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**Carlsbad Fish and Wildlife Office** <http://www.fws.gov/carlsbad/>

## **Estimation of San Diego County California Gnatcatcher Population Size and Recovery Following the 2003 October Wildfires**

The coastal California gnatcatcher (*Poliophtila californica californica*, gnatcatcher), listed in 1993 as federally threatened under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*), is considered one of the most important species in southern California conservation planning, with many of the conservation related activities in this area linked directly to gnatcatchers or the scrub vegetation it inhabits. In southern California, the gnatcatcher has become both the flagship species and umbrella species identified with conservation, where the goal is to have persistent populations maintained within a preserve system. Estimating gnatcatcher distribution and abundance is of utmost importance to regional planning efforts, as well as for maintaining viable populations. Estimates of these parameters are used to establish baseline numbers to assess direct loss of habitat, identify areas for conservation, and to track the regional gnatcatcher population status or trend.

Evaluating basic ecological parameters such as distribution and abundance along with fundamental habitat characteristics

represented by plant communities and environmental attributes will aid in the development of a comprehensive habitat model for the gnatcatcher. Robust habitat models play a key role in conservation planning. Models should consider changes in habitat characteristics brought about by development, natural successional process, and abrupt and unpredictable alterations to the landscape created by large wildfires. It is critical to understand how gnatcatchers respond to these changes in order for managers to plan their management actions.

Gaining this knowledge both prior to and along with the expansion of the transportation network serving San Diego County is paramount to offsetting environmental impacts to the natural resources so commonly identified with the quality of life in southern California. This work should provide a greater understanding of how ecosystems function to support gnatcatchers, provide guidance to land managers challenged with restoring lands for conservation, and provide planners with information that assists in land acquisition prioritization.

## Goals and Objectives

In the spring of 2007, the San Diego Association of Governments (SANDAG) supported and funded the U.S. Fish and Wildlife Service (USFWS) to conduct the first comprehensive survey in San Diego County for coastal California gnatcatchers. The objectives for this project were to:

- 1) Provide a population estimate of gnatcatcher pairs in San Diego County during the 2007 breeding season.
- 2) Determine the distribution of gnatcatchers by calculating the Percent Area Occupied of habitat in San Diego County.
- 3) Improve the gnatcatcher habitat suitability model developed in 2002.
- 4) Evaluate the recolonization of gnatcatchers in habitat burned in the 2003 wildfires.
- 5) Explore the concept of “extinction and colonization” of gnatcatchers in space and time.

## Study Area

The study area or sample frame for this project was strictly limited to lands within San Diego County currently designated as public or quasi-public, and some military lands (Figure 1). In general, this included preserve lands regulated under Habitat Conservation Plans, other public lands regulated by local jurisdictions, and lands separately managed by Marine Corps Air Station Miramar and Naval Weapons Station Seal Beach, Detachment Fallbrook. Marine Corps Base Camp Pendleton was not included because of logistical considerations. Additionally, private lands and Tribal lands were excluded from the sample frame because of access limitations and liability concerns.

None of the results of this report can or should be extrapolated to private lands, or other lands, that are outside of the design sampling frame. The results from data collected on this project should only be applied to the greater landscape to which access was granted.

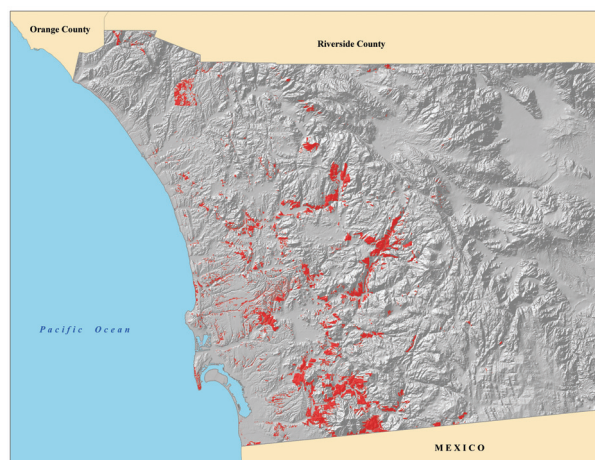


Figure 1. Areas in red indicate public lands supporting scrub communities that were included in 2007 gnatcatcher surveys.

## Methods

Potential sampling locations were identified as the center points of a 600-meter (m) × 600-meter (m) grid randomly overlaid on the study area. Sampling points were placed 600-m apart to avoid double-counting birds and assure independence among points. This design feature is based on USFWS gnatcatcher spot-mapping records that indicated that the longest axis across a territory was 295 m for birds studied at the San Diego National Wildlife Refuge (C. S. Winchell, USFWS, unpubl. data, 2000).

The California Gnatcatcher Habitat Evaluation Model (TAIC 2002) was run to predict areas where gnatcatcher habitat was expected to occur. Preliminary analyses from the 2002 and 2004 surveys suggest that this habitat model adequately predicted occupancy relative to habitat parameters.

The habitat model can thus be used to classify land within the preserve system as one of four strata: Very High, High, Moderate, and Low quality habitat. These strata overlaid onto lands making up the sampling frame became the survey lands. Further stratification was completed using elevation because surveys during 2004 indicated a relationship between gnatcatcher occupancy and elevation in modeled Very High and High strata. Therefore, within these two strata, elevation was used to further separate groups to test if elevation affected gnatcatcher occupancy.

In addition to classifying habitat into strata, survey lands were further divided into two groups, lands that burned during the 2003 wildfires and land that did not burn. This division was made for all lands that the 2002 California Gnatcatcher Habitat Evaluation Model classified. Habitats modeled as Very High and High were surveyed as it was assumed recolonization of these areas would occur first and the chance of detecting a bird would be higher since previous work showed occupancy to be greater in these habitats.

Points were classified to be in the sample pool, or available for selection for sampling, if a point from the 600-m x 600-m grid fell within the study area. Surveyed points were randomly selected from the sample pool. A stratified random sample design was employed to determine how many sample points should be visited within each stratum. Very High and High quality strata received a larger sampling effort, with higher percentages of points being surveyed, than Medium and Low quality strata. The sample intensity within each stratum was determined using the estimates of gnatcatcher occupancy from the 2002 and 2004 surveys. A power analysis was conducted to determine sample size,

minimizing statistical confidence intervals for estimates derived in Very High and High strata, while maximizing allotted field effort.

Points were attempted to be visited 6 times over a 6-week period, once per week, beginning 30 April 2007 and ending 08 June 2007. Observers located each point using a GPS unit, where the accuracy was +/- 5 m. Once the GPS unit zeroed at the point, the observer placed a pin flag. The observer was not permitted to adjust the point due to topography or terrain. For consistency, all subsequent visits used the pin flag as the survey point. This technique placed points without bias by individual field observers.

At each sample point data were collected in three sets: 1) population point counts, 2) vegetation relevés, and 3) photo plots. To collect point transect data the observer began each visit with a 2-minute "cool down" period. During this period observers recorded temperature (° C), relative humidity (%), average wind speed (km/hr), and cloud cover. Surveys were not conducted at a point if the average wind speed exceeded 20 kilometers per hour, precipitation was greater than a drizzle, or ambient temperature was less than 4.5°C.

Following the "cool down" period the observer began a bird data collection period. Each collection period consisted of an 18-minute period within which each detected gnatcatcher was recorded and individual movements tracked. This 18-minute period was divided equally into six 3-minute periods. A call-back tape was played during the last 3-minute period. The exact time (minutes and seconds) of detection and distance and angle to each gnatcatcher were recorded for each 3-minute period. During the survey, observers visually tracked birds to help control for double counting, and any points of confusion were noted. Whenever

possible, age (adult or juvenile) and sex of the bird were noted. Because of the time it takes to establish complete breeding pairs, this study focused on estimating percent area occupied and abundance as it related to pairs. Juveniles were recorded but were not counted in occupancy or abundance estimates. A pair was defined as one individual bird or 2 birds of different sex. Two birds of the same sex or 3 adult birds were considered as 2 pairs.

Simple relevés were completed to classify the vegetation community within 50-m of each point. Shrub species were listed in order of abundance and cover. Grasses and bare ground were measured as percent cover across the 50-m radius circle. In addition, the average shrub height for each plot was recorded. Plant communities were classified using criteria set forth by Holland in 1986.

Data collected about plant communities were combined with the physical environmental parameters associated with each sample point. These environmental parameters were slope, aspect, elevation, distance from coast, fire history, and habitat patch size. These data collectively are considered covariates and will be evaluated when analyzing data to better understand what characteristics of the ecosystem gnatcatchers select. Program MARK, available to the public from Colorado State University, was used for the analysis.

For purposes of historical context, each survey point was photographed to document the habitat and topography. Four photographs were taken at each point, along the four cardinal coordinates. The horizon was placed in the center of the view screen to standardize each picture.

## Results

The sample frame, to which findings can be extrapolated, is restricted to public lands, quasi-public lands, and preserve lands within San Diego County. Table 1 lists the area of surveyed lands classified within each stratum.

Four-hundred and nine points were surveyed for gnatcatchers (Table 2). Three-hundred and two points received the full compliment of 6 visits. The remaining points were visited less frequently because of safety and logistical issues. For instance, some points required pairs of surveyors because of remote terrain, and the “buddy system” was used for safety. Therefore, the effort to normally complete two points was used to collect data at only one point.

Table 1. Land area included in each stratum.

BURNED IN 2003 WILDFIRES	HABITAT STRATA	AREA (Hectares)
No	Very High	11,100
No	High	6,338
No	Moderate	4,212
No	Low	3,048
Yes	Very High	4,690
Yes	High	3,704
Yes	Moderate	5,517
Yes	Low	3,944

Table 2. Number of points surveyed by frequency.

NUMBER OF VISITS TO A SURVEY POINT						
Number of Visits	1	2	3	4	5	6
Number Points Surveyed	6	9	12	8	72	302
TOTAL POINTS SURVEYED					409	

Table 3 shows how sample effort was proportioned among strata, with a high of 49% of the Very High quality habitat points being sampled and a low of only 14% of the total points in Low quality habitat. Overall, 34% of the 1213 total points in the sample frame were surveyed.

Table 3. Sample effort proportioned by stratum. Burn points are included in the total number of points in each stratum.

HABITAT STRATA	TOTAL NUMBER OF POINTS IN STRATUM	NUMBER OF POINTS SAMPLED	PERCENT
Very High	435	211	49%
High	305	129	42%
Moderate	286	43	15%
Low	187	27	14%
TOTAL	1213	409	34%

Burned points modeled as Very High and High quality habitat were sampled at percentages lower than unburned habitat of the same classification because gnatcatcher occupancy was expected to be low in burned areas and placing a large amount of effort in this stratum would erode sampling effort from the overall project. Burned points were sampled at a minimum level to determine whether or not gnatcatcher recolonization had begun. Additionally, burn strata were not further divided by elevation because this covariate was already under evaluation and it would have been inappropriate to confound effects of elevation and fire with smaller sample size.

Table 4 illustrates the proportion of points sampled within strata as individual strata are

grouped for analysis. The highest proportion of points sampled in any strata was 96% of the total pool of sample points. This was in Very High quality habitat, no burn, and elevations greater than 301 meters. A high percentage was sampled here because this stratum contained very few points, and in order to satisfy statistical concerns of minimum sample size nearly all points were sampled.

Table 4. Number of points sampled within stratum and groups.

STRATUM	BURNED	ELEVATION	SAMPLE SIZE	PERCENT SAMPLED
Very High	No	0 - 150 m	74	55%
Very High	No	151 – 300 m	72	50%
Very High	No	>301 m	26	96%
High	No	0 - 150 m	36	50%
High	No	151 – 300 m	37	50%
High	No	>301 m	27	50%
Moderate	No	Lumped	43	32%
Low	No	Lumped	27	33%
Very High	Yes	Lumped	39	30%
High	Yes	Lumped	28	25%

In summary, strata where gnatcatcher occupancy was predicted to be greater were sampled at or above 50%, and strata where occupancy was predicted to be low were sampled at close to 30%.

## Preliminary Findings

### Fire

This project attempted to evaluate the early recolonization by gnatcatchers of habitat impacted by the 2003 fires. Sixty-seven points were surveyed in the fire footprint of 2003. Thirty-nine points were in Very High quality habitat, and 28 points were in High Quality habitat. Surveys were conducted on burn points during the 2004 breeding season following the October 2003 fires. No gnatcatchers were observed on burned plots during 2004 surveys. In 2007, 3 of the 67 points surveyed within the 2003 fire perimeter were occupied by gnatcatchers.



All 3 points were in areas previously modeled as Very High quality habitat prior to the 2003 fire and were on the perimeter or margin of the burn. The shortest distances measured from each point to the fire perimeters are 184 m, 263 m, and 500 m. For each point the shortest distance to unburned areas also measured to habitat modeled as Very High.

These data indicate that some gnatcatchers have begun to recolonize areas burned during the 2003 firestorm. However, the percentage of points occupied is fairly low (4.5%), and any recovery is most likely restricted to the interface of the burn area with existing coastal sage scrub communities. Recovery appears to be associated to the habitat quality immediately adjacent to the burned area. Recovery may be aided by adjacent habitats of higher quality.

These surveys were completed in the spring of 2007 prior to the October 2007 wildfires (Figure 2). Therefore this project is in an extremely unique position to have data recorded several months following the October 2003 wildfires, and several months prior to the October 2007 fires (Figure 3). In 2009, efforts afield will evaluate long-term recovery from the 2003 fires, this time with a longer time period for recolonization to occur, and should continue to develop a timeline for recovery of sage scrub communities at a landscape perspective. The opportunity to document a pattern of post-fire, pre-fire, and post-fire events at the same survey points spanning a period of 6 years is unique and should provide useful insights to understanding impacts firestorms have on coastal sage scrub and the species dependent on these habitats over the long term.



Figure 2. Monitoring vegetation communities near Point 1384 prior to the 2007 October wildfires.



Figure 3. Point 1384, looking due east from center point, photographs taken pre and post fire 2007.

## Habitat Model

Habitat models were developed *a priori*, building models based on science and biology. This approach avoids “data dredging” which can lead to over-fitted models with spurious effects and little biological relevance. Models were ranked using Akaike’s Information Criteria. This analysis technique is a blend of information theory and mathematical statistics yielding an estimated “best approximate model” from an *a priori* model set. Models were constructed that included various combinations of underlying habitat variables associated with each survey point, to evaluate whether these covariates could be used to explain gnatcatcher occupancy.

Most points were visited 6 times during the survey period. The number of visits is important when trying to achieve a high cumulative detection probability giving a high level of confidence in instances where gnatcatchers were never observed at a point. The probability of detection, the chance of observing a gnatcatcher at a point given the survey point is occupied, was estimated for the 2007 surveys at 0.45 ( $\hat{SE} = 0.023$ , 95% CI 0.404, 0.492). Six visits to a site are adequate for a project where the probability of detection is at this level, 45%. In fact, the number of visits to Very High quality stratum could be reduced to 4 and still have little change in confidence. Points in High quality stratum need to remain at 6 visits for the survey period.

The California Gnatcatcher Habitat Evaluation Model developed by TAIC in 2002, used for sample stratification, was applied as the base model for testing. Modeling suggests that the presence of California sagebrush (*Artemisia californica*) and distance to the coast, in combination, are stronger influences on occupancy

probability when data are grouped by strata. A model using only patch size as a predictor ranked last whereas other models including all variables except patch size improved the original model used for stratification. These results support the assertion that patch size is relatively unimportant for occupancy for coastal populations. Other parameters in the original California Gnatcatcher Habitat Evaluation Model, that is slope and climate, remain good predictors of gnatcatcher occupancy. However, results indicate that the presence of California sagebrush, in combination with proximity to coast, tend to increase gnatcatcher occupancy.

## Occupancy and Extinction/Colonization

Occupancy represents the percent of area, or habitat, occupied by a study species during the sample period. This is a very important metric about the condition of the species, possibly more important than a population estimate. Occupancy can be evaluated across a landscape and takes into account the dynamic nature of populations changing with time. Additionally, occupancy is estimated by developing and selecting a series of *a priori* models. Choosing the best model involves the intellectual challenge of understanding what parameters in the ecosystem influence species presence. Learning this relationship integrates monitoring as a component of a larger conservation effort that both includes and relates to management activities. Occupancy developed through presence-absence models permits managers to incorporate extinction and colonization rates into long term conservation planning. Surveillance monitoring, estimating abundance without the understanding of *a priori* models, is inefficient, because it takes a long time to collect sufficient data and

then provides little reason for a change in the species status or trend.

Data from 2007 (Table 5) indicate the footprint for gnatcatcher populations occupying preserve lands in San Diego County shifted between years and is very fluid. One-hundred and seventy four points were surveyed during 2004 and again in 2007. Approximately 45% of the points where gnatcatchers were present during any one of two survey years changed presence/absence status (i.e., points that were occupied became unoccupied and vice versa), demonstrating movement of breeding gnatcatchers across the landscape between years. Only slightly more than half of the population consistently occupied the same area between 2004 and 2007.

Therefore, an area of habitat that remains unchanged or unaltered between years has roughly a 50% chance of maintaining the status of gnatcatchers being present or absent at that area, provided an area is occupied by gnatcatchers over a series of years.

Table 5. Change in occupancy between years.

Total Number Points that had gnatcatchers in 2007	44
Number Points that had gnatcatchers in 2007 and NOT in 2004	21
<b>Percent Change from unoccupied to occupied between years</b>	<b>48%</b>
Total Number Points that had gnatcatchers in 2004	39
Number Points that had gnatcatchers in 2004 and NOT in 2007	16
<b>Percent Change from occupied to unoccupied between years</b>	<b>41%</b>

Occupancy estimates for 2007 were calculated for each habitat stratum using Program MARK (Table 6). Habitat categorized in the Very High stratum had the highest occupancy at 35%.

High quality habitat followed with 23% occupancy, Moderate with 4% and Low with 17%. The results are presented in Table 6 and Figure 4.

Table 6. Percent area occupied by strata.

STRATA (Habitat Quality)	PERCENT OCCUPIED	95% CI	
		Lower	Upper
Very High	35	27	43
High	23	15	34
Moderate	4	0	22
Low	17	5	43

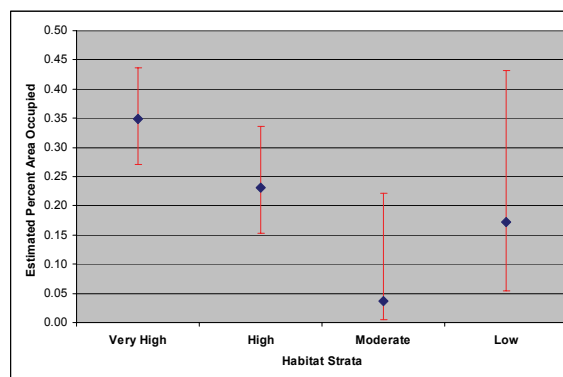


Figure 4. Percent area occupied and confidence intervals for each stratum.

The 95% Confidence Interval for Low quality habitat encompasses all other estimates with the exception of the low end of Moderate habitat. The occupancy estimate for Low quality habitat is relatively large when compared to Moderate quality habitat and when compared to similar data analyzed for 2002 and 2004 surveys conducted in San Diego County.

Gnatcatcher surveys conducted in 2002 and 2004 show the proportion area occupied in Low quality habitat to be minimal, significantly less than 1 percent. Whereas, these same surveys for 2002 and 2004 had similar results for Moderate quality habitat with estimates roughly about 5%.

Therefore, it is the estimate for Low quality habitat in 2007 that appears to troublesome. This can be explained.



In general as occupancy estimates decrease, the corresponding confidence intervals increase. Furthermore, statistically as sampling effort decreases on any measured variable, confidence intervals also increase. And when sample size is small, any positive observations will represent a disproportionately large, or biased high, occupancy estimate.

In 2007 there was a design decision made to decrease sampling effort to a minimal level in the Low stratum. Primarily, this decision was made because points located in habitat modeled as Low quality were logistically difficult to access and lowered the rate of data return for the project as a whole. Only 27 points (Table 3) in Low quality habitat were surveyed for gnatcatchers during 2007. The combination of several factors, low sample size of which very few points were observed to supported breeding pairs of gnatcatchers, resulted in an occupancy estimate biased high with large confidence intervals.

The Low quality stratum was sampled at a minimum level to check whether or not gnatcatchers were at least occupying this stratum. Accuracy and precision were sacrificed for this stratum because it was believed that the information that was important to attain was not an estimate of occupancy in Low quality habitat but whether or not the habitat supported some birds. Low quality habitat may serve a different role for gnatcatcher conservation than the other strata, by providing refugia and dispersal linkages.

The statistical results are not surprising given the sampling strategy. There is little confidence, or reliability, in the occupancy estimate for lands classified as Low stratum. There is confidence, however, that these

lands are supporting some function for conservation.

## Population Estimate

The number of gnatcatcher pairs was estimated using percent area occupied results. Each occupied point was assumed to support only a single pair of gnatcatchers, and it was also assumed each survey point equals a circle with radius 101 m (detection radius was calculated using Program DISTANCE). A presence-absent naïve estimate can be calculated by dividing the area represented by the circle surrounding each survey point into the total sample area (Table 1) represented by each stratum and multiplying that number by the corresponding percent area occupied (Table 6). Using this method, results for Very High and High strata were extrapolated over the sample frame to estimate the number of pairs of gnatcatchers, resulting in an estimate of 1667 (95% CI 1240, 2176) pairs.

Moderate and Low strata data were not included in calculating this estimate. Inclusion of these data in the population estimate would have two deleterious results. First, the confidence intervals for these strata are large, especially for the Low stratum, thus incorporating these data would result in confidence intervals for the population estimate to be huge and nearly meaningless. Second, the percent area occupied estimate for the low stratum is not reliable and would most likely bias the population estimate high.

This estimate, 1667 pairs, strictly applies to the area included in the sample frame. These results do not account for birds occupying private lands and other land not included in the sample design.

## Management Implications

One of the most important pieces of information for managers is knowing what factors cause changes in the distribution and abundance for managed and/or covered species on preserve lands. And thus, monitoring should feedback into management efforts. For example, a management action could be the purchase of land, and monitoring would allow managers to determine whether land acquisitions contributed to the overall goals of a preserve. Conversely, this same information could be used to prioritize future land acquisitions.

Survey efforts conducted in 2007 were the first county-wide surveys conducted using sample stratification. This is important as the design strategy for this project, coupled with the analysis methods, increased the efficiency and usefulness of monitoring data in a region-wide conservation framework. Additionally, 2007 surveys provided the second survey conducted exclusively on preserve lands managed under the San Diego Multiple Species Conservation Plan (MSCP), the first survey being conducted during the 2004 breeding season. However, trends cannot be determined until a minimum of three data points, or survey sessions, are completed. Therefore, after the 2009 survey is completed trends can be analyzed. The completion of the 2007 surveys provides the baseline for determining county-wide trends and sets the second population estimate for gnatcatchers managed on San Diego MSCP preserve lands. Managers will have information regarding gnatcatcher trends for lands managed by the San Diego MSCP once estimates for 2009 surveys are calculated.

Other useful information can be extracted from this dataset. Survey results from 2007

support results from 2002 and 2004 survey efforts indicating that patch size is a poor predictor of gnatcatcher occupancy. Additionally, 2007 survey results indicate that Very High quality habitat close to the coast and containing California sagebrush increases occupancy by gnatcatchers. This information may be used to prioritize management effort, as numerous small patches of habitat occur in canyons within the urbanized areas associated with the southern California coastline.

The recovery of gnatcatcher populations in response to large wildfires takes time. This study indicates that populations recolonized burn areas at extremely low levels within the first 4 years following a fire, at least when no habitat rehabilitation program was implemented. Managers should consider directing habitat rehabilitation efforts towards areas of habitat that are modeled as either Very High or High prior to a fire to increase recolonization rates or at least assure the habitat reestablishes to pre-fire conditions. If money is limited, then habitat rehabilitation efforts could be concentrated in concentric bands bordering the perimeter of the fire and adjacent to habitat modeled as Very High.

One important finding from this project is that gnatcatchers tend to be fluid in their locations or move about the landscape through time. It may be less important for managers to determine the number of nesting pairs of gnatcatchers in a small area and place more effort into collectively maintaining a general occupancy rate across the larger preserve landscape that supports a known quality of habitat. Such efforts may be a more efficient utilization of conservation funds.

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## **Cooperators**

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