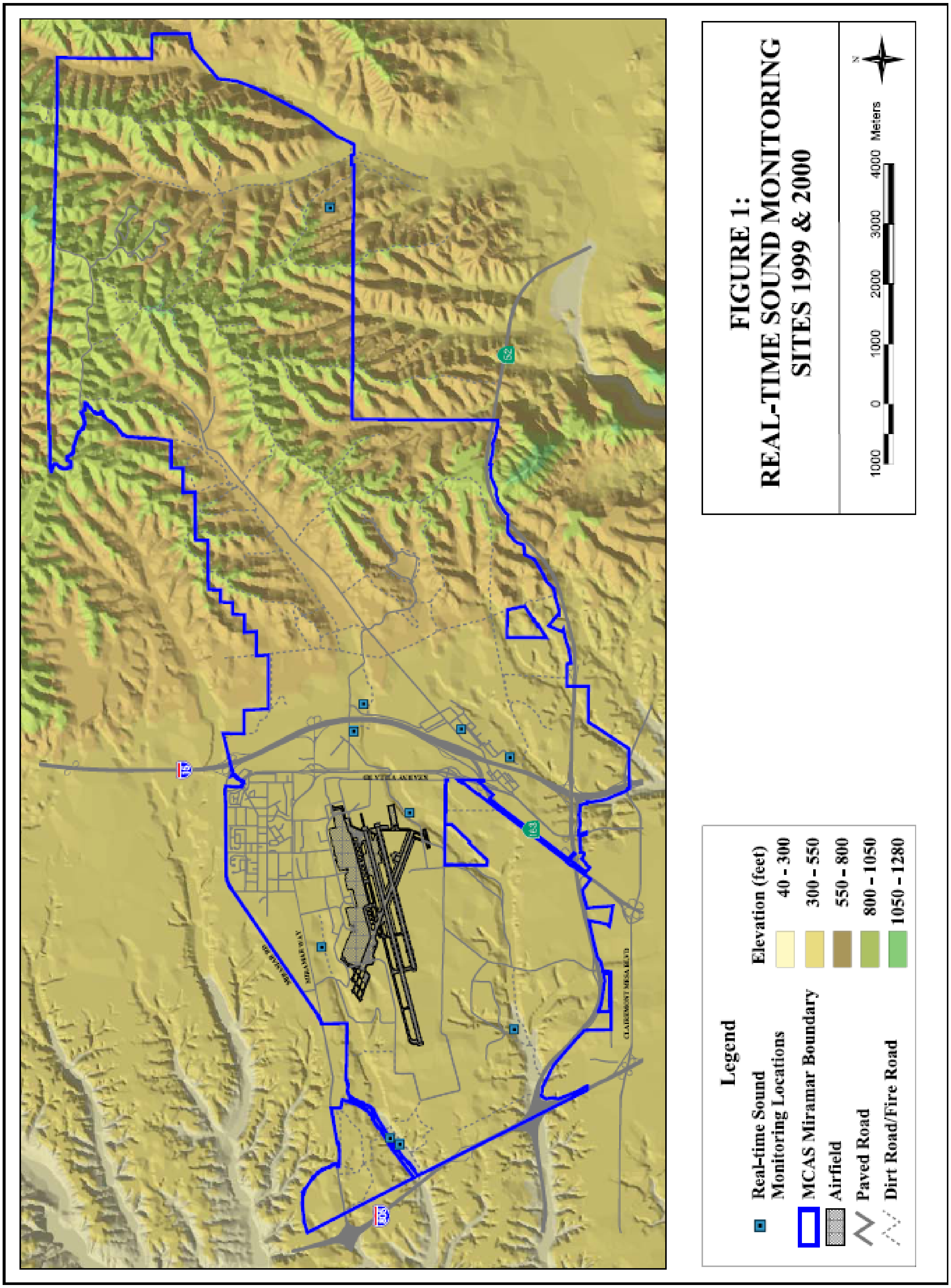


FIGURE 1:
REAL-TIME SOUND MONITORING
SITES 1999 & 2000

Observers made annotated records of all sound event sources during recording sessions using a laptop computer and the Observer 3.0 software program (Noldus, Inc.). Sound sources noted included aircraft, automobiles, trains, human voices, gunfire, construction, insects, and wind moving vegetation. Constant sources, such as birdcalls, were characterized qualitatively in field notes. The time of occurrence and duration of each sound event was noted, and overflights were characterized by type, number of aircraft, and proximity of aircraft to recording site. A Davis Instruments anemometer and WinDisplay software program were used to record wind speed and direction during recording sessions.

Data from WinDisplay and the Observer were summarized for each recording session and compared to corresponding LD 720 sound event reports. The source of each sound event recorded by the 720 was identified by observers and entered into a spreadsheet. The frequency of events other than aircraft overflights was counted. These sounds were included in the calculation of average sound level because they are still part of the overall noise environment in the vicinity of gnatcatchers.

In addition to real-time monitoring and sound recording, bird behaviors during overflights were viewed using binoculars, and vocalizations were recorded using a directional microphone and Tascam DA-P20 DAT recorder (20 Hz-20 kHz, 91 dBA dynamic range.

Real-time recordings of events detected by the LD 720s were analyzed. Sound events were digitized into Spectra Plus using a Turtle Beach Tahiti Pro sound card. Narrowband sound power spectra were calculated using Spectra Plus 2.32 (Sound Technology, Inc.; 44.1 kHz sampling rate, 2048 point FFT: linear averaging, Hanning window). Third octave band spectra were calculated using a Stanford Research Systems (SRS) 780 Signal Analyzer (44.1 kHz sampling, linear averaging).

Subsets of sound events were chosen as representative samples of high, intermediate and low amplitude sound events. Third-octave band spectra were generated for these events and combined to show the sound pressure level exceeded by 5%, 50% and 95% of aircraft overflights in each 1/3-octave band. These percentile spectra were then compared to spectra of gnatcatcher "mew" calls to demonstrate the masking potential of overflight noise.

In order to get a representative sample of different types of noise environments, a total of ten days of real-time recording in conjunction with LD 720 monitoring was completed at ten sites on the Station between 8 June and 6 July 1999 and 23 May and 10 August 2000 (See Figure 1). Sites were chosen to monitor a representative sample of noise exposure across the Station.

2.1 Monitoring Site Locations and Descriptions

OW-02-99 was located approximately three kilometers southeast of the main flightline and just east of the I-15 and State Route 163 (SR 163) merge. At this site, aircraft pass directly overhead. Aircraft types observed were F-18, C-5, CH-46, CH-53, and UH-1. F-18s were the most common, passing overhead at 150-200 meters. Helicopters mostly flew across the Station one mile to the northwest, at an altitude of approximately 250-350 meters. During takeoff and landing training (touch-and-go), flight noise was constant. Aircraft were loudest when directly overhead, but were audible throughout the entire elliptical flight path.

RC-09-99 is located approximately 2.5 kilometers west-northwest of the flightline in Rose Canyon, an east-west oriented canyon. Train tracks (Amtrak and Coaster) run along the north boundary of the canyon approximately 100 meters from the recording site. Most aircraft passing overhead were single F-18s, although some flights of two to three were observed. The only helicopters observed were hovering to the west approximately two kilometers away. Two flight patterns were observed over this area. One pattern originated southeast from the flightline with the aircraft taking off and flying overhead (approximately 300-500 meters) to the northwest. The second pattern is associated with touch-and-go training, with aircraft taking off from the flightline and traveling south to southeast, in a circular pattern.

QC-02-99 is located in Quail Canyon; an undeveloped area predominated by hilly terrain and deep canyons approximately nine kilometers from the flightline. The recording site was located at the eastern boundary of the Station on a northeast facing slope. Air traffic in this area was minimal; five total events were recorded during real-time monitoring at this site. Military aircraft were seen and heard flying from the northwest to east-southeast at a distance of approximately four to six kilometers. Private aircraft were also noted in this area, flying from north to south at a distance of approximately one to two kilometers.

LSC-01-00 was located approximately 3.3 km east-northeast of the center of the runway west of the I-15 highway on a plateau that is at the same elevation as the runway. Jet aircraft approaching the runway for landing passed directly overhead, at an approximate height of 500-700 m. These aircraft could be seen but not heard during most of their elliptical flight path. Jet aircraft that were taking off could be heard, but not seen. Helicopters observed were 1.5 - 4 km to the west-northwest performing circular flights. A few helicopters were seen heading east passing directly overhead, but at heights greater than 2000 m, and were usually faint but detectable.

LSC-03-00 was located approximately 2 km east-southeast of the center of the runway and 1.25 km west of the I-15 and State Route 163 (SR 163) merge. This site is in a valley located northwest of the Skeet and Pistol Range. Most aircraft did not pass directly overhead because the location of this site is at the center of the elliptical flight pattern typically flown during touch and go exercises. Aircraft that landed directly without first performing a loop were seen approaching from the west-northwest and passing to the north (at approximately 1 km range) as they landed. Jet aircraft that were taking off could be heard, but not seen. Helicopters observed were 1 - 2 km to the north performing circular flights. A few helicopters were seen following the touch and go pattern of the jets and utilizing a landing pad approximately 0.75 km to the southwest.

MC-02-00 was approximately 13.6 km southeast of the center of the runway and lies immediately to the east of the I-15 highway (less than 1 km). Aircraft encountered here were mostly jets passing from the west to the northeast as part of their touch and go pattern; at a range of approximately 1 km. Helicopters could be seen and heard at a distance.

RC-04-00 was 3.3 km west of the center of the runway and less than 1 km east of the I-805 corridor. This site is in a narrow canyon and bordered by active train tracks to the north. Most aircraft that flew directly over this site were either F-18s or helicopters taking off from the east and heading towards the northwest. Numerous aircraft passed from the southeast to the southwest while flying a closed touch and go pattern.

RC-01-00 was in a narrow canyon 1.1 km north of the center of the main runway and was very close to the helicopter launching pads. Both jets and helicopters were observed at this site. Jets approached the runway from the northeast and passed overhead before turning back to the southwest. Most of the jets and helicopters that were taking off passed approximately 1 km to the west of this site. Additional helicopters could be seen and heard to the east.

The landfill site LF-00 was located about 2.7 km southwest of the center of the main runway and located in a wide canyon about 1 km to the east of the I-805 highway. At this site, most of the aircraft observed were F-18s and C-5s flying a touch-and-go pattern. They approached the site from the north and turned to the northeast, occasionally passing directly overhead. Most of the aircraft that were taking off could be heard, but not seen, from this site.

At USC-01-01, which was located about 3.8 km east-northeast of the center of the main runway; the vast majority of aircraft observed were F-18s. This site was located less than 500 meters east of the I-15 highway, and directly underneath the flight path of aircraft both approaching directly to land, or circling the airfield as part of touch and go exercises. Various other jets flew the same type of closed oval pattern, but at such distances that they did not pass directly overhead.

3.0 REAL-TIME MONITORING RESULTS

All real-time monitoring was conducted mid-week. During the real-time monitoring sessions, military aircraft caused 93% of the events detected by the LD 720 (435 of 470 total events). Military jets caused 85% of events detected, while military helicopters caused only 8% of events. The remaining events were caused by road noise (2%), recreational planes (1%) and unknown sources (1%) (Table 1). In ten instances, one aircraft caused 21 sound events as a result of touch and go training. Transient noise events such as birdcalls, wind, vegetation, human voices, and traffic noise did not register as events at any time.

Military aircraft triggered 100% of events at OW-02-99; F-18s triggered 56%, E-2 and C-5 triggered 26%, and helicopters triggered 18% of the events (Table 2). At RC-09-99, military aircraft caused 83% of events, with 7% caused by private aircraft and 10% by trains (Table 3). At QC-02-99, 40% of events were caused by military aircraft and 60% were caused by private aircraft, probably from nearby Gillespie Field (Table 4). Thus, in high to moderately exposed areas near the flight line, military aircraft were the predominant source of high-amplitude noise exposure. In outlying areas, other sources were proportionately more important.

Table 1
Event Proportions

Event Category	# of Events	Percentage of Events
Military Jets	314	85%
Military Helicopters	30	8%
Unknown Events	16	4%
Road Noise	8	2%
Miscellaneous Planes	3	1%

Table 2

Real Time Recordings
OW-02-99

Event Source	Event Type	Total Events	Percentage of All Events	Avg. Duration *Std. Dev.*	Avg. L_{eq} *Std. Dev.*	Avg. SEL *Std. Dev.*	Avg. L_{max} *Std. Dev.*	Avg. Peak *Std. Dev.*	Avg. UWPeak *Std. Dev.*
F-18	Overflight	16	25.00	53.58 *53.27*	78.60 *8.91*	94.13 *12.13*	89.35 *11.97*	103.13 *13.50*	89.65 *45.15*
F-18	Takeoff	20	31.25	41.65 *18.38*	71.65 *3.40*	87.48 *4.53*	78.13 *5.43*	90.27 *6.07*	80.88 *41.57*
C-5	Overflight	7	10.94	13.10 *5.03*	69.04 *2.55*	79.96 *3.36*	75.14 *3.97*	86.40 *4.49*	43.20 *53.90*
E-2	Overflight	10	15.63	19.90 *17.09*	73.79 *6.08*	85.84 *8.11*	80.41 *8.63*	91.76 *9.35*	52.49 *55.57*
UH-1	Overflight	1	1.56	9.20	67.90	77.60	71.50	84.80	0.00
CH-46	Overflight	3	4.69	18.73 *2.00*	67.10 *2.71*	79.77 *2.71*	73.80 *3.83*	90.97 *3.87*	100.8 *2.60*
CH-53	Overflight	7	10.94	24.87 *19.04*	71.74 *3.45*	84.36 *7.15*	79.11 *6.51*	92.89 *6.60*	103.69 *3.53*

Table 3

Real Time Recordings
RC-09-99

Event Source	Event Type	Total Events	Percentage of All Events	Avg. Duration *Std. Dev.*	Avg. L_{eq} *Std. Dev.*	Avg. SEL *Std. Dev.*	Avg. L_{max} *Std. Dev.*	Avg. Peak *Std. Dev.*	Avg. UWPeak *Std. Dev.*
F-18	Overflight	24	80.00	33.40	83.07	97.26	92.84	102.32	0.00
				19.35	*8.87*	*11.68*	*11.09*	*32.23*	*0.00*
C-5	Overflight	1	3.33	19.20	74.00	86.80	80.20	101.60	0.00
Prop Plane	Overflight	2	6.67	9.00	71.95	81.45	77.10	50.20	106.40
				0.99	*2.05*	*1.63*	*2.40*	*70.99*	
Train		3	10.00	9.77	67.47	77.33	70.70	33.03	
				1.65	*0.32*	*1.06*	*0.56*	*57.22*	
Total		30	100.00						

Table 4

Real Time Recordings
QC-02-99

Event Source	Event Type	Total Events	Percentage of All Events	Avg. Duration *Std. Dev.*	Avg. L_{eq} *Std. Dev.*	Avg. SEL *Std. Dev.*	Avg. L_{max} *Std. Dev.*	Avg. Peak *Std. Dev.*	Avg. UWPeak *Std. Dev.*
F-18	Overflight	2	40.00	19.60 *5.09*	70.70 *0.00*	83.50 *1.13*	77.90 *0.99*	90.55 *0.64*	0.00 *0.00*
Prop Plane	Overflight	2	40.00	6.10 *1.13*	66.90 *0.85*	74.70 *1.70*	72.15 *1.06*	90.85 *1.48*	0.00 *0.00*
Lear Jet	Overflight	1	20.00	40.10	81.30	97.30	90.70	105.60	106.40
Total		5	100.00						

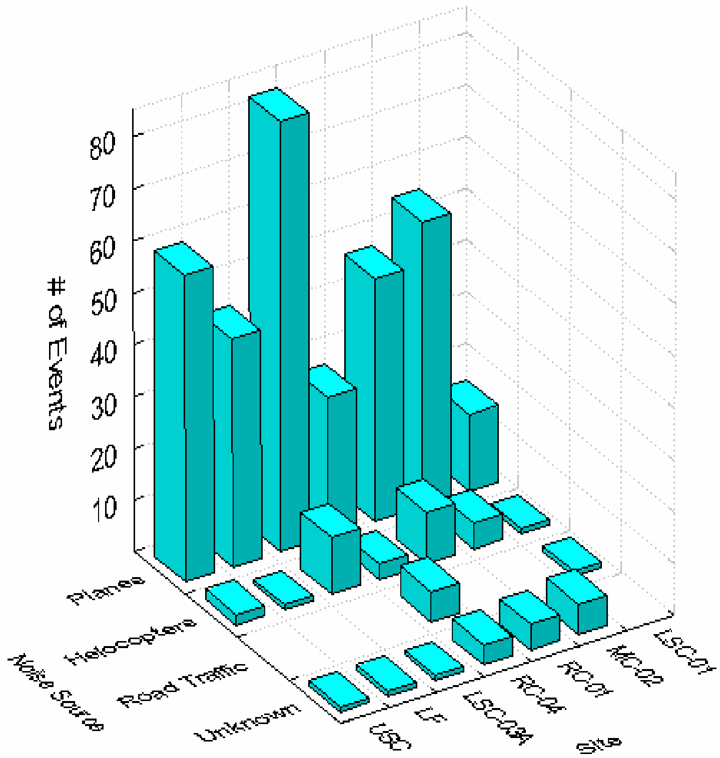
At OW-02-99, there were 60 jet overflights, and only seven were missed by the meter. Out of eleven helicopter overflights, seven were missed. The higher proportion of undetected helicopter overflights was a result of them not passing directly overhead. At RC-09-99, there were 25 jet overflights and only two were missed. The opposite was true of helicopters. Five helicopters flew over the area, but none were detected. Due to the altitudes of overflights at QC-02-99, events were usually missed by the meters. Out of 14 jet overflights, only two were detected. No helicopter overflights were detected by the meter.

As indicated above, the vast majority of events recorded by sound meters during real-time monitoring were caused by military jets. However, the proportion of events caused by road noise and different types of aircraft appeared to be affected by recording location. At locations near helicopter pads, such as RC-01-00, or those sites occurring under helicopter flight paths, such as LSC-03-00, the proportions of events caused by helicopters was higher than at other sites (Figure 2). In addition, the number of overflights that had sound levels below 70 dBA, and were thus not recorded by the sound level meter, also fluctuated with recording position.

At sites located on the fringes of regularly flown paths, such as LF-00 and RC-04-00 (see Figure 1), the proportion of observed aircraft that did not cause events were 58% and 53%, respectively. At recording sites located closer to the flight path the proportions were typically lower, averaging 37%. This demonstrates that, as expected, noise exposure levels caused by military aircraft are location-dependent.

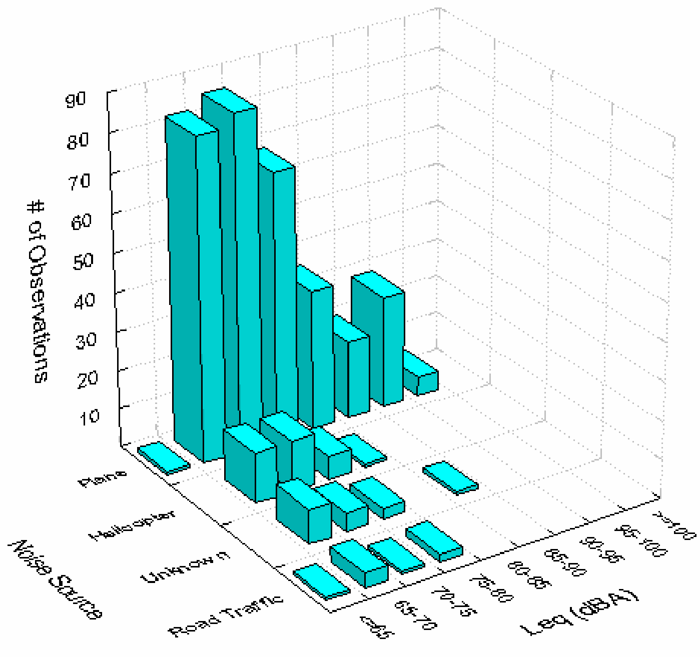
Most high-intensity events with L_{eq}s above 80 dBA were caused by military jets (Figure 3), most of which were F-18s (Figure 4). Helicopter noise of sufficient intensity to trigger the sound meter ranged from 65 to 80 dBA, with CH-53E and AH-1 noise triggering the majority of events (Figure 5). The proportions of sound events observed are only a "snapshot" of aircraft activity over a short period, as well as at a finite area of the military installation.

Since the focus of this study is not the number of aircraft overflights but the overall sound environment at a gnatcatcher nest, measures that incorporate all data collected (e.g., total L_{eq}, L_5) will correlate better with levels of military aircraft noise to which birds are exposed. For example, the L_{eq} and L_5 metrics incorporate background noise levels while summaries of total event counts do not. This is because quieter overflights that do not cause events on sound level meters are still

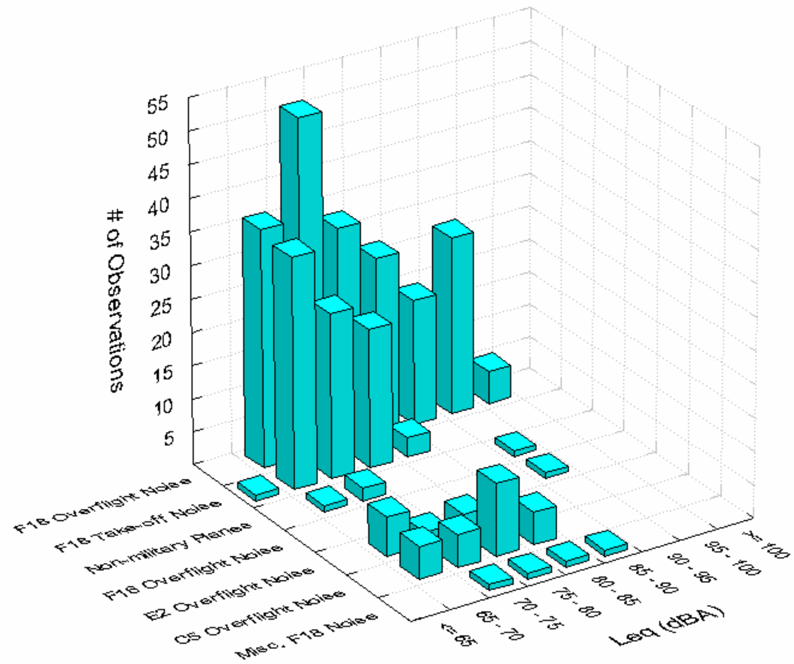


Category -Site Locations

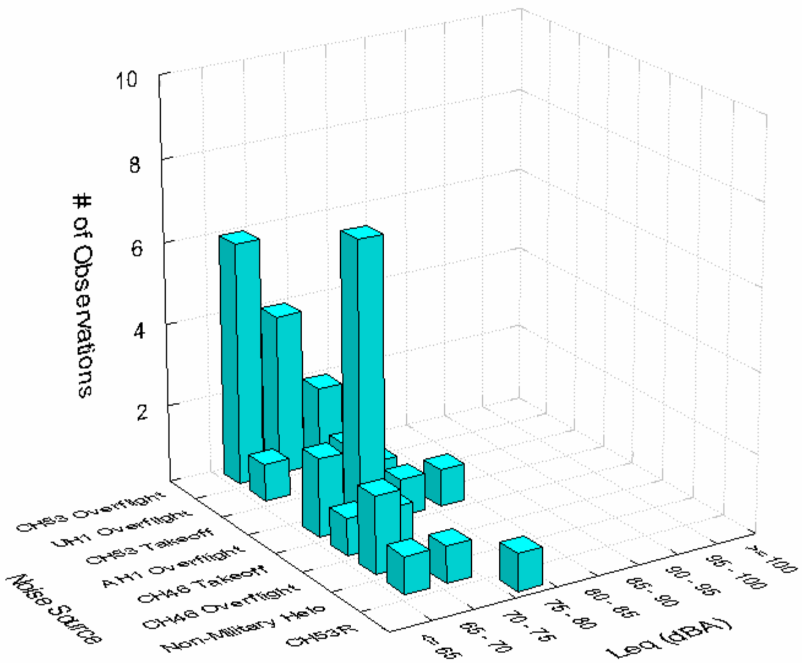
Figure 2



Category -Leq	Figure 3



Plane Leq	Figure 4



Helo Leq

Figure 5

included in measures of overall L_{eq} and L_5, while these data are not reflected by total event counts.

3.1 Levels and Frequency Characteristics of Aircraft Noise

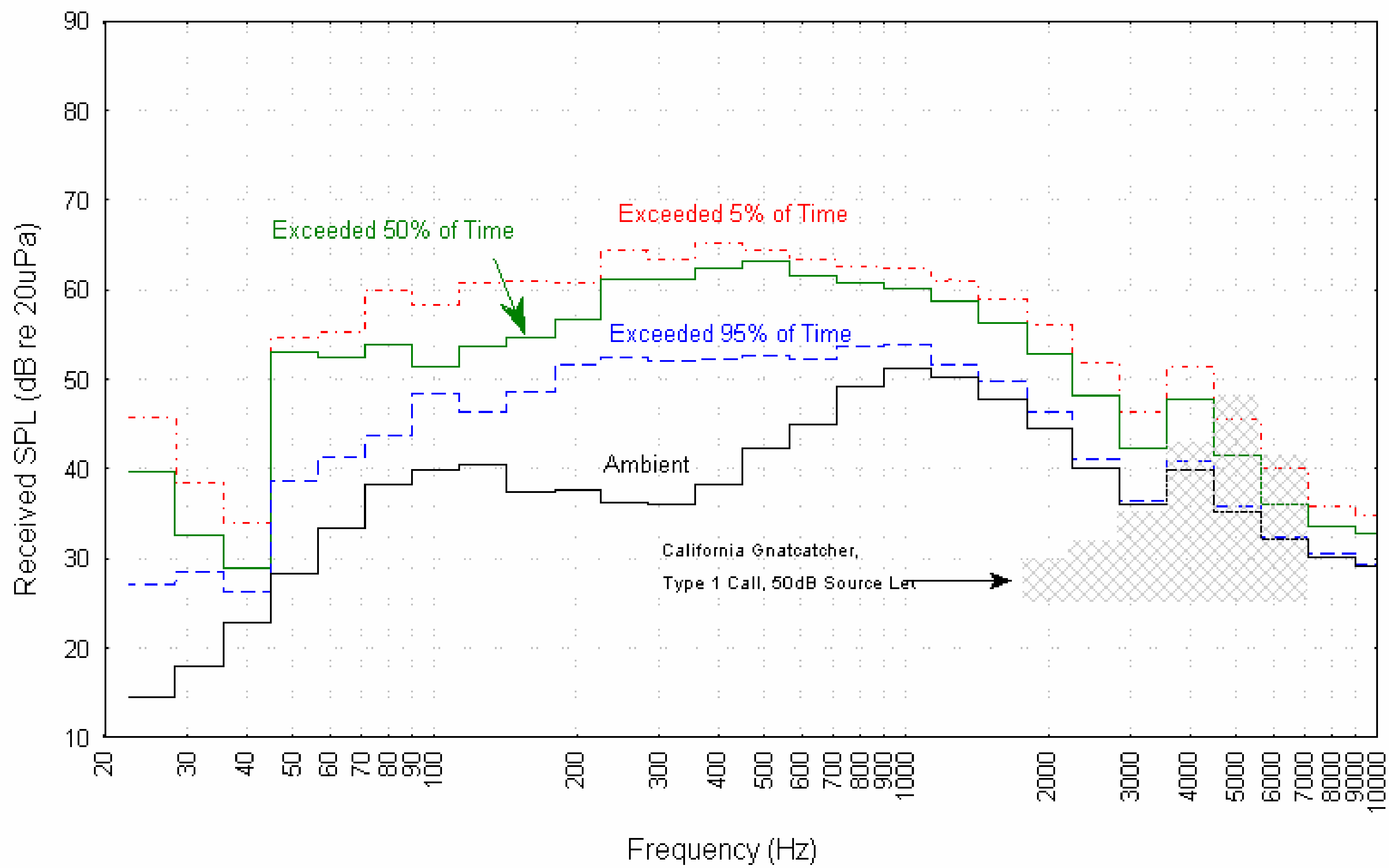
Real-time recordings of high, moderate and low intensity overflights (as determined by ASEL and Peak measurements from a LD 720) were examined for overall amplitude and spectral characteristics. Aircraft produced noise across the bandwidth of the recording system, in the range from 20 Hz to 20 kHz. For helicopters, most energy was in the 20 Hz to1 kHz band (Figure 6). It is possible that rotor-thump also produced lower-frequency components (below 20 Hz). For F-18 jets, most energy fell between 100 Hz and 2 kHz (Figure 7).

F-18 overflights were the most common trigger for events and produced the most noise at OW-02-99 (Table 2). F-18 overflights lasted the longest and had the highest average ASEL and L_{max}. CH-46 overflights averaged 18.73 seconds with an average ASEL of 79.77 dBA and an average L_{max} of 73.80 dBA. CH-53 overflights averaged 24.87 seconds and had an average ASEL of 84.36 dBA and an average L_{max} of 79.11 dBA.

At RC-09-99, F-18 overflights were of shorter duration, but event levels were actually higher than OW-02-99 (Table 3). F-18 overflights lasted the longest and had the highest average ASEL and L_{max}. Helicopter overflights did not trigger the sound meters in this area due to the distance between the aircraft and the site.

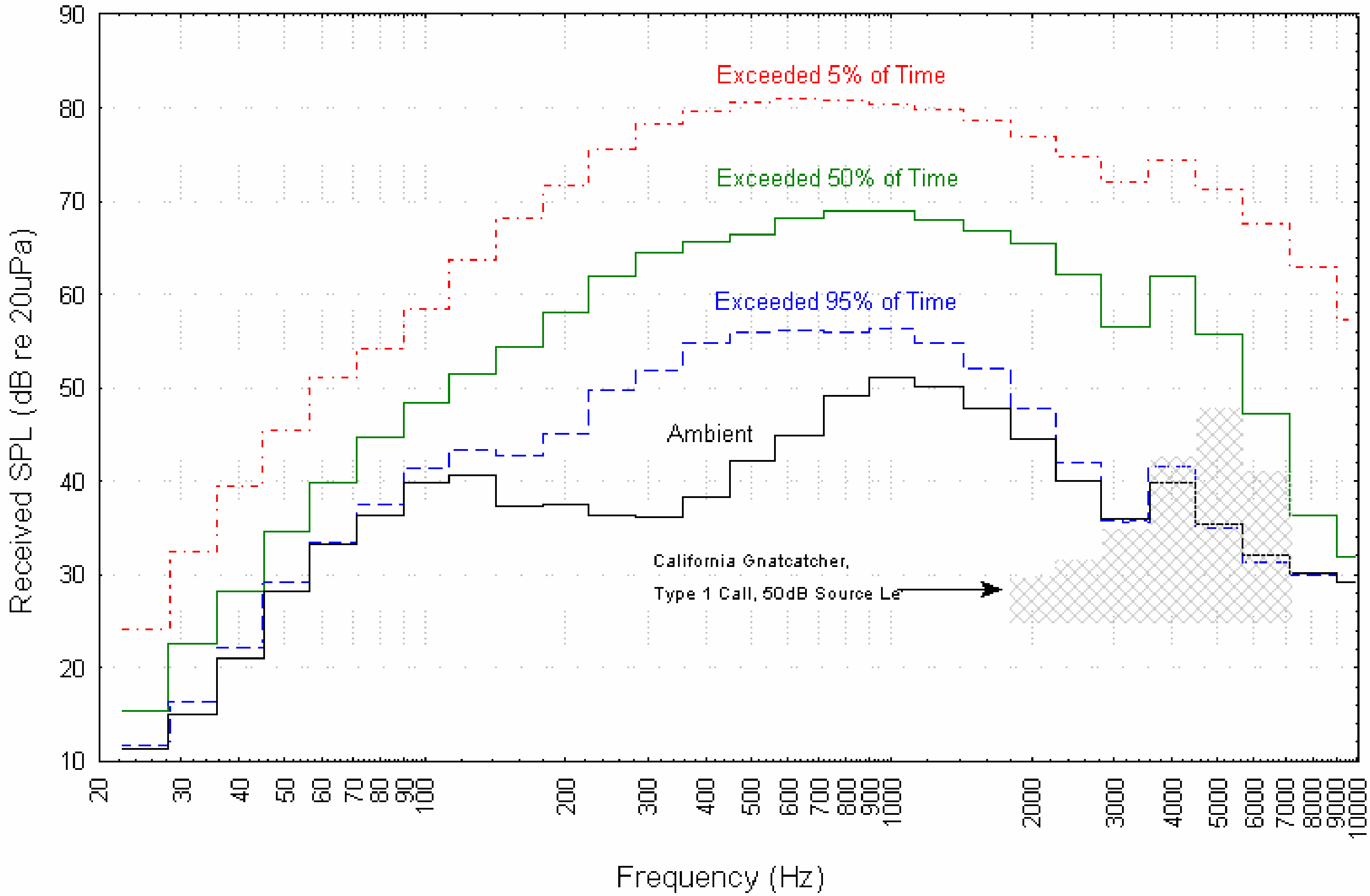
At QC-02-99 (Table 4), most F-18 and private aircraft overflight events were short (<20 seconds) and had L_{eq} levels close to threshold. A single Learjet overflight, lasting 40 seconds, was the most intense exposure received, with an ASEL of 97.3 dBA. This suggests that in Quail Canyon, military aircraft may contribute very little to the event ASEL. Further analysis will be needed to determine their contribution to the L_5 and overall L_{eq}.

Figures 8, 9 and 10 show the medians and ranges of 1/3-octave band spectra for aircraft overflights at specified sites. Median spectral levels are shown as red lines, with 50% of the range of variation shown in light grey, and 90% of the range of variation shown in dark grey.



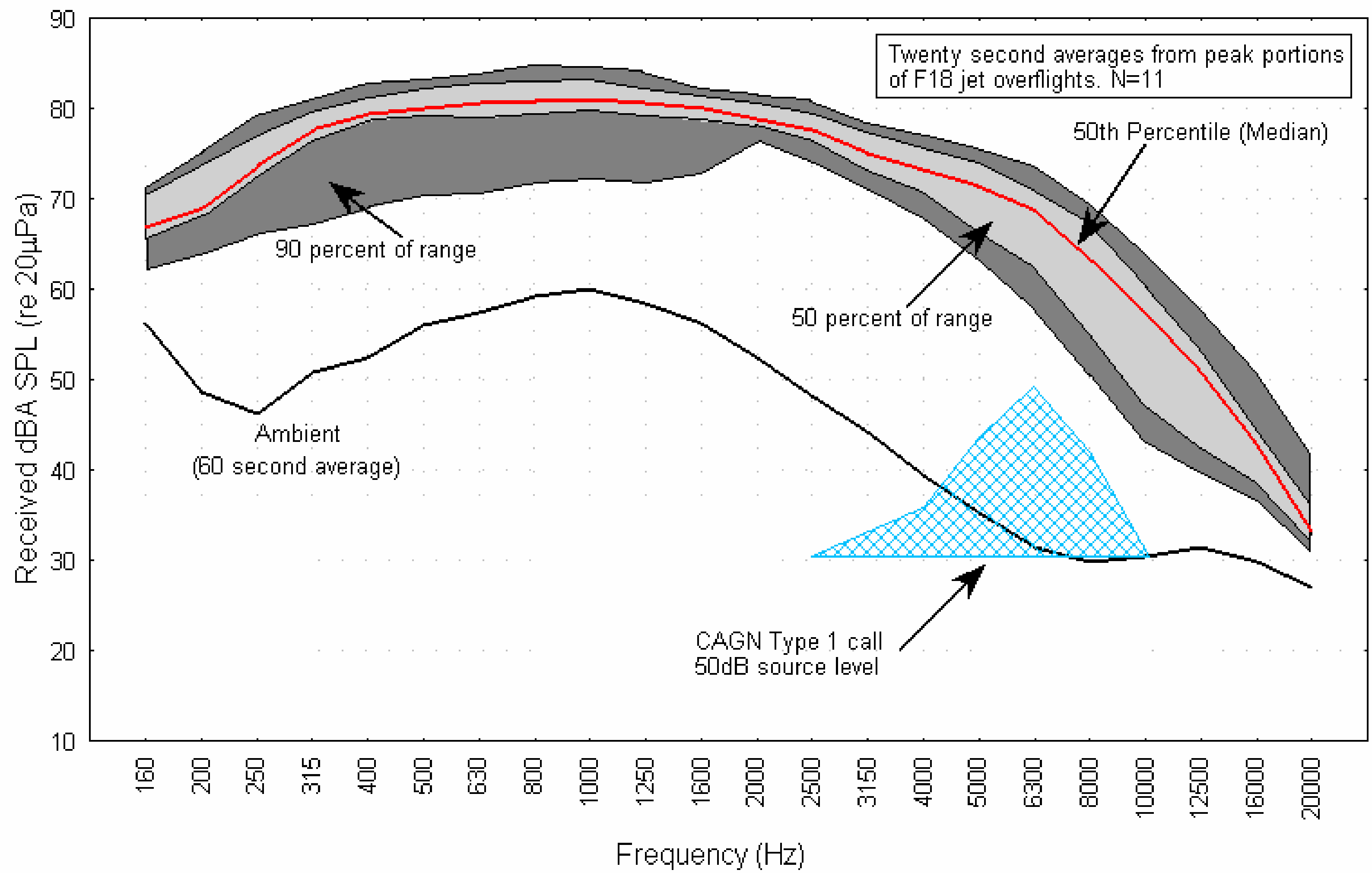
A-Weighted 1/3 Octave Sound Levels Exceeded by CH-53 Overflights at OW-02-99

Figure 6



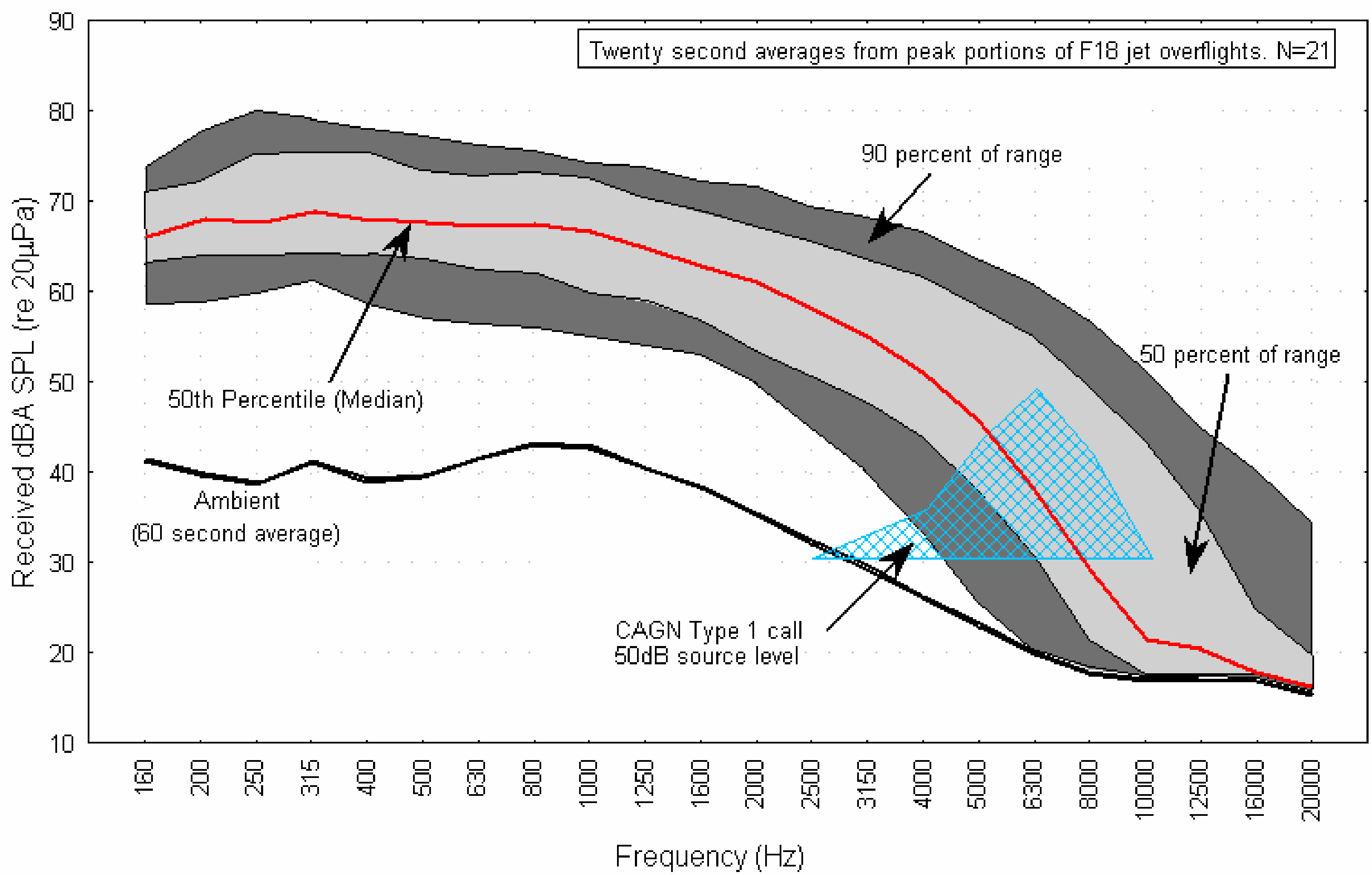
A-Weighted 1/3 Octave Sound Levels Exceeded by F-18 Overflights at OW-02-99

Figure 7



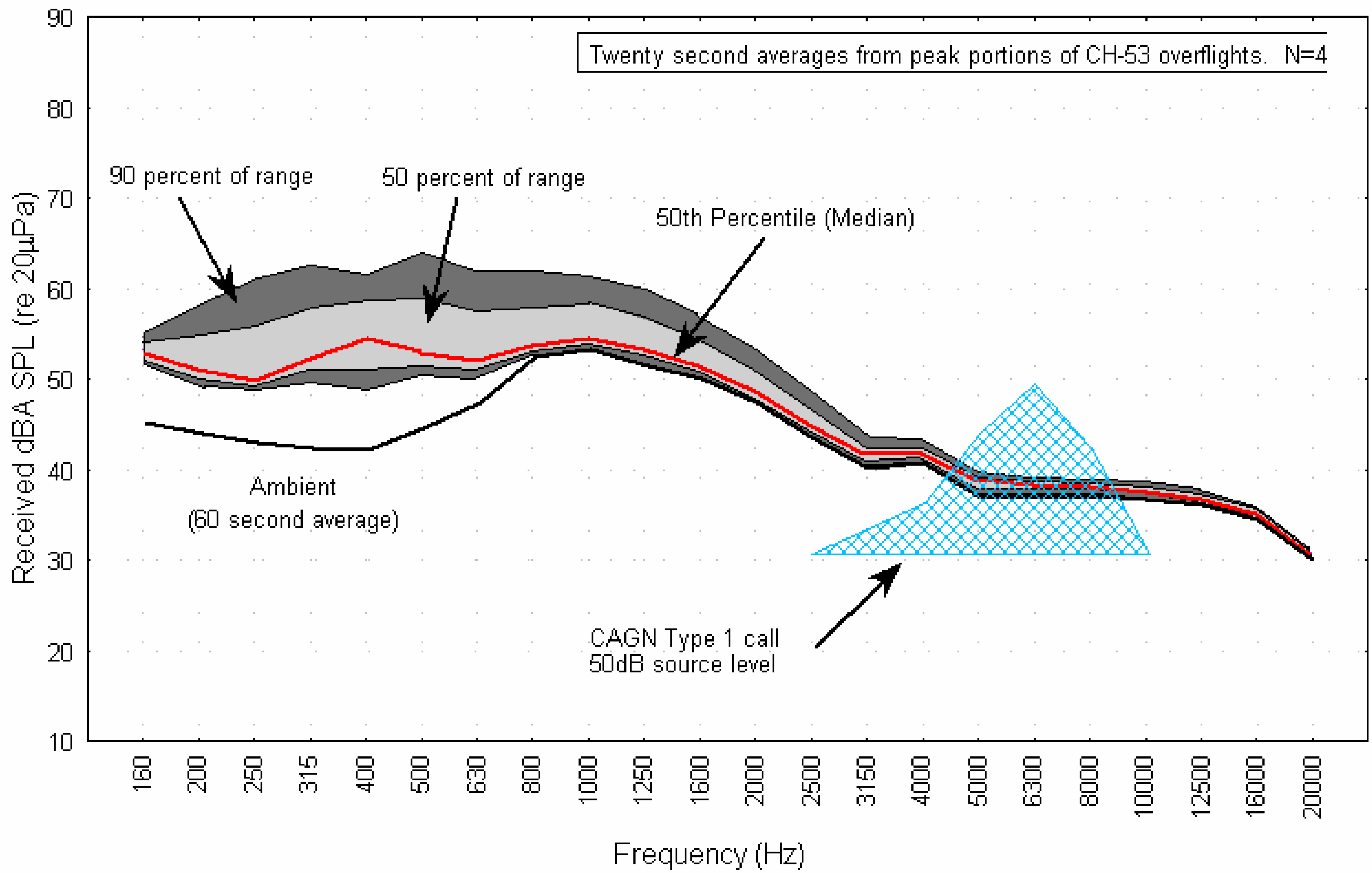
F-18 LSC-01-00

FIGURE 8



F-18 USC-01-01 Site

FIGURE 9



CH 53 OW-02-00 Site

FIGURE 10

The amplitude and frequency characteristic of any given overflight is directly dependent on the relative positions of the sound receiver and the aircraft, as well as the type of maneuver performed by the aircraft. If an aircraft is traveling directly overhead, relatively slow, and low to the ground, the resultant noise is higher intensity and more broadband than other types of overflights. This is evidenced by the recordings made at LSC-01-00, which is under the incoming flight path just east of the runway. At this position, all aircraft approached the runway at a slow rate of speed and low to the ground. There is a narrow range of variation in the way aircraft overfly this site resulting in similar sound properties for overflights, i.e., broadband and high intensity (Figure 8). Thus, this position is exposed to similarly loud and wideband noise for every overflight.

In contrast, less than 1 kilometer away at site USC-00, there is wide variation in overflight patterns and the range of frequencies and intensities experienced. As aircraft turn to begin their final approach to the runway, some make sharper turns than others. Thus the relationship between aircraft and sound receiver varies from overflight to overflight, producing differential levels of exposure (Figure 9). Clearly, different areas under a flight pattern will be exposed to different levels and frequencies of noise, and proximity to the main runway is not always a good indicator of the noise levels experienced.

According to real-time monitoring in 1999, site OW-02-99 experienced more helicopter overflights than other sites that were monitored. Sound levels from helicopters were fairly consistent from overflight to overflight, even with the variation in flight path, altitude, and speed (Figure 10). Although there were many helicopter overflights, sound levels from helicopters did not trigger the sound level meter as often as jets. This is because, in part, most of the energy from helicopter noise is below 2 kHz. Because sound level meters used in this study employ A-weighting, energy at frequencies below 1 kHz are de-emphasized, resulting in lower overall sound pressure levels (dBA) for helicopters.

3.2 Potential for Noise Masking

Noise masking of biologically important sounds occurs when noise has equal or greater energy (intensity) in the same frequency range as the biological sound (Scharf, 1970). Because noise masking has the potential to reduce the range over which animals can effectively detect and recognize conspecific calls, it potentially limits their communication over large distances. In addition to limiting intraspecific communication, noise masking interferes with the detection of other biologically important sounds, such as those produced by predators and prey.

Spectral levels of overflight noise at three sites on the Station were compared to a California gnatcatcher Type I (‘mew’) call (Atwood 1988) in order to examine the potential for noise masking. A 1/3-octave band spectrum of a mew call with an estimated source level of 50 dBA at one meter (Awbrey, unpublished data) is compared with 1/3-octave band spectra for overflights of F-18 jets (at USC and LSC sites) and CH-53E helicopters (at OW-02, 1999 data).

As shown in Figure 8, the majority of energy in a California gnatcatcher mew call lies between 3 and 6 kHz with peak energy between 4 and 5 kHz (as shown by the blue-shaded region). A third-octave band spectrum of a mew call with an estimated source level of 50 dBA at one meter (Awbrey unpublished data) was compared with the 1/3-octave band spectra of F-18 jet and helicopter overflights. These values were summarized by calculating the upper 5%, 50% and 95% confidence limit within each band. An equal number of ambient noise spectra were also examined for comparison with gnatcatcher mew calls.

At OW-02-99, ambient noise levels were high due to highway and road noise. At ambient levels, the high frequency components of gnatcatcher calls are audible at short range. However, the low frequency components (below 4 kHz) are masked. In the presence of helicopters, gnatcatcher calls are audible (See Figure 8). However, even at close range, gnatcatcher calls are inaudible approximately 50% of the time during F-18 overflights (See Figure 9).

At LSC-01-00, a location where jets fly directly overhead at low altitudes and airspeed, noise levels are typically consistent and high. Approximately 90 percent of all jet overflights recorded at the LSC site have energy above that of the gnatcatcher call in the 3 to 6 kHz range. This suggests that most gnatcatcher calls that occur during jet overflights are masked beyond approximately 1 meter range.

At the USC-00 location the variation within overflights is higher than at LSC-01-00, and overall noise levels of jet overflights are lower as well. Figure 9 illustrates the variation among overflights at this site and indicates that a lower proportion of overflights have the potential to mask California gnatcatcher calls. At least 50% of recorded overflights at this location do not have sufficient energy in the appropriate frequency bands to mask the gnatcatcher call. At OW-02-99, the lower observed sound levels and variation in spectral levels among overflights indicate that the majority of helicopters do not produce sufficient noise in the frequency range of 3-6 kHz to mask the gnatcatcher Type I call (Figure 10). Most of the spectral energy in CH-53E overflights observed at OW-02-99 was below 2 kHz, with little energy at 4 kHz (peak frequency of the gnatcatcher call).

Demonstrating that overflight noise has the potential to mask California gnatcatcher calls is only the first step in evaluating a disturbance effect due to masking. It remains unclear whether peak periods of aircraft activity and bird calling overlap temporally, whether a significant number of calls are masked, and ranges at which birdcalls may be limited by noise.

3.3 Bird Behavior During Overflights

When possible, bird behavior was recorded during real-time recordings. Birds were most active during the early morning, with calling behavior most frequent between 0800-1000. A second smaller peak occurred between 1600-1800. Gnatcatchers were heard sporadically calling from a distance of 10 to 30 meters. Gnatcatcher calls were heard by observers during the course of four overflights, two at OW-02-99 and two at QC-02-99, suggesting that the level is sufficiently moderate for calls to be audible at close range.

Seven birds (18 total observations) were observed opportunistically and their behavior recorded during aircraft overflights on MCAS Miramar (Table 5).
The species observed in addition to the California gnatcatcher were Bewick's wren, black phoebe, bushtit, spotted towhee and Bullock's oriole. The black phoebe and Bullock's oriole were observed during overflights of a CH-46 helicopter, and the rest of the birds were observed during F-18 jet overflights.

Bird behaviors during overflights were viewed using binoculars and vocalizations were recorded using an AKG CK68-ULS directional microphone and Tascam DA-P20 DAT recorder (20 Hz-20 kHz, 91 dBA dynamic range). Calling birds were observed in locations where aircraft were noted to pass directly overhead (~400-800 m range), thus behavior prior to, during, and after overflights could be noted. It is difficult to generalize the birds' responses or to make comparisons between species because so few observations were made. However, several observations are noteworthy and may beg future study.

Table 5

Observations of bird behaviors during military aircraft overflights on MCAS Miramar and Pendleton.
Aircraft passed directly overhead unless otherwise noted.

Station/Site	Species	Aircraft Type	Behavior Prior to Overflight	Behavior During Overflight
MCAS/MC02	Black phoebe	Two F-18 jets	Perched high in tree calling every 5-10 sec.	Cocked head and oriented to passing jets; continued calling.
MCAS/MC02	Black phoebe (same)	CH-46*	Perched high in tree calling every 5-10 sec.	Continued calling; did not orient towards helicopter
MCAS/MC02	Black phoebe (same), Bullock's oriole	CH-46*	Perched in tree calling every 5-10 sec; oriole perched in top of low shrub calling sporadically.	Phoebe heard calling, oriole was not heard.
MCAS/LSC	Bewick's wren	F-18 take-off†	Perched in dead tree, calling every 5-10 sec.	Continued calling; no notable change in behavior.
MCAS/LSC	Bewick's wren (same)	F-18 overflight	Perched in dead tree, calling every 5-10 sec.	Continued calling; no notable change in behavior.
MCAS/LSC	California towhee	F-18 overflight‡	On ground under low shrub, pecking under leaves; 'Pip' heard every 10-20 sec.	Flushed (along with several bushtits) just prior to aircraft passing overhead.
MCAS/LSC	CAGN adult male and fledgling	F-18 overflight	Moving around in a low shrub, calling every 2-10 sec.	Remained in shrub, both birds called through overflight.
MCAS/LSC	CAGN adult male and fledgling (same)	F-18 overflight‡	Perched in a low shrub, calling every 2-10 sec.	Remained in shrub, both birds called through overflight
MCAS/LSC	CAGN adult male and fledgling (same)	F-18 overflight	Moving around in low shrub, calling every 2-10 sec.	Remained in shrub, both birds called through overflight
MCAS/LSC	CAGN adult male and fledgling (same)	F-18 overflight	Moving around in low shrub, calling every 2-10 sec.	Remained in shrub, both birds called through overflight
MCAS/LSC	CAGN adult male and fledgling (same)	F-18 overflight	Moving around in low shrub, calling every 2-10 sec.	Remained in shrub, both birds called through overflight
MCAS/LSC	Bushtit	F-18 overflight	Moving around in low shrub, calling every 5-10 sec.	Remained in shrub, continued calling.

'Same' in the species column indicates multiple observations of an individual bird.
* CH-46 passed approximately 40 deg SE from bird and observer.
† Take-off approximately NW from bird and observer (did not pass overhead) but had noise levels similar to CH-46 overflights.
‡ Low-level overflight, directly overhead, particularly high sound levels.

3.4 Acoustic Behavior During Overflights

In all but one case (when a bird flushed from the area), calling birds continued to call during overflights. In many cases birdcalls were masked by aircraft noise, but the birds could be seen calling although they could not be heard. Awbrey, Hunsaker and Church (1995) conducted a limited study on vocalization of California gnatcatchers and other species to test the calling rate as a function of ambient noise levels. They determined there was no significant correlation between ambient sound pressure level and Gnatcatcher call repetition rate. With the California gnatcatcher and other passerines recorded and observed, compensating for higher background noise levels is at best a minor reason why birds vary their calling rates.

3.5 Behavioral Threshold For Flight Response

On one occasion a California towhee (along with several bushtits) were observed to flush during a particularly low altitude, high sound intensity (~ 115 dBA Peak SPL) overflight of an F-18 jet. The event occurred in Lower San Clemente Canyon (LSC), a site where direct, low-altitude overflights occur somewhat regularly. As noted in Table 5, various birds were observed in this area and most continued on-going behaviors (including calling) during overflights, suggesting that birds inhabiting these areas have habituated somewhat to aircraft. However, the flight response ('flush') of several birds during a particularly high-intensity overflight suggests that habituated birds may retain a response threshold potentiated by unusually low altitude or high sound intensity. In other words, birds inhabiting 'loud' areas may be habituated to most overflights, but still respond defensively to extremes. It cannot be determined whether the birds were responding to the visual stimulus of the aircraft or the associated noise, but observers noted that the birds appeared to flush immediately after a sudden-onset peak in noise level, rather than at the point when the aircraft was nearest or directly overhead.

3.6 Effects of Behavioral State on Response Thresholds

On one occasion a black phoebe (at MC02) had a visible response (orienting on aircraft) to overflight by a pair of F-18 jets, but the bird remained on perch and continued to vocalize. The phoebe was seen vocalizing frequently and consistently from its perch for at least 10 minutes prior to the overflight. It appeared to observers that the bird was highly motivated to continue vocalizing (perhaps because it was defending its territory or calling to a mate) and thus continued despite an obvious behavioral response to the overflight. These observations raise the question of whether behavioral state might influence responsiveness to noise disturbance, resulting in particular times when birds are more or less sensitive to noise and thus more or less likely to be disturbed.

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APPENDIX D

Vegetation Data Groupings for Analysis

Group	Species	Abbreviation	Common Name
Dead wood	Dead wood	Dwoo	Dead wood in shrub layer
Gap	Gap	Gap	Gap between shrubs
Primary Coastal Sage Scrub	*Artemisia californica*	Acal	California sagebrush
	Baccharis pilularis	Bpil	Coyote bush
	Baccharis sarothroides	Bsar	Broom baccharis
	Encelia californica	Ecal	Encelia
	Encelia farinosa	Efar	Brittlebush
	Eriodyctyon crassifolium	Ecra	Yerba santa
	Eriogonum fasciculatum	Efas	California buckwheat
	Malosma laurina	Mlau	Laurel sumac
	Salvia apiana	Sapi	White sage
	Salvia mellifera	Smel	Black sage
Primary Chaparral	*Adenostoma fasciculatum*	Afas	Chamise
	Ceanothus tomentosus	Ctom	California lilac, Coast blue lilac
Primary Other Shrub	*Eriophyllum confertiflorum*	Econ	Golden yarrow
	Helianthemum scoparium	Hsco	Peak-rush rose, rock rose
	Lessingia filaginifolia	Lfil	California aster
	Lotus scoparius	Lsco	Deer Weed, California Broom
	Mimulus aurantiacus	Maur	Bush monkey flower
	Opuntia littoralis	Olit	Prickly pear
	Yucca whipplei	Ywhi	Our lord's candle

Secondary Coastal Sage Scrub	*Cneoridium dumosum*	Cdum	Spicebush
	Isocoma menziesii	Imen	Goldenbush
	Rhamnus crocea	Rcro	Spiny redberry
	Rhamnus ilicifolia	Rili	Holly-leaf redberry
	Salvia hybrid (apiana X mellifera)	SaXm	Sage
	Viguiera laciniata	Vlac	San Diego county viguiera
Secondary Chaparral	*Arctostaphylos glandulosa*	Agla	Eastwood manzanita
	Ceanothus crassifolius	Ccra	Hoaryleaf ceanothus
	Ceanothus verrucosus	Cver	Wart-stemmed ceanothus
	Cercocarpus betuloides	Cbet	Mountain mahogany
	Clematis pauciflora	Cpau	Rope vine
	Heteromeles arbutifolia	Harb	Toyon, Christmas berry
	Prunus ilicifolia	Pili	Holly-leafed cherry
	Quercus berberidifolia	Qber	Scrub oak
	Quercus dumosa	Qdum	Nuttall's scrub oak
	Rhus integrifolia	Rint	Lemonade berry
	Rhus ovata	Rova	Sugar bush
	Ribes indecorum	Rind	White flower currant
	Ribes speciosum	Rspe	Fuschia flowered gooseberry
	Toxicodendron diversilobum	Tdiv	Poison oak
	Trichostema lanatum	Tlan	Woolly blue curls
	Xylococcus bicolor	Xbic	Mission manzanita
Secondary Other	*Agave sp.*	AgavSp	Agave
	Artemisia douglasiana	Adou	Mugwort
	Artemisia palmeri	Apal	Sagewort
	Baccharis salicifolia	Bsal	Mule fat
	Bouganvillea species	BougSp	Bouganvillea
	Brickellia californica	Bcal	Bricklebush
	Dudleya lanceolata	Dlan	Dudleya
	Dudleya sp.	DudlSp	Dudleya
	Eriogonum cinereum	Ecin	Ashy-leaf buckwheat

Secondary Other (Cont.)	*Ferocactus viridescens*	Fvir	Coast barrel cactus
	Gutierrezia californica	Gutcal	California matchweed
	Hazardia squarrosa	Hsqu	Saw-toothed goldenbush
	Isomeris arborea	Iarb	Bladder pod
	Lonicera subspicata	Lsub	Honeysuckle
	Malacothamnus fasciculatus	Mfas	Chaparral mallow, Bush mallow
	Marrubium vulgare	Mvul	Horehound
	Mimulus longiflorus	Mlon	Bush (or sticky) monkey flower
	Mirabilis californica	Mcal	Wishbone bush
	Opuntia prolifera	Opro	Cholla
	Opuntia sp.	OpunSp	Beavertail cactus, Prickly pear
	Phoradendron macrophyllum	Pmac	Big leaf mistletoe
	Porophyllum gracile	Porgra	Odora, stinky bush
	Ricinus communis	Rcom	Castor bean
	Salvia leucophylla	Sleu	Purple sage
	Solanum douglasii	Sdou	Douglas' nightshade
	Solanum parishii	Spar	Parish' nightshade
	Unknown shrub	UnkShrub	Unknown shrub
	Yucca baccata	Ybac	Spanish bayonet
Native Forb	*Acourtia microcephala*	Amic	Sacapellote
	Adiantum jordanii	Ajor	California maiden-hair
	Allium haematochiton	Ahae	Wild onion
	Amaranthus palmeri	Amapal	Palmer amaranth
	Ambrosia psilostachya	Apsi	Western ragweed
	Amsinckia intermedia	Aint	Fiddleneck
	Amsinckia menziesii	Amen	Fiddleneck
	Antirrhinium sp.	AntiSp	Snapdragon
	Apiastrum angustifolium	Aang	Wild celery
	Asclepias sp.	AsclSp	Milkweed
	Bloomeria crocea	Bcro	Common goldenstar
	Brodiaea sp.	BrodSp	Brodiaea
	Calochortus concolor	Ccon	Goldenbowl mariposa
	Calochortus macrocarpus	Cmac	Mariposa lily

Native Forb (Cont.)	*Calochortus plummerae*	Cplu	Pink mariposa lily
	Calochortus species	CaloSp	Mariposa lily
	Calochortus splendens	Cspl	Splendid mariposa lily
	Calystegia macrostegia	Calmac	Morning glory
	Castilleja densiflora	Cden	Indian paintbrush
	Castilleja exserta	Cexs	Owl's clover
	Centaurium venustum	Cven	Canchalagua
	Chaenactis glabriscula	Cgla	Yellow pincushion
	Chaetopappa aurea	Caur	Golden daisy
	Chamaesynce sp.	ChamSp	Prostrate spurge
	Chenopodium californicum	Checal	Chenopodium
	Chlorogalum parviflorum	Cpar	Soap plant, Amole
	Chlorogalum pomeridianum	Cpom	Soap plant, Amole
	Chlorogalum sp.	ChloSp	Soap plant, Amole
	Chorizanthe fimbriata	Cfim	Fringed spineflower
	Chorizanthe polygonoides	Cpol	Knotweed spineflower
	Chorizanthe staticoides	Csta	Turkish rugging
	Clarkia purpurea	Cpur	Large clarkia
	Claytonia perfoliata	Cper	Miners lettuce
	Conyza canadensis	Ccan	Horseweed
	Crassula connata	Cracon	Pigmy weed
	Cryptantha intermedia	Cint	Common forget me not
	Cryptantha micromeres	Cmic	Minute-flower cryptantha
	Cuscuta californica	Ccal	Dodder
	Cyperus esculentus	Cesc	Nutsedge
	Daucus pusillus	Dpus	Wild carrot
	Delphinium parryi	Dpar	Parrys larkspur
	Dicentra chrysantha	Dchr	Golden eardrops
	Dichelostemma capitatum	Dcap	Blue dicks
	Dodecatheon clevelandii	Dcle	Shooting Star
	Eleocharis macrostachya	Emac	Spikerush
	Epilobium canum	Ecan	California fuschia, Zauschneria
	Eremocarpus setigerus	Eset	Turkey Mullein, Dove weed
	Eriastrum filifolium	Efil	Thread leaf woolly star
	Erigeron foliosus	Efol	Fleabane

Native Forb (Cont.)	*Eryngium aristulatum var. hooveri*	Eari	San Diego button celery
	Eschscholzia californica	Esccal	California poppy
	Eucrypta chrysanthemifolia	Echr	Common eucrypta
	Fern	Fern	Fern
	Filago californica	Fcal	Herba impia
	Galium angustifolium	Gang	Narrow-leaved bedstraw
	Galium aparine	Gapa	Goose grass
	Galium nuttallii	Gnut	San Diego nutgrass
	Geranium carolinianium	Gcar	Cranesbill, Geranium
	Gilia angelensis	Gilang	Gilia
	Gnaphalium bicolor	Gbic	Bicolor cudweed
	Gnaphalium californicum	Gcal	California everlasting
	Gnaphalium canescens	Gcan	White everlasting
	Gnaphalium palustre	Gpal	Lowland cudweed
	Gnaphalium species	GnapSp	Gnaphalium
	Gnaphalium stramineum	Gstr	Cotton-batting plant
	Helianthus annuus	Hann	Common sunflower
	Heliotropium curassavicum	Hcur	Chinese parsley
	Hemizonia fasciculata	Hfas	Tarweed, tarplant
	Hemizonia paniculata	Hpan	Tarweed, tarplant
	Heterotheca grandiflora	Hgra	Telegraph weed
	Juncus bufonius	Jbuf	Toad rush
	Juncus dubius	Jdub	Mariposa rush
	Juncus sp.	JuncSp	Rush
	Lathyrus vestitus	Lves	Wild pea
	Lepidium nitidum	Lnit	Shiny peppergrass
	Lepidium virginicum	Lvir	Peppergrass
	Linaria canadensis	Lcan	Blue toadflax
	Lomatium dasycarpum	Ldas	Wooly-fruit lomatium
	Lotus hamatus	Lham	Grab Lotus, Birds Foot Trefoil
	Lotus purshianus	Lpur	Spanish Clover
	Lupine sp.	LupiSp	Lupine
	Lupinus bicolor	Lbic	Miniature lupine, Lindley's annual lupine
	Lythrum hyssopifolium	Lhys	Loosestrife
	Marah macrocarpus	Mmac	Wild cucumber

Native Forb (Cont.)	*Mimulus brevipes*	Mbre	Wide-throat yellow monkey flower
	Mimulus guttatus	Mgut	Common large monkey flower
	Monardella linoides ssp. viminea	Mlin	Willowy monardella
	Muilla clevelandii	Mcle	San Diegan goldenstar
	Navarretia hamata	Nham	Hooked skunkweed
	Osmadenia tenella	Oten	Osmadenia
	Oxalis albicans	Oalb	Wood sorrel
	Parietaria hespera	Phes	Pellitory
	Pellaea mucronata	Pmuc	Birds-foot-fern
	Penstemon centranthifolius	Pcen	Scarlet bugler
	Pentagramma triangularis	Ptri	Silverback fern
	Phacelia cicutaria	Pcic	Caterpillar phacelia
	Phacelia grandiflora	Phagra	Large-flowered phacelia
	Phacelia parryi	Ppar	Parry's phacelia
	Phacelia sp.	PhacSp	Phacelia
	Plagiobothrys sp.	PlagSp	Popcornflower
	Plantago erecta	Pere	California plantain
	Pluchea odorata	Podo	Salt marsh fleabane
	Pogogyne abramsii	Pabr	San Diego mesa mint
	Polygonum amphibium	Pamp	Water smartweed
	Polygonum sp.	PolySp	Smartweed, Knotweed, Bindweed
	Psilocarphus brevissimus	Pbre	Woolly marbles
	Pterostegia drymarioides	Pdry	Granny's hairnet
	Rumex sp.	RumeSp	Dock
	Salvia columbariae	Scol	Chia
	Sanicula arguta	Sarg	Snakeroot
	Scirpus acutus	Sacu	Tule
	Scirpus robustus	Srob	
	Scirpus sp.	ScirSp	
	Sedge	Sedge	Sedge
	Selaginella bigelovii	Sbig	Spike moss
	Selaginella cinerascens	Scin	Ashy spike moss
	Sidalcea malviflora	Smal	Checker mallow
	Silene laciniata	Slac	Mexican pink
	Sisyrinchium bellum	Sbel	Blue-eyed grass

Native Forb (Cont.)	*Stachys ajugoides*	Saju	Hedge nettle
	Stephanomeria virgata	Svir	Tall stephanomeria
	Stylocline gnaphalioides	Sgna	Everlasting nest straw
	Trichostema lanceolatum	Trilan	Vinegar weed
	Trifolium tridentatum (willdenovii)	Ttri	Tomcat clover
	Triodanus biflora	Tbif	Venus looking glass
	Typha latifolia	Tlat	Broad-leaf cattail
	Uropappus lindleyi	Ulin	Silver puffs
	Vicia californica (americana)	Vcal	American vetch
	Vicia ludoviciana	Vlud	Deerpea vetch
	Viola pedunculata	Vped	Johnny jump-up
Non-native Forb	*Alyssum sp.*	AlysSp	White alyssum
	Anagallis arvensis	Aarv	Pimpernel, Scarlet pimpernel
	Apium graveolens	Apigra	Celery
	Atriplex semibaccata	Asem	Australian saltbush
	Brassica nigra	Bnig	Black mustard
	Brassica rapa	Brap	Birdsrape mustard
	Carduus pycnocephalus	Cpyc	Italian thistle
	Carpobrotus edulis	Cedu	Fig-marigold, ice plant
	Centaurea melitensis	Cmel	Star thistle
	Cerastium glomeratum	Cglo	Mouse-ear chickweed
	Chamomilla suaveolens	Csua	Pineapple weed
	Chenopodium album	Calb	Pigweed, Lamb's quarters
	Cirsium arvense	Carv	Canada thistle
	Cirsium undulatum	Cund	Wavyleaf thistle, Artichoke thistle
	Conium maculatum	Conmac	Poison hemlock
	Cynara cardunculus	Ccar	Cardoon, Artichoke thistle
	Dipsacus sativus	Dsat	Fuller's teasle
	Erodium botrys	Ebot	Longbeak filaree
	Erodium cicutarium	Ecic	Red-stemmed filaree
	Filago gallica	Fgal	Herba impia
	Foeniculum vulgare	Fvul	Fennel
	Gypsophila paniculata	Gpan	Baby's breath
	Hedypnois cretica	Hcre	Crete weed

Non-native Forb (Cont.)	*Hirschfeldia incana*	Hinc	Mustard
	Hypochaeris glabra	Hgla	Smooth cats ear
	Lactuca serriola	Lser	Prickly lettuce
	Matricaria matricarioides	Mmat	Pineapple weed
	Medicago polymorpha	Mpol	California burclover
	Melilotus indica	Mind	Sourclover, Sweetclover
	Moss sp.	MossSp	Moss
	Oxalis pes-caprae	Opes	Bermuda buttercup, Lemon grass
	Picris echioides	Pech	Bristly ox-tongue
	Raphanus sativus	Rsat	Wild radish
	Reseda luteola	Rlut	Dyers rocket
	Rorippa palustris	Rpal	Yellow or water cress
	Rumex crispus	Rcri	Curly dock
	Salsola tragus	Stra	Russian thistle, tumbleweed
	Silene gallica	Sgal	Catchfly, campion
	Silybum marianum	Smar	Blessed milkthistle
	Sonchus asper	Sasp	Prickly sow thistle
	Sonchus oleraceus	Sole	Common sow thistle
	Sonchus species	SoncSp	Sonchus
	Spergula arvensis	Sarv	Stickwort, starwort
	Spergularia sp.	SperSp	Sand-spurrey
	Tetragonia tetragonioides	Ttet	New Zealand spinach
	Thistle sp.	ThisSp	Thistle
	Trifolium hirtum	Thir	Rose clover
	Trifolium sp.	TrifSp	Clover
	Unknown forb	UnkHerbForb	Unknown herb/forb
	Unknown species	UnkSp	
	Unknown vine	UnkVine	
	Vicia sativa	Vsat	Narrow-leaved vetch
	Vicia species	ViciSp	Vetch
	Xanthium spinosum	Xspi	Spiny cocklebur
	Xanthium strumarium	Xstr	Cocklebur
Native Tree	*Platanus racemosa*	Prac	Western sycamore
	Quercus agrifolia	Qagr	Coast live oak

Native Tree (Cont.)	*Quercus engelmannii*	Qeng	Engelmann oak
	Salix goodingii	Sgoo	Black willow
	Salix laevigata	Slae	Red willow
	Salix lasiolepis	Slas	Arroyo willow
	Sambucus mexicana	Smex	Blue elderberry
Non-native Tree	*Acacia sp.*	AcacSp	Acacia
	Casuarina species	CasuSp	Ironwood tree
	Coral Tree	CoTree	Coral Tree
	Elaeagnus angustifolia	Eang	Russian olive
	Eucalyptus sp.	EucSp	Eucalyptus
	Exotic tree	ExTree	Exotic tree
	Ficus species	FicuSp	Ficus tree
	Nicotiana glauca	Ngla	Tree tobacco
	Pinus sp.	PinuSp	Pine tree
	Schinus molle	Smol	Peruvian pepper tree
	Schinus terebinthifolius	Ster	Brazilian pepper tree
	Tamarix ramosissima	Tram	Tamarisk, Salt cedar
	Tamarix sp.	TamaSp	Tamarisk, Salt cedar
	Washingtonia filifera	Wfil	California fan palm
Non-vegetated Surface	Algae	Algae	Algae
	Bare ground	Bgro	Bare ground
	Rock	Rock	Rock
	Sand	Sand	Sand
	Water	Water	Water
Grass	Annual grass	Agra	
	Arundo donax	Adon	Arundo, Giant reed
	Cortaderia selloana	Csel	Pampas grass
	Elymus glaucus	Egla	Blue wildrye
	Grass	Grass	Unknown grass
	Lamarckia aurea	Laur	Goldentop

Grass (Cont.)	Perennial grass	Pgra	
	Sporobolus cryptandrus	Scry	Sand dropseed
	Turf	Turf	
Leaf litter/Twigs	Leaf litter	Llit	
	Twig	Twigs	Twig (dead)
	Woodrat nest	Wnest	
Man-made	Asphalt	Asph	
	Barbed wire	Bbwire	
	Board (Reptile shelterboard)	Board	
	Concrete	Conc	
	Drain	Drain	Drain
	Drift fence (Pitfall array fencing)	Dfen	
	Fence (Chain link)	Fence	
	Gravel (human-placed gravel)	Grav	
	Metal barrel	Mbar	
	Metal pipe	Mpipe	
	Post	Post	
	Rubble	Rubble	Rubble
	Sign	Sign	Sign
	Steam pit	Spit	Steam pit
	Tar	Tar	
	Wood chips	Wchips	Wood chips
Road	Dirt road	Droa	Dirt road
	Off-road vehicle trail	Orvt	Orv trail
	Paved road	Proa	Paved road
	Rail bed	Rbed	Rail bed
	Railroad track	Rtrack	Railroad track
	Road	Road	Road