Target Bird Monitoring Study
Nature Reserve of Orange County
Combined Report, 1999-2001

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I. Introduction

Nature Reserve of Orange County History

The Nature Reserve of Orange County (NROC) is an extensive open space network that includes the central and coastal subareas of Orange County's participation in California's Natural Community Conservation Plan (NCCP) for the coastal sage scrub plant community. Due to the presence of federally-listed threatened species in this planning area, the NCCP for these subregions also served as a Habitat Conservation Plan (HCP) to address Section 10 of the Endangered Species Act. As part of the NCCP effort, the County of Orange and U.S. Fish and Wildlife Service (USFWS) prepared an Environmental Impact Report/Environmental Impact Statement (EIR/EIS) in 1996 for the Central/Coastal Orange County NCCP/HCP. Following distribution, review and public comments, this NCCP/HCP was approved, and the NROC was designated as the name for the reserve areas within the Central/Coastal Orange County NCCP/HCP area.

The need for a coastal sage scrub NCCP/HCP was made apparent by a combination of cumulative impacts on coastal sage scrub resources and the legislative and regulatory responses to those impacts. The federal listing of the Coastal California Gnatcatcher (*Polioptila californica californica*) as "threatened," and the potential listing of several additional species that depend upon coastal sage scrub habitat, generated a need for a shift from single-species management and project-by-project decisions to conservation planning at the natural community level. The coastal sage scrub NCCP program was developed to address this need, with the goal of designating regional reserves to protect a wide range of species while allowing compatible land uses to occur in the reserves and appropriate growth and economic development outside the reserves.

The NROC's coastal subregional reserve includes approximately 6,961 hectares (17,201 acres) located primarily in and surrounding the San Joaquin Hills. It extends from the shoreline of Crystal Cove State Park northwest almost 7.5 miles inland, and from Upper Newport Bay southeast approximately 16 miles to the confluence of Oso and Trabuco creeks. The NROC's central subregional reserve comprises approximately 8,166 hectares (20,177 acres) located south and west of the Cleveland National Forest in the foothills and southwestern slopes of the Santa Ana Mountains. From its western boundary at Santiago Oaks Regional Park in the City of Orange, the subarea extends east about 14 miles to El Toro Road. From its northernmost point in the Coal Canyon Preserve, it continues about 7.5 miles southwest to the southern edge of the Lomas de Santiago.

The NROC Biological Monitoring Program

During the initial years of implementing the NCCP/HCP for central and coastal Orange County, the NROC Technical Advisory Committee developed a comprehensive monitoring program to document baseline conditions within the NROC, and to monitor population trends and ecological functions within the reserve. It is anticipated that these monitoring results will be used to help guide NROC adaptive management activities, and to demonstrate the extent to which the NCCP program is successful in conserving coastal sage scrub habitat values for a variety of native plant and wildlife species, particularly those considered to be "covered" under the NCCP/HCP.

The NROC's integrated bird monitoring program is expected to include (1) monitoring of population trends for the NCCP's two "target" bird species, the California Gnatcatcher and Cactus Wren (*Campylorhynchus brunneicapillus*), in each subregional reserve; (2) constant-effort mist-netting each spring/summer according to protocols developed by the Institute for Bird Populations (IBP) for the Monitoring Avian Productivity and Survivorship (MAPS) program; (3) Peter Bloom's ongoing studies of raptors in the coastal and central subregional reserves; and (4) periodic monitoring of toxin levels in raptor eggs. To the extent these programs are implemented, each component will provide a more complete picture of the fluid status and distribution of bird populations within the NROC.

The goal of the California Gnatcatcher and Cactus Wren study is to determine and document the NROC's level of success in conserving populations of the NCCP's two target bird species over time. The remaining studies are designed to obtain integrated data on avian population trends and their potential causes, information that is required to inform the NROC's "adaptive management" program with the overall goal of conserving avian biodiversity within the NROC's covered habitats over the long term. These data would also establish a robust "baseline" that future researchers would need in order to track long-term changes in the reserve's bird populations.

This report provides methods and results of the target bird monitoring study for 1999, 2000, and 2001, including statistical analysis of these first three years of data.

II. Purpose and Objectives

The purpose of the target bird study is to obtain standardized information on the numbers of California Gnatcatchers (CAGN) and Cactus Wrens (CACW) occupying specified study sites within each of the NROC's two subregional reserves, in order to effectively track population trends for these species across the NROC. The monitoring approach used in this study has evolved during each of the NROC's first five years.

In 1997, consistent with the NCCP Implementing Agreement, CAGN and CACW were monitored at six sites that were selected by Trish Smith and Robert Hamilton of the NROC Technical Advisory Committee. In 1998, at the request of the USFWS, the number of target bird monitoring sites was increased from six to eight, the two additional sites again being selected by Smith and Hamilton. The requirements of all eight sites were that they (1) supported one or both target bird species, (2) were of particular interest to NROC land managers, and (3) could be surveyed in a single morning.

The annual report for 1998 identified the following limitations of the study design employed in 1997 and 1998:

- For purposes of data analysis, selection of target bird monitoring sites based on their interest to reserve managers and/or the resource agencies is considered inferior to selecting sites at random, since with non-random sampling the monitoring results cannot be inferred to pertain to the reserve system at large.
- Conducting four surveys per site generates a finer level of detail than is necessary to obtain a reliable index of the target species' population levels across the reserve system, and this labor-intensive approach limits the number of sites that may be sampled under the NROC's annual monitoring budget.
- Only eight sites were being surveyed annually in the NROC, a quantity inadequate to monitor target species population trends across the reserve system.

In these important ways, the 1997 and 1998 target species sampling designs were inconsistent with the monitoring approach developed by the TAC in conjunction with biometrician Tyson Holmes and biologist Michael Patten. On 15 January 1999, the relevant issues were reviewed with USFWS biologists Will Miller and Loren Hays, who agreed with the general monitoring approach employed in 1999. A draft version of the monitoring plan was peer-reviewed in February 1999, and target species monitoring was conducted using the new approach (with some modifications) in 1999, 2000, and 2001.

The monitoring approach outlined in this report focuses on estimating temporal trends for CAGN and CACW in coastal sage scrub within the NROC. The Brown-headed Cowbird (BHCO; *Molothrus ater*) is known to parasitize the nests of California Gnatcatchers and has been identified by the USFWS as a potentially important cause of gnatcatcher decline, particularly in areas fragmented by human developments; thus, tracking cowbird abundance across the NROC is set forth as a secondary objective of this monitoring study. No hypotheses will be tested with respect to BHCO.

Hypotheses to be Tested

For each of the 10 "target species population trend hypotheses" listed below, two to six years of pilot sampling will be conducted in order to answer the following study-design hypotheses:

For each relevant sampling stratum (core, development edge, road edge), how large a sample size is required (1) to set the odds of obtaining false-positive results at 20%, and (2) to have at least 90% power to detect an annual change in population size of 20% or more?

For each relevant sampling stratum (core, development edge, road edge, mixed edge), how large a sample size is required (1) to hold the false alarm rate at 20% if there is no five-year trend in population size, and (2) to have at least 90% power to detect a five-year population trend of 10% or more?

Target Species Population Trends

Hypothesis 1: When examined over at least five consecutive years, changes in mean detection rate of CAGN territories across the NROC (all strata combined) include a linear trend over time.

Hypothesis 2: When examined over at least five consecutive years, changes in mean detection rate of CACW territories across the NROC (all strata combined) include a linear trend over time.

Hypothesis 3: When examined over at least five consecutive years, changes in mean detection rate of CAGN territories within the "core" sampling strata include a linear trend over time.

Hypothesis 4: When examined over at least five consecutive years, changes in mean detection rate of CACW territories within the "core" sampling strata include a linear trend over time.

Hypothesis 5: When examined over at least five consecutive years, changes in mean detection rate of CAGN territories within the "edge" sampling strata include a linear trend over time.

Hypothesis 6: When examined over at least five consecutive years, changes in mean detection rate of CACW territories within the "edge" sampling strata include a linear trend over time.

Hypothesis 7: When examined over at least five consecutive years, changes in mean detection rate of CAGN territories within the "fragment" sampling strata include a linear trend over time.

Hypothesis 8: When examined over at least five consecutive years, changes in mean detection rate of CACW territories within the "fragment" sampling strata include a linear trend over time.

Hypothesis 9: When examined over at least five consecutive years, changes in mean detection rate of CAGN territories within the "edge" and "fragment" sampling strata (combined) include a linear trend over time.

Hypothesis 10: When examined over at least five consecutive years, changes in mean detection rate of CACW territories the "edge" and "fragment" sampling strata (combined) include a linear trend over time.

III. Methods

Sampling Design

Sampling follows a stratified design. The County's Geographic Information System (GIS) analyst partitioned those portions of the NROC containing at least 50% cover of coastal sage scrub into potential monitoring sites of approximately 20 ha (50 acres) each. Land manager Trish Smith of the TAC then used a random number generator to randomly select 20 sites within each of the NROC's two sub-regional reserves, for a total of 40 monitoring sites across the NROC. The sites were further stratified such that 19 sites fell within "reserve core," 15 sites fell within "reserve edge," and six sites fell within "reserve fragment" strata. These strata apply to each of the biological monitoring programs being undertaken within the NROC, and are defined in the NROC's evolving "umbrella monitoring plan." Areas designated "reserve core" encompass at least 1,000 acres of contiguous reserve exclusive of the "reserve edge," which extends 300 m from existing developments and from major arterial roads. "Habitat fragments" include all areas less than 1,000 acres in size, including areas less than 300 m from existing developments and major arterial roads.

The sampling design is summarize in Table A, below. The number of 20-ha plots with at least 50% cover of CSS is denoted "Population Total," and the simple random sample of size "N" was drawn independently within each stratum. The design has approximately equal sampling rates within each stratum, while the fraction of the population in each stratum varies between 5 and 27%. The difference between the sampling fraction and the population fraction was found to be enough to substantially impact some estimates. Hence estimates of means, and mean differences, should be appropriately weighted as described below.

Table A – Sampling Fractions

Subarea	Land Designation	Population Total	Sampling Rate	Sites Randomly Selected (N)	Fraction of Population
Central	Core	87	11.5%	10	23.3%
	Edge	67	10.4%	7	18.0%
	Fragment	20	15.0%	3	5.4%
Coastal	Core	101	8.9%	9	27.1%
	Edge	73	11.0%	8	19.6%
	Fragment	25	12.0%	3	6.7%

The choice of model for these estimates is examined in greater detail in Appendix C. In summary, the data are not normally distributed, and a Poisson model is more appropriate than a standard normal weighted estimate. The weighted normal estimate will be unbiased for CAGN densities or counts, however the attached confidence interval may not be correct. On the other hand, a standard

Poisson (or GEE) model will not produce weighted estimates. Hence either of these choices is apt to produce incorrect standard errors, and in addition the un-weighted Poisson model is apt to be biased in its estimates of mean CAGN density or total CAGN count. In practice, either model works well for estimating changes in CAGN counts, as verified by a bootstrap computation. The standard errors for CACW are at times too wide due to the small counts obtained in the coastal reserve. An un-weighted model is misleading for estimating population totals. The project's statistical consultant, Dr. Karen Messer, has adopted the policy in this analysis of consistently using weighted estimates from a normal model for major results, and occasionally using an un-weighted Poisson regression model for convenience. For future analyses, she has advised to program a weighted version of Poisson regression to obtain more accurate and narrower confidence intervals. All statistical computations were completed using SAS statistical software, version 8.2.

From 1999 to 2001, the boundaries of the selected sites were adjusted in the field to ensure that (1) that all portions of the sites can be safely and thoroughly covered on foot in a single morning without excessive trampling of woody vegetation or creation of new trails judged likely to degrade habitat quality, and (2) site boundaries conform to watershed boundaries or other topographic features that will allow survey personnel to accurately determine the position of target birds relative to site boundaries. In most cases, the study areas could be substantially enlarged while still allowing personnel to thoroughly cover the site. Site boundaries were also adjusted in cases where field investigation showed the extent of coastal sage scrub habitat within the randomly selected polygon to be substantially less than that depicted on plant community mapping (e.g., in cases where chaparral was mapped as coastal sage scrub). Due to modifications to monitoring site boundaries, the total area surveyed increased 18% from 1999 to 2000, and then 2% from 2000 to 2001. As discussed in Appendix C (Section 1.8), these changes were not a significant predictor of change in territory counts ($p = 0.91$), and the estimated effect size was negligible (0.002 territories per additional hectare of survey area). Hence no adjustment for the boundary change was included. Territories per site is, thus, the appropriate unit of measurement for tracking population trends in this study.

The study's lead biologist, Robert Hamilton, was responsible for confirming the current boundaries of each site, which have been entered into the NROC's GIS system. Compared with using the original polygons, this initial adjustment of the site boundaries will reduce habitat disturbance, reduce hazards for survey personnel, increase the area sampled, increase the number of target birds detected per site, and for these reasons should yield more consistent and useful survey results. Future site boundary changes, if any, are expected to be slight.

The order in which sites are surveyed will be randomized each year, and the number of monitoring sites may be changed depending on the results of sample size analyses conducted after the fifth year of data collection.

Since the avian subjects of this study can, presumably, readily disperse into virtually all of the NROC's "fragments," these areas essentially function as "reserve edge" with respect to this study. Thus, for certain analyses, "edge" and "fragment" strata could be combined into a single sampling stratum divided into "road edge," "residential edge," and "mixed edge" (the latter refers to a combination of road, residential, and/or agricultural edges). Depending on statistical considerations, stratification along these lines may eventually help to highlight potential differences between the various classes of reserve edge. At this time, however, analyses have been limited to just the main land designations (core, edge, fragment).

Data analyses will present comparisons between the central and coastal subregional reserves, and between various sampling strata, with the purpose of detecting trends and potential differences among different parts of the NROC.

During a 15 January 1999 meeting, USFWS biologists Will Miller and Loren Hays were asked to identify areas within the NROC that they felt should be included in ongoing monitoring; they took this request under advisement, but did not identify any areas at that meeting. The California Department of Fish and Game (CDFG) was not represented at this meeting, but may later identify additional portions of the reserve that they feel should receive monitoring. Any such would be monitored in addition to the existing 40 randomly selected sites. Data from any subjectively selected sites would not be combined with the random sample for reserve-wide inferential analyses.

Sampling Period

The initial study plan specified a sampling period of 1 February to 31 May, timing that was subject to review during the study's pilot phase. A sampling period of 15 March to 30 June was adopted in 2000 and 2001, and this was extended to 1 March to 30 June in 2002.

Survey Personnel

The 1999 surveys were conducted by Robert Hamilton, Mike San Miguel, and Kathy Keane. The 2000 surveys were completed by Robert Hamilton, Mike San Miguel, and Kathy Molina. The 2001 surveys were conducted by Robert Hamilton and Mike San Miguel. Per the study design, each surveyor possessed a current federal permit to survey for the CAGN and was familiar with the relevant plumage, bare part, and vocal characteristics of adult and juvenile CAGN, CACW, and BHCO.

Survey Methods

"Territories" are recorded in the target bird study, with the assumption that all adult target birds detected during the spring survey window are territorial. Thus, any detection of a single adult is considered equivalent to detection of a mated pair or family group occupying a territory. By this convention, field personnel do not guess at the status of lone adults or search extensively for a lone bird's mate, which could have adverse effects on target birds if pursued too aggressively (e.g., by disrupting incubation). All relevant data were recorded and entered into the NROC's database.

Since monitoring of the BHCO is not a primary goal of this study, and determining the nesting intent/status of a cowbird is not always straightforward, an individual cowbird (adult or juvenile) comprises the monitoring unit of the BHCO component of this study. As with the target birds, data were taken on cowbirds detected and entered into the NROC's database.

The number of repeated visits to each site during a field season changed during the first three years of the study. The switch from single-visit to a multiple-visit protocols reflected the general desire of all biologists involved to gather more reliable survey information on the number of target bird territories at each site while remaining vigilant about budgetary considerations. In 1999, all 40 monitoring sites were visited once. In 2000, 16 sites were visited once, the remaining 24 sites visited twice. Sites were chosen at random to be included in the 2 visit protocol. In 2001, the 16 sites visited once the previous year were visited twice, and the remaining sites were again visited 3 times.

This raises two issues: whether the data are adequate to determine the optimal number of visits, and how to adjust counts at sites which were visited fewer times. The first is addressed in detail in Appendix C, Section 1.12, where it is estimated that on average, at 95% confidence, the first two visits to a site will detect 90% of the birds that would be detected at three visits. Hence it was decided to use two-visit data where available, and to adjust counts upward if only one visit occurred.

However, it is recommended that future analyses explicitly incorporate the number of visits into the model, using a "missing data formulation" in a Poisson model.

It was decided to use a simple ratio adjustment based on the number of birds seen at visit two relative to visit one. The two field personnel who have participated in all years of the study (Hamilton and Mike San Miguel) felt that the counts obtained during the first visits in 2001 were unusually low compared to those of the second visit, probably due to rainy, damp weather at the first visit. Because the results obtained in 2000 were judged to be more typical than those from 2001, only the 2000 data were used in the adjustment, as shown below. We then analyzed these results in order to recommend a final sampling strategy that will test the study hypotheses with an appropriate level of field work.

Survey times and weather conditions were recorded at the beginning and end of each survey. Field work was conducted primarily between dawn and 12:00, although surveys lasted until as late as 13:30. On these longer days, temperatures typically did not exceed 80°F and estimated wind did not exceed 5 mph. Per USFWS 10(a) permit conditions, surveys were not conducted during periods of very hot or very cold weather, high winds, or storm events.

Surveys were conducted by walking slowing through all appropriate habitat, pausing at intervals not greater than every 50 meters to play tapes of the two target species and to listen and watch for responses. Target birds responded to taped vocalizations throughout the duration of each survey. Locations of all target bird sightings were mapped, and information on gender and group size (single, pair, or family group) was noted notes where possible, along with the vegetative composition of occupied habitats. Microsoft Access files, available from the author upon request, specify survey dates, areas, times and weather conditions for each survey conducted in 1999-2001.

Locations of Monitoring Sites

Please refer to Appendix A for maps showing the locations and 2001 boundaries of the 40 long-term target bird monitoring sites.

Physical Site Characteristics

The area of each site was calculated in hectares using the NROC's GIS system. It is anticipated that, eventually, the following additional geographic and land management information will be determined for each monitoring site:

- Distance to Nearest Arterial Highway in meters.
- Distance to Nearest Residential Edge in meters.
- Distance to Nearest Agricultural Edge in meters.
- Minimum and Maximum Site Elevations in meters.
- Mean Slope in degrees.
- Fire History — the percentage of each site burned within one or more of the following categories: (a) 0-2 years; (b) 3-7 years; (c) 8-12 years; (d) 13-20 years; and (e) 21+ years. The percentages burned should be rounded to the nearest 10% and sum of these categories should be 100%.
- Revised plant community mapping, and break-downs of habitat composition, on each site and across the various sampling strata.

The goal of cataloging these physical site characteristics would be to investigate how these characteristics may influence the abundance and distribution of target bird populations, to assist with adaptive management of the reserve.

IV. Results

Target Bird Territory Detection Rates

This section provides detailed information on the occurrence of California Gnatcatchers and Cactus Wrens in the NROC during each of the first three years of this study.

California Gnatcatcher Territory Detections - 1999

A single round of surveys was conducted in 1999. As discussed previously, and examined in Appendix C, a two-visit survey effort is considered adequate to analyze population trends as described under Purpose and Objectives. Thus, two-visit detection rates are used in this report.

In order to permit comparisons between the 1999 detection rates and the two-visit rates obtained in later years of the study, Table B includes projections of the Round 2 detection rates, employing a multiplier derived from the results of multiple-visit surveys conducted at 24 of the 40 sites in 2000.

Hamilton and San Miguel, who completed most of the surveys from 1999 to 2001, consider it likely that Round 1 detection rates were comparable (relatively high) in 1999 and 2000. As Tables C and D show, the Round 1 detection rate was substantially lower in 2001 compared with 2000. For this reason, 2001 detection rates were not used to develop the Round 2 projections for 1999 data.

In 2000, 88% of the three-visit total was detected in Round 1, and 94% of the three-visit total was detected (cumulatively) through Rounds 1 and 2. Thus, the cumulative total after Round 2 was 1.07 times greater than the Round 1 total, and this multiplier is used to project Round 2 detection rates for 1999 data.

California Gnatcatcher Territory Detections - 2000

During the 2000 field season, 24 of the sites were surveyed three times and the remaining 16 sites covered once.

Table C gives projected Round 2 territory detection rates for the 16 sites that were covered only once in 2000 (the actual cumulative totals through Round 2 are used for the 24 multi-visit sites).

In 2000, 88% of the three-visit total was detected in Round 1, and 94% of the three-visit total was detected (cumulatively) through Rounds 1 and 2. Thus, the cumulative total after Round 2 was 1.07 times greater than the Round 1 total, and this multiplier is used to project Round 2 detection rates.

California Gnatcatcher Territory Detections - 2001

In 2001, the same 24 sites were covered three times and other 16 sites were covered twice.

The Round 2 detection rates specified in Table D should be used when comparing 2001 data with data gathered in future years of the study.

Tables Q and R give the results of 1, 2, and 3 visit surveys (raw counts).

Table B – California Gnatcatcher Detection Rates, 1999

These projected Round 2 detection rates should be used when comparing 1999 data with data gathered in future years of the study.

Fractional entries under "Territories Detected (Round 2 Projected)" result from application of the 1.07 multiplier.

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS.

For example, the method computes the estimated mean number of territories per site for the central subregion as the sum of the mean territories per site in each stratum, weighted by the percent of the reserve in the stratum. The resulting mean per site is then multiplied by the total number of sites in the central subregion to obtain an estimate of the total number of territories for the central subregion (e.g. 4.79 x 174 = 833, which differs slightly from the value in the table due to rounding error.)

Reserve	Land Designation (Stratum)	Territories Detected (Round 2 Projected)	Number of Sites Sampled	Number of 20-ha Sites in Stratum	% of Subregional Reserve in Stratum	Mean Territories Detected per Site	Mean Territories Detected/Site, Weighted by % of Reserve in Stratum	Estimated Total Territories
Central	core	7.49	10	87	50.0%	0.75	0.37	
	edge	53.5	7	67	38.5%	7.64	2.94	
	fragment	38.52	3	20	11.5%	12.84	1.48	
	total	**99.51**	**20**	**174**	**100.0%**	**4.98**	**4.79**	**834 ± 393**
Coastal	core	14.98	9	101	50.8%	1.66	0.85	
	edge	28.89	8	73	36.7%	3.61	1.33	
	fragment	20.33	3	25	12.6%	6.78	0.85	
	total	**64.2**	**20**	**199**	**100.0%**	**3.21**	**3.02**	**601 ± 298**
Total		**163.71**	**40**	**373**		**4.09**	**3.85**	**1435 ± 475**

Table C – California Gnatcatcher Detection Rates, 2000

These projected Round 2 detection rates should be used when comparing 1999 data with data gathered in future years of the study.

Fractional entries under "Territories Detected (Round 2 Projected)" result from application of the 1.07 multiplier.

Reserve	Land Designation (Stratum)	Territories Detected (Round 2 Projected)	Number of Sites Sampled	Number of 20-ha Sites in Stratum	% of Subregional Reserve in Stratum	Mean Territories Detected per Site	Mean Territories Detected/Site, Weighted by % of Reserve in Stratum	Estimated Total Territories
Central	core	4.00	10	87	50.0%	0.40	0.20	
	edge	30.07	7	67	38.5%	4.30	1.65	
	fragment	27.77	3	20	11.5%	9.26	1.06	
	total	**63.84**	**20**	**174**	**100.0%**	**3.19**	**2.92**	**508 ± 301**
Coastal	core	4.07	9	101	50.8%	0.45	0.23	
	edge	10.63	8	73	36.7%	1.33	0.49	
	fragment	8.00	3	25	12.6%	2.67	0.34	
	total	**22.70**	**20**	**199**	**100.0%**	**1.14**	**1.05**	**210 ± 164**
Total		**86.54**	**40**	**373**		**2.16**	**1.92**	**717 ± 330**

Table D – California Gnatcatcher Detection Rates, 2001

All sites were covered at least twice in 2001, and so no fractional multiplier was required to adjust this year's data.

Reserve	Land Designation (Stratum)	Territories Detected (Round 2 Projected)	Number of Sites Sampled	Number of 20-ha Sites in Stratum	% of Subregional Reserve in Stratum	Mean Territories Detected per Site	Mean Territories Detected/Site, Weighted by % of Reserve in Stratum	Estimated Total Territories
Central	core	4	10	87	50.0%	0.40	0.20	
	edge	38	7	67	38.5%	5.43	2.09	
	fragment	40	3	20	11.5%	13.33	1.53	
	total	**84**	**20**	**174**	**100.0%**	**4.20**	**3.82**	**665 ± 425**
Coastal	core	10	9	101	50.8%	1.11	0.56	
	edge	25	8	73	36.7%	3.13	1.15	
	fragment	17	3	25	12.6%	5.67	0.71	
	total	**52**	**20**	**199**	**100.0%**	**2.60**	**2.43**	**483 ± 309**
Total		**136**	**40**	**373**		**3.40**	**3.08**	**1148 ± 506**

Cactus Wren Territory Detections – 1999

As discussed previously, a single round of surveys was conducted in 1999. A two-visit survey protocol is now recommended, and this report bases its analyses on two-visit detection rates. In order to permit comparisons between the 1999 detection rates and the two-visit rates obtained in later years of the study, Round 2 detection rates have been projected for 1999, employing a multiplier derived from the results of multiple-visit surveys conducted at 24 of the 40 sites in 2000.

Hamilton and San Miguel, who completed most of the surveys from 1999 to 2001, consider it likely that Round 1 detection rates were comparable (relatively high) in 1999 and 2000. As Tables F and G show, the Round 1 detection rate was substantially lower in 2001 compared with 2000. For this reason, 2001 detection rates were not used to develop the following Round 2 projections.

In 2000, 85% of the three-visit total was detected in Round 1, and 98% of the three-visit total was detected (cumulatively) through Rounds 1 and 2. Thus, the cumulative total after Round 2 was 1.15 times greater than the Round 1 total, and this multiplier is used to project Round 2 detection rates for 1999 data.

Cactus Wren Territory Detections – 2000

During the 2000 field season, 24 of the sites were surveyed three times and the remaining 16 sites covered once. Two-visit detection rates are used in this report, and Table F gives projected Round 2 detection rates for the 16 sites that were covered only once in 2000 (the actual cumulative totals through Round 2 are used for the 24 multi-visit sites).

In 2000, 85% of the three-visit total was detected in Round 1, and 98% of the three-visit total was detected (cumulatively) through Rounds 1 and 2. Thus, the cumulative total after Round 2 was 1.15 times greater than the Round 1 total, and this multiplier is used to project Round 2 detection rates.

Cactus Wren Territory Detections – 2001

In 2001, the same 24 sites were covered three times and other 16 sites were covered twice.

The Round 2 detection rates specified in Table G should be used when comparing 2001 data with data gathered in future years of the study.

Tables Q and R give the results of 1, 2, and 3 visit surveys (raw counts).

Table E – Cactus Wren Detection Rates, 1999

These projected Round 2 detection rates should be used when comparing 1999 data with data gathered in future years of the study.

Fractional entries under "Territories Detected (Round 2 Projected)" result from application of the 1.15 multiplier.

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS.

Reserve	Land Designation (Stratum)	Territories Detected (Round 2 Projected)	Number of Sites Sampled	Number of 20-ha Sites in Stratum	% of Subregional Reserve in Stratum	Mean Territories Detected per Site	Mean Territories Detected/Site, Weighted by % of Reserve in Stratum	Estimated Total Territories
Central	core	35.65	10	87	50.0%	3.57	1.78	
	edge	34.50	7	67	38.5%	4.93	1.90	
	fragment	4.60	3	20	11.5%	1.53	0.18	
	total	**74.75**	**20**	**174**	**100.0%**	**3.74**	**3.86**	**671 ± 180**
Coastal	core	4.60	9	101	50.8%	0.51	0.26	
	edge	11.50	8	73	36.7%	1.44	0.53	
	fragment	2.30	3	25	12.6%	0.77	0.10	
	total	**18.40**	**20**	**199**	**100.0%**	**0.92**	**0.88**	**175 ± 124**
Total		**93.15**	**40**	**373**		**2.33**	**2.27**	**847 ± 211**

Table F – Cactus Wren Detection Rates, 2000

These projected Round 2 detection rates should be used when comparing 1999 data with data gathered in future years of the study.

Fractional entries under "Territories Detected (Round 2 Projected)" result from application of the 1.15 multiplier.

Reserve	Land Designation (Stratum)	Territories Detected (Round 2 Projected)	Number of Sites Sampled	Number of 20-ha Sites in Stratum	% of Subregional Reserve in Stratum	Mean Territories Detected per Site	Mean Territories Detected/Site, Weighted by % of Reserve in Stratum	Estimated Total Territories
Central	core	40.05	10	87	50.0%	4.01	2.00	
	edge	25.45	7	67	38.5%	3.64	1.40	
	fragment	4.30	3	20	11.5%	1.43	0.16	
	total	**71.80**	**20**	**174**	**100.0%**	**3.59**	**3.57**	**621 ± 237**
Coastal	core	1.15	9	101	50.8%	0.13	0.06	
	edge	7.60	8	73	36.7%	0.95	0.35	
	fragment	4.30	3	25	12.6%	1.43	0.18	
	total	**13.05**	**20**	**199**	**100.0%**	**0.65**	**0.59**	**118 ± 78**
Total		**84.85**	**40**	**373**		**2.12**	**1.98**	**739 ± 240**

Table G – Cactus Wren Detection Rates, 2001

All sites were covered at least twice in 2001, and so no fractional multiplier was required to adjust this year's data.

Reserve	Land Designation (Stratum)	Territories Detected (Round 2 Projected)	Number of Sites Sampled	Number of 20-ha Sites in Stratum	% of Subregional Reserve in Stratum	Mean Territories Detected per Site	Mean Territories Detected/Site, Weighted by % of Reserve in Stratum	Estimated Total Territories
Central	core	42	10	87	50.0%	4.20	2.10	
	edge	23	7	67	38.5%	3.29	1.27	
	fragment	1	3	20	11.5%	0.33	0.04	
	total	**68**	**20**	**174**	**100.0%**	**3.40**	**3.40**	**592 ± 215**
Coastal	core	2	9	101	50.8%	0.22	0.11	
	edge	11	8	73	36.7%	1.38	0.50	
	fragment	3	3	25	12.6%	1.00	0.13	
	total	**16**	**20**	**199**	**100.0%**	**0.80**	**0.74**	**148 ± 99**
Total		**84**	**40**	**373**		**2.10**	**1.98**	**740 ± 228**

Brown-headed Cowbird Detections

In accordance with the study plan, Brown-headed Cowbirds were recorded during the first round of surveys each year. Since very few cowbirds were detected during each of the first three years of this study, and this species is not a primary focus of the study, Table H presents these results in summary form. More detailed analyses of Brown-headed Cowbird data may be conducted in future years of this study, but probably only if the numbers detected increase sharply.

Table H – Summary of Brown-headed Cowbird Detections
1999, 2000, 2001

Reserve	Land Designation/ Sub-Designation	Sites	1999	2000	2001
Central	Core	10	0	1	0
	Edge & Fragment	10	4	1	0
	Road Edge	[3]	[0]	[0]	[0]
	Residential Edge	[2]	[1]	[0]	[0]
	Mixed Edge	[5]	[3]	[1]	[0]
	Total	20	4	2	0
Coastal	Core	9	0	0	0
	Edge & Fragment	11	1	0	0
	Road Edge	[4]	[0]	[0]	[0]
	Residential Edge	[5]	[0]	[0]	[0]
	Mixed Edge	[2]	[1]	[0]	[0]
	Total	20	1	0	0
Overall	Core	19	0	1	0
	Edge & Fragment	21	5	1	0
	Road Edge	[7]	[0]	[0]	[0]
	Residential Edge	[7]	[1]	[0]	[0]
	Mixed Edge	[7]	[4]	[1]	[0]
	Total	40	5	2	0

Target Bird Habitat Composition & Structure

At each target bird territory encountered, surveyors estimated/assessed habitat-related vegetation parameters. The following parameters were measured during one or more year:

- Dominant Plant Species
- Cactus Cover
- Mean Plant Height
- Absolute Shrub Cover
- Primary Herbaceous Species
- Absolute Herbaceous Cover.

The methods of collecting this habitat information have varied somewhat from year to year, and should continue to evolve over time to serve researchers' interests. Although the study's habitat data estimation are relatively simple and somewhat subjective, they are expected to yield valuable information on the composition and structure of habitats used by the target bird species within the NROC's subregional reserves. Recording standardized habitat information annually will permit tracking of changes in habitat usage and could play a role in the adaptive management of target bird populations.

Dominant Plant Species

During each year of the study, field personnel have listed, in descending order of perceived abundance, up to four plant species within each target bird territory. Plant species listed first were given a score of 4, those listed second were given a score of 3, etc. The scores for each species were then divided by the total number of territories to derive a weighted average score for each plant species. Thus, hypothetically, a plant ranked as the most abundant species in every territory would receive a weighted average of 4.0.

Tables I and J list weighted average scores for dominant plant species in CAGN and CACW territories. Only data sheets from the first round of surveys were included in this analysis. Species are listed in approximate order of abundance, and species ranking lower than 0.2 for a given year are denoted with "–".

Table I – Ranking of Dominant Plant Species in California Gnatcatcher Territories, 1999-2001

Reserve	Dominant Plants	Average Rank Score 1999	2000	2001
Central	*Artemisia californica*	3.3	3.2	3.3
	Eriogonum fasciculatum	2.1	2.2	1.7
	Salvia mellifera	1.1	1.6	1.6
	Encelia californica	0.5	0.6	1.1
	Opuntia littoralis	0.5	0.4	0.4
	Malosma laurina	0.6	--	0.3
	Rhus integrifolia	0.5	0.2	0.2
	Sambucus mexicana	0.7	--	--
	Malacothamnus fasciculatus	0.4	--	--
	Baccharis salicifolia	--	--	0.2
Coastal	*Artemisia californica*	3.7	3.5	2.5
	Eriogonum fasciculatum	2.1	1.2	1.1
	Salvia mellifera	0.9	1.0	0.3
	Mimulus aurantiacus	0.6	1.0	1.0
	Baccharis pilularis	--	1.1	0.2
	Malosma laurina	0.5	0.2	0.5
	Encelia californica	0.4	0.7	--
	Rhus integrifolia	0.3	0.3	--
	Opuntia littoralis	--	--	0.4
	Sambucus mexicana	0.3	--	--

Table J – Ranking of Dominant Plant Species in Cactus Wren Territories, 2000, 2001

Table J includes only 2000 and 2001 results, because the 1999 data collection methods yielded results unsuitable for comparison with future years of this study. The 2001 results exclude 18 of the 60 territories detected in Round 1 because these habitat data were mistakenly collected according to the 1999 methodology.

Reserve	Dominant Plants	Average Rank Score 2000	2001
Central	*Opuntia littoralis*	3.4	3.6
	Artemisia californica	1.5	1.8
	Rhus integrifolia	0.6	1.1
	Eriogonum fasciculatum	0.6	0.8
	Malosma laurina	0.8	0.5
	Salvia mellifera	0.2	0.4
	Sambucus mexicana	0.2	0.3
	Lotus scoparius	--	0.7
	Opuntia prolifera	0.2	--
Coastal	*Opuntia littoralis*	2.8	2.9
	Artemisia californica	2.5	2.3
	Eriogonum fasciculatum	1.9	1.8
	Rhus integrifolia	0.6	0.3
	Malosma laurina	0.2	0.6
	Opuntia prolifera	0.4	0.3
	Mimulus aurantiacus	--	0.7
	Salvia mellifera	0.2	0.5
	Sambucus mexicana	0.2	0.3

Estimated Cactus Cover

In 2001, as another measure of the relative dominance of cactus (*Opuntia* spp.) in CACW versus CAGN territories, areal cover of cactus in each target territory was attributed to one of five cover classes (0%; 1-25%; 26-50%; 52-75%; 76-100%). Table K specifies the percentage of territories within each cover class. Only data sheets from the first round of surveys were included in this analysis.

Table K – Estimated Cactus Cover in California Gnatcatcher & Cactus Wren Territories, 2001

Reserve	Estimated Cactus Cover	Percent of Territories	
		California Gnatcatcher	Cactus Wren
Central	0%	49%	0%
	1-25%	47%	66%
	26-50%	4%	32%
	51-75%	0%	2%
	76-100%	0%	0%
		(n=70)	(n=47)
Coastal	0%	62%	0%
	1-25%	38%	93%
	26-50%	0%	0%
	51-75%	0%	7%
	76-100%	0%	0%
		(n=39)	(n=13)

Mean Woody Vegetation Height

In 1999, 2000, and 2001, field personnel estimated the mean height of woody plants within each target bird territory by circling one of the following choices: 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, or >2.5m. Tables L and M specify the percentage of territories within each cover class. Only data sheets from the first round of surveys were included in this analysis.

Table L – Mean Woody Vegetation Height in California Gnatcatcher Territories, 1999-2001

Reserve	Estimated Mean Plant Height (m)	Percent of Territories		
		1999	2000	2001
Central	0.5	11%	7%	10%
	1.0	73%	74%	80%
	1.5	15%	17%	10%
	2.0	1%	2%	0%
	2.5	0%	0%	0%
	>2.5	0%	0%	0%
		(n=93)	(n=58)	(n=70)
Coastal	0.5	23%	5%	0%
	1.0	55%	70%	64%
	1.5	20%	25%	36%
	2.0	2%	0%	0%
	2.5	0%	0%	0%
	>2.5	0%	0%	0%
		(n=60)	(n=20)	(n=39)

Table M – Mean Woody Vegetation Height in Cactus Wren Territories, 1999-2001

Reserve	Estimated Mean Plant Height (m)	Percent of Territories 1999	2000	2001
Central	0.5	13%	13%	9%
	1.0	41%	32%	40%
	1.5	33%	47%	47%
	2.0	13%	8%	2%
	2.5	0%	0%	0%
	>2.5	0%	0%	2%
		(n=64)	(n=60)	(n=47)
Coastal	0.5	6%	0%	0%
	1.0	50%	73%	69%
	1.5	38%	27%	31%
	2.0	6%	0%	0%
	2.5	0%	0%	0%
	>2.5	0%	0%	0%
		(n=16)	(n=11)	(n=13)

Absolute Vegetative Cover

In 1999, 2000, and 2001, field personnel used the following cover classes to estimate absolute cover of woody vegetation, and of herbaceous vegetation, within each target bird territory: 0-20%, 21-40%, 41-60%, 61-80%, 81-100%. Tables N and O specify the percentage of territories within each cover class. Only data sheets from the first round of surveys were included in this analysis.

Table N – Absolute Woody Vegetation Cover in California Gnatcatcher Territories, 1999-2001

Reserve	Estimated Woody Cover	Percent of Territories 1999	2000	2001
Central	0-20%	0%	0%	0%
	21-40%	1%	5%	4%
	41-60%	2%	16%	7%
	61-80%	22%	26%	30%
	81-100%	75%	53%	59%
		(n=93)	(n=58)	(n=70)
Coastal	0-20%	0%	0%	0%
	21-40%	3%	0%	0%
	41-60%	22%	5%	8%
	61-80%	45%	25%	36%
	81-100%	30%	70%	56%
		(n=60)	(n=20)	(n=39)

Table O – Absolute Woody Vegetation Cover in Cactus Wren Territories, 1999-2001

Reserve	Estimated Woody Cover	Percent of Territories		
		1999	2000	2001
Central	0-20%	5%	23%	2%
	21-40%	16%	11%	28%
	41-60%	19%	8%	19%
	61-80%	14%	23%	21%
	81-100%	47%	34%	30%
		(n=64)	(n=61)	(n=47)
Coastal	0-20%	0%	0%	0%
	21-40%	0%	9%	0%
	41-60%	13%	9%	15%
	61-80%	56%	27%	23%
	81-100%	31%	55%	62%
		(n=16)	(n=11)	(n=13)

Results of Multiple-Visit Surveys

During each of the first three years of this study, sites within the NROC were surveyed more than once for the purpose of determining an appropriate number of visits to be used in the final design of this study. This section summarizes the results of these multiple-visit surveys.

Biometrician Karen Messer has reviewed this information, along with all the other pilot data gathered 1999-2001, and has made preliminary recommendations for sampling the NROC at a level of intensity that will competently test the study-design hypotheses, taking into account NROC budget constraints. Please refer to Appendix C.

1999 Multiple-Visit Surveys by Harmsworth Associates

The NROC's 40 long-term target bird monitoring sites were covered only once in 1999, but Harmsworth Associates conducted three rounds of CAGN and CACW surveys at twenty 20-hectare sites located elsewhere in the Coastal Reserve. These surveys followed the NROC target bird study's methodology, and Table P provides their results.

For information on these 20 monitoring sites and further discussion of Harmsworth's surveys and results please refer to Harmsworth Associates (1999).

Table P – Target Bird Territories Recorded by Harmsworth Associates During Sequential Surveys at 20 Coastal Reserve Sites, 1999

	California Gnatcatcher			Cactus Wren		
Site Number	Visit 1	Visit 2	Visit 3	Visit 1	Visit 2	Visit 3
C1	2	2	2	0	0	0
C2	0	0	0	0	0	0
C3	0	0	0	0	0	0
C4	0	0	0	0	0	0
C5	0	0	0	0	0	0
C6	0	0	0	0	0	0
C7	0	0	0	0	0	0
C8	3	3	3	0	0	0
C9	0	2	2	0	0	0
C10	1	2	2	5	6	6
C11	2	2	3	4	5	5
C12	0	0	1	0	0	0
F	13	15	15	0	0	0
D1	1	1	1	0	0	0
D2	0	0	0	0	0	0
D3	2	3	3	2	2	2
D4	4	7	7	7	7	7
R1	3	4	4	0	0	0
R2	4	5	6	0	0	0
R3	1	1	1	1	1	1
Cumulative Total	**36**	**47**	**50**	**19**	**21**	**21**
Percent of 3-Visit Total	72%	94%	100%	90%	100%	100%

2000 Multiple-Visit Surveys

In 2000, 24 of the 40 long-term target bird monitoring sites were surveyed three times (the remaining 16 sites were covered only once). Table Q provides results of the 24 multi-visit surveys.

Table Q – Target Bird Territories Recorded During Sequential Surveys at 24 NROC Long-Term Monitoring Sites, 2000

	California Gnatcatcher			Cactus Wren		
Site Number	Visit 1	Visit 2	Visit 3	Visit 1	Visit 2	Visit 3
3	16	16	16	2	2	2
4	0	0	0	1	1	1
6	11	8	9	4	2	3
7	0	0	0	2	2	2
9	0	0	0	10	10	9
11	3	1	2	6	7	4
12	11	9	10	5	6	5
14	3	4	6	1	3	2
15	1	1	1	2	2	3
16	0	0	0	8	9	8
17	0	0	0	2	2	3
18	2	0	1	6	6	5
22	0	0	0	0	1	1
24	1	0	0	0	0	0
25	0	0	0	2	2	1
28	1	0	1	2	0	1
31	0	1	0	0	0	0
32	0	0	0	0	0	0
33	6	6	6	0	0	0
34	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	2	2	1	0	0	0
Total This Visit	57	48	53	53	55	50
Percent of 3-Visit Total	88%	74%	82%	85%	89%	81%
Cumulative Total	57	61	65	53	61	62
Percent of 3-Visit Total	88%	94%	100%	85%	98%	100%

2001 Multiple-Visit Surveys

In 2001, the same 24 long-term target bird monitoring sites were surveyed three times, and the remaining 16 sites were covered twice each. Table R provides results and analyses for the three-visit sites.

Table R – Target Bird Territories Recorded
During Sequential Surveys at 24 NROC Long-Term Monitoring Sites, 2001

	California Gnatcatcher			Cactus Wren		
Site Number	Visit 1	Visit 2	Visit 3	Visit 1	Visit 2	Visit 3
3	24	23	20	0	0	0
4	0	0	0	2	1	2
6	8	5	5	3	3	3
7	0	0	0	3	2	2
9	0	0	0	7	5	5
11	2	1	1	4	5	3
12	13	18	16	4	6	6
14	4	5	3	1	2	2
15	1	1	0	5	7	4
16	0	0	0	3	8	5
17	0	0	0	2	3	3
18	2	1	2	4	5	4
22	1	1	1	2	1	1
24	0	0	0	0	0	0
25	3	0	2	2	2	2
28	2	2	1	0	0	2
31	1	0	0	0	0	0
32	0	0	0	0	0	0
33	12	13	17	0	0	0
34	0	0	0	0	0	0
36	0	0	0	0	0	0
37	1	0	0	0	0	0
38	1	2	1	0	0	0
39	2	3	4	0	0	0
Total This Visit	**77**	**75**	**73**	**42**	**50**	**44**
Percent of 3-Visit Total	**79%**	**77%**	**74%**	**66%**	**78%**	**69%**
Cumulative Total	**77**	**93**	**98**	**42**	**61**	**64**
Percent of 3-Visit Total	**79%**	**95%**	**100%**	**66%**	**95%**	**100%**

Summary of California Gnatcatcher Results

Harmsworth Associates' 1999 surveys of 20 sites in the coastal reserve detected 72% of the three-visit CAGN total after one pass and 94% after two passes.

The 2000 surveys of 24 long-term target bird monitoring sites detected 88% of the three-visit total after one pass, and 94% after two passes. Between 74% and 88% of the three-visit total was detected during any given round of surveys.

The 2001 surveys of the same 24 long-term target bird monitoring sites detected 79% of the three-visit total after one pass and 95% after two passes. Between 74% and 79% of the three-visit total was detected during any given round of surveys.

Thus, during these three years, 72% to 88% of the three-visit total was detected during any given round of surveys, and 94% to 95% of the three-visit total was detected after two passes.

Summary of Cactus Wren Results

Harmsworth Associates' 1999 surveys of 20 sites in the coastal reserve detected 90% of the three-visit CACW total after one pass and 100% after two passes.

The 2000 surveys of 24 long-term target bird monitoring sites detected 85% of the three-visit total after one pass, and 98% after two passes. Between 81% and 89% of the three-visit total was detected during any given round of surveys.

The 2001 surveys of the same 24 long-term target bird monitoring sites detected 66% of the three-visit total after one pass and 95% after two passes. Between 66% and 78% of the three-visit total was detected during any given round of surveys.

Thus, during these three years, 66% to 90% of the three-visit total was detected during any given round of surveys, and 95% to 100% of the three-visit total was detected after two passes.

V. Discussion

Although it is too early to start testing the hypotheses listed in Section II of this report, data gathered during the first three "pilot" years of the target bird study, and other relevant information, warrant discussion.

Recent NROC Fire History

The 1998 Santiago Canyon Fire burned approximately 3,100 ha (38%) of the central reserve, and the 1993 Laguna Beach Fire burned approximately 5,200 ha (75%) of the coastal reserve. These fires consumed more vegetation in the core stratum than in the edge or fragment strata and, at least in the short term, appear to have driven target birds from core areas into unburned "habitat refugia" along reserve edges and in reserve fragments (cf. Atwood et al. 1998a for the coastal reserve). The larger Laguna Beach Fire fully consumed more cactus patches than did the Santiago Canyon Fire and, as anticipated by Bontrager et al. (1995), those cactus patches are recovering very slowly. The effects of recent NROC fires on cactus and coastal sage scrub in general are discussed in later subsections of this report.

POTENTIAL EFFECTS OF WEATHER ON TARGET BIRD POPULATIONS

Avian populations fluctuate for reasons unrelated to weather conditions, and detailed explication of potential short-term effects of weather/precipitation on target bird populations in the NROC exceeds the scope of this study. Nonetheless, weather conditions appear to affect regional songbird populations (e.g., Gessaman and Worthen 1982, Lustick and Adams 1977, Atwood et al. 1998b, Atwood and Bontrager 2001) and so each year's monitoring report should include a discussion of how weather may have affected both the survey effort and the results obtained.

Mock (1998), evaluating a model by Root (1998), provided evidence that Coastal California Gnatcatcher populations occur mainly where "January mean minimum temperature resulted in thermal compensation (i.e., thermoregulation plus basal requirements) less than 2.49 times a species' basal metabolic requirement." He found that the species' eastern limit appears to coincide with a distribution-limiting isotherm of 2.5°C (like many small songbirds, gnatcatchers are relatively intolerant of very low winter temperatures). Since January mean minimum temperatures at Laguna Beach (6.1°C)[1], and Yorba Linda (5.4°C)[2] are well above the distribution-limiting isotherm, this variable may have relatively little effect on passerine survivorship in the NROC (particularly for Cactus Wrens, which are relatively large and maintain enclosed brood nests that provide warmth and shelter during cold winter weather). Nevertheless, it seems likely that sensitivity to cold, wet weather is at least partially responsible for the CAGN's absence or near-absence from numerous portions of the NROC that contain apparently suitable topography and vegetation.

Erickson and Miner (1998) provided evidence that Coastal California Gnatcatcher population size during a given breeding season is inversely correlated with the quantity of precipitation during the preceding rainy season, although they allowed that other environmental variables, such as the severity of winter storms, may be more important than seasonal rainfall averages. Patten and Rotenberry (1999) found that cumulative seasonal precipitation during a given rainy season was a poor predictor of Coastal California Gnatcatcher clutch size in the following spring, but identified a strong positive correlation between clutch size and cumulative rainfall 30 to 90 days before clutch completion (mean estimated clutch completion date was 6 May ± 22 days).

DeSante et al. (2001) discussed the "productivity/population" dynamic, where productivity increases during years when the adult population decreases, and vice-versa. Mark-recapture of birds under the continent-wide MAPS program has shown this dynamic to be characteristic of regions like southern California that tend to lack dramatic interannual weather effects. Disruptions of this alternating cycle have appeared to be related to unusually favorable or unfavorable weather. Using nine or ten years of data from other MAPS stations, the Institute for Bird Populations has examined the relationship between productivity and various global climate cycles. They have found, for example, that productivity in western North America averages higher in a breeding season that follows a wet El Niño winter (as in 1997/98) compared to a breeding season that follows a dry La Niña winter (such as 1998/99).

From the above information, it is postulated that severe winter weather generally reduces target bird populations in the NROC during the following breeding season, while heavy rainfall from February through April generally increases productivity among survivors.

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[1] www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?calagu

[2] www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?cayorb

Table S summarizes precipitation at Costa Mesa, as reported by the Orange County Public Resources and Facilities Department. Although the Laguna Beach weather station has been established much longer, the Costa Mesa station was chosen because their web page until recently included daily precipitation totals for recent years, facilitating more useful data analyses than can be performed on the Laguna Beach data set that is available on the internet (this information is now available by request at http://www.oc.ca.gov/pfrd/envres/rainfall/intro.asp). Table S provides monthly totals from 1998/99 to 2000/01, and also shows the 23-year average (1978/79 to 2000/01).

Table S – Centimeters of Precipitation at Costa Mesa 1998/99 to 2000/01

Precipitation in the shaded period (February to April) is positively correlated with CAGN clutch size (Patten and Rotenberry 1999).

	Month												
Season	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
98/99	0.00	0.00	1.27	0.10	3.35	3.40	3.63	2.11	4.01	5.29	0.00	0.43	**23.59**
99/00	0.30	0.00	0.00	0.00	0.56	0.00	2.03	8.64	5.21	1.98	0.00	0.00	**18.72**
00/01	0.00	0.00	0.58	4.72	0.00	0.00	13.49	17.45	1.70	1.42	0.00	0.00	**39.36**
3-Year Avg.	0.10	0.00	0.62	1.61	1.30	1.13	6.38	9.40	3.64	2.90	0.00	0.14	**27.22**
23-Year Avg.	0.10	0.03	0.72	1.21	2.81	4.23	7.28	8.00	6.59	1.69	0.41	0.21	**33.29**

1998/99 Precipitation

The seasonal total of 23.6 cm recorded at Costa Mesa was 29% below the 23-year average. Nearly all of the rain fell between 8 November and 12 April, and no storm (i.e., consecutive days with measurable precipitation) dropped more than 5 cm. February-April rainfall was 30% below average, with February-March rainfall being 58% below average.

Below-average rainfall spread evenly through the winter and early spring months, and a lack of severe storms, may have helped to maintain relatively high populations of the target birds through the winter of 1998/99, while below average rainfall during the February-April egg-formation period probably contributed to poor reproduction of these populations in spring/summer 1999. As discussed previously, the Institute for Bird Populations has observed that productivity averages lower in seasons following dry La Niña winters like 1998/99.

1999/00 Precipitation

The seasonal total of 18.7 cm was 44% below average. Only 1.1 cm fell between 1 July and 24 January, and many coastal sage scrub plants in the NROC were observed to have dropped their leaves by December/January, apparently due to lack of moisture (Dan Songster pers. comm.). Nearly half the seasonal total (8.3 cm) fell 11-24 February, including 6.7 cm during the season's most severe storm (20-24 February). Another 5.2 cm fell 4-9 March. February-April rainfall was just 3% below average.

On the heels of a year with high adult survivorship but low productivity, the prolonged dry period in fall/winter, followed by two relatively severe late winter storms, probably contributed to substantial one-year CAGN declines documented in this study. The winter culling of adult populations, combined with average rainfall during the February-April egg-formation period, probably combined to produce better-than-average nesting conditions for the surviving birds. As discussed later in this report, data from this study suggest that CAGN in parts of the reserve occupied at low density perished at greater rates than did CAGN in parts of the reserve occupied at high density.

2000/01 Precipitation

The seasonal total of 39.4 cm was 19% above average. November and December were dry, while January-February rainfall was 202% of average, with three relatively severe storms: 9-12 January (9.9 cm), 10-14 February (9.1 cm), and 23-28 February (7.9 cm). While some storm-related mortality of CAGN probably occurred, the major CAGN decline in 1999/2000 is hypothesized to have concentrated the surviving birds in higher quality territories that provide relatively good protection against bad weather. Note also that productivity of scrub-nesting birds was generally high in 2000 (see subsequent discussion of MAPS results), helping to offset any weather-related losses.

Rainfall during the February-April 2001 egg-formation period was 26% above average, and field personnel noted unusually high levels of fog and dew into the summer months, compared with previous years of this study. For these reasons, nesting conditions for CAGN and CACW appeared to be better-than-average in 2001.

Monitoring Avian Productivity and Survivorship (MAPS) Program 1998-2001
The Institute for Bird Populations

Although CAGN and CACW are captured at very low rates at the NROC's MAPS stations, it will be useful to compare target bird population trends determined by the target bird monitoring study with productivity and survivorship data that the MAPS program collects for a suite of scrub-dwelling passerines.

In the NROC, two MAPS stations were operated in 1998, another two were added in 1999, and another two had their first full year of operation in 2000, for a total of six stations. Four more were added in 2001, for a total of 10 stations. The ultimate goal is to operate 12 stations in the NROC. The following brief summaries only begin to hint at the productivity and survivorship data collected so far under the NROC's MAPS program. For analysis of results through 2001, see DeSante et al. (2002).

1998 MAPS Results

In 1998, considering only confirmed and likely breeding species, the combined adult:juvenile capture proportion for Weir Core (central reserve core) and Little Sycamore Canyon (coastal reserve core) was 54:46 (286 adults to 242 juveniles), with neither station differing greatly from this proportion.

1999 MAPS Results

In 1999, the combined adult:juvenile capture proportion at the two "reserve core" stations sampled in 1998 was 88:12 (277 adults to 39 juveniles), with neither station differing greatly from this proportion. Thus, captures of breeding adults at these two stations dropped 3% from the levels of 1998 while captures of juveniles dropped 84%.

At two new "road edge" stations added in 1999 (Irvine Park and Upper Laurel Canyon), the adult:juvenile capture proportion was 86:14 – further evidence of a reserve-wide collapse in productivity from 1998 to 1999.

2000 MAPS Results

The following information is summarized from the 2000 annual report prepared by DeSante et al. (2001).

In 2000, captures of breeding adults dropped 35% (from 646 to 419) at the four MAPS stations operated both years.

The combined adult:juvenile capture proportion was 60:40 (437 adults to 292 juveniles). Thus, captures of breeding adults at these four stations dropped 27% from the levels of 1999 while captures of juveniles increased 211%.

In 2000, 1280 birds of 52 species were banded at the six stations; additionally, various individuals were recaptured a total of 186 times, and 385 birds were captured and released unbanded. Thus, 1851 captures of 60 species were recorded.

Analyses of constant-effort data indicate that adult population sizes decreased by 35% on both a reserve-wide and a species-wide basis between 1999 and 2000. The decreases in breeding populations in 2000 are likely attributable to decreased recruitment resulting from the low productivity noted in 1999. As discussed previously, weather conditions may also have played a role in the decline. The number of young birds captured and productivity (proportion of young in the catch) increased by 230% and 256%, respectively, between 1999 and 2000. These patterns were noted at all four of the stations operated in both 1999 and 2000. It is likely that the combination of a larger proportion of experienced breeders and less competition for food resources among breeding individuals resulted in the substantial and significant increase in productivity between 1999 and 2000. Recall also that rainfall was average during the February-April egg-formation period.

Capture data indicate that the three coastal reserve MAPS stations generally had higher breeding passerine populations in 2000 than did the three stations in the central reserve. In both reserves, road-edge stations had correspondingly higher breeding populations than did core stations, while the newly established residential edge stations appeared to have either intermediate or high breeding populations. Productivity indices, however, tended to show the opposite patterns, with productivity in the central reserve being higher than in the coastal reserve. More years of data will be needed to confirm these initial findings.

2001 MAPS Results

The following information is summarized from the 2001 annual report prepared by DeSante et al. (2002).

A total of 2150 birds of 53 species were banded at the ten stations during the summer of 2001, various individuals were recaptured a total of 563 times, and 688 birds were captured and released unbanded. Thus, a total of 3401 captures of 62 species was recorded.

At the six stations sampled in 2000 and 2001, adult captures decreased by 4% (625 to 600). This overall decrease was composed of a 17% increase in the central reserve (259 to 303) and a 24% decrease in the coastal reserve (426 to 322). These decreases were likely caused by decreased recruitment of young resulting from the relatively low productivity noted at the coastal stations in 2000. The opposite pattern was seen at the central reserve stations, where increased productivity in 2000 apparently led to increases in adult population sizes in 2001. Productivity followed the opposite pattern and increased slightly between 2000 and 2001, although the increases were again primarily limited to the coastal reserve stations; productivity at two of the central reserve stations decreased in 2001.

Capture data on adult birds at NROC indicate that adult population sizes for all species pooled and for the majority of target species tended to be higher at coastal reserve than central reserve stations, both in 2001 and over the three year period 1999-2001. In contrast, no consistent pattern of differences in adult population sizes were detected among core, road-edge, and housing-development stations in either reserve. Using 2001 data alone, both the two road-edge stations and the four housing-development stations had adult population sizes for all species pooled that averaged at least as high as those in the four core stations. These indices of adult population size at NROC stations generally compare rather favorably to those found at other MAPS stations across the United States, even those in forested areas.

Productivity indices in 2001 showed relatively small amounts of variation across the ten NROC stations. Indeed, logistic regression analyses of data from the six stations operated in both 2000 and 2001, when controlling for year and local landscape, revealed no significant differences in productivity between coastal and central reserve stations for all species pooled or for 11 of 12 target species. The only significant difference was that Spotted Towhee productivity was significantly greater at central than coastal reserve stations.

Analogous logistic regression analyses controlling for year and geographic location, however, revealed that productivity was significantly greater at housing-development stations than at core stations for all species pooled and for both Spotted and California towhees, and nearly significantly greater for House Wren, but significantly less at housing-development stations than at core stations for Orange-crowned Warbler. No significant or even near-significant differences in productivity were detected by logistic regression between road-edge and core stations, although productivity at road-edge stations tended to be higher than at core stations for all species pooled and for eight of 12 target species.

Thus, overall, productivity at both the housing-development and road-edge stations tended to be at least as high as that at the core stations. As with indices of adult population size, productivity indices at NROC stations tended to be at least as high as those found at other MAPS stations across the United States.

Four years of data indicate that a regular alternating "productivity/ population" dynamic may be manifest at NROC, but that the cycles at the coastal and central reserve stations are offset by one year. Lower breeding populations and higher productivity tend to occur in odd-numbered years (such as 2001) at the coastal stations, but the opposite pattern (higher breeding populations and lower productivity) occurs in those years at the central stations. DeSante et al. (2002) suggest that this pattern may be caused by a density-dependent effect on productivity along with low productivity of first-time breeders. If this pattern continues, we might expect higher breeding populations with lower reproductive success at the coastal reserve stations in 2002, but lower breeding populations with higher reproductive success at the central reserve stations.

Annual Target Bird Census in the Laguna Beach Fire Area
Harmsworth Associates

Annual CAGN/CACW surveys that Harmsworth Associates conducted throughout the Laguna Beach Fire area showed the CAGN population steadily increasing to near pre-fire levels by 1999 then declining 42% in 2000 (Harmsworth Associates 2000). That one-year reduction is smaller than the 65% one-year decline suggested by Hamilton's sampling of the entire coastal reserve (including burned and unburned sites), which is discussed later in this report.

Harmsworth Associates (2000) also found that CACW numbers in the Laguna Beach Fire area peaked in 1999, then declined 28% in 2000. They suggested that the drop may have resulted from some combination of (1) slow recovery of burned cactus; (2) construction of housing where CACW "source" populations formerly existed at upper Muddy and Los Trancos canyons; (3) a general lack of unburned "source" populations on the coastal side of the San Joaquin Hills Toll Road; (4) diminished dispersal capability from inland to coastal areas due to the toll road's presence; and (5) potentially high levels of predation along the northern edge of Laguna Beach. The 28% decline in CACW numbers reported by Harmsworth is consistent with Hamilton's finding of a 33% one-year decline in the coastal reserve, which is discussed later in this report.

California Gnatcatcher and Cactus Wren Sampling, 1999-2001
Robert A. Hamilton

The following analyses pertain to the cumulative results of two rounds of surveys per year at the NROC's 40 long-term target bird monitoring sites. As described previously, only one round of surveys was undertaken in 1999, and 16 of the 40 sites were covered only once in 2000; thus, two-round detection rates were projected for these years. Each of the 40 sites was covered at least twice in 2001, and two-rounds of surveys will be conducted at each site in future years of this study.

As discussed under Methods (and at greater length in Appendix C, Sections 1.1 and 1.7), trends have been analyzed following a normal model. Numbers in parentheses reflect the 95% confidence interval. Confidence intervals are provided only for overall trends reported for the two subregional reserves and for the NROC; confidence intervals would tend to be wider for trends reported at finer scales (e.g., at core sites in the central reserve), due to smaller sample sizes.

Percent changes are estimated as the ratio of the weighted estimate of total change in number of territories divided by the weighted estimate of the starting value. The standard error of the estimated change is computed using a second order Taylor expansion, which includes the correlation between the numerator and the denominator; and 95% confidence intervals are given in parentheses using a normal approximation.

California Gnatcatcher Short-term Population Trends

The following analyses compare weighted mean territories detected/site (see Tables B, C, D) with the 95% confidence interval given in parentheses.

From 1999 to 2000, the overall CAGN population declined 50% (41–59%). The central reserve decline was 39% (27-51%), and the coastal reserve decline was 65% (49-82%).

From 2000 to 2001, the overall CAGN population increased 60% (45-75%). The central reserve increase was 31% (19-43%), and the coastal reserve increase was 130% (100-160%).

From 1999 to 2001, the overall CAGN population declined 20% (0-40%). The central reserve decrease was 20% (12% increase to 52% decrease), and the coastal reserve decrease was also 20% (0-40%).

The approximate 50% reserve-wide decline from 1999 to 2000 is greater than the 35% reserve-wide decline among scrub-dwelling passerines estimated through constant-effort mist netting (see preceding discussion of MAPS results). As discussed previously, it seems likely that several months of unusually dry conditions in 1999/2000, followed by two weeks of relatively intense rains in February 2000, contributed to short-term declines of scrub-dwelling bird populations. It bears noting that the approximate 39% CAGN decline in the central reserve was comparable to the general reserve-wide decline in scrub-dwelling birds measured by MAPS, while the 65% coastal reserve decline in CAGN detections/site was considerably higher.

California Gnatcatcher Patterns of Distribution

For the reasons discussed in the Methods section, the monitoring sites are not of uniform size; for example, core sites in the coastal reserve average double the size of fragment sites in the central reserve. Although it would be intuitive to adjust for this difference by comparing detection densities between strata, this would result in substantial bias because low-density sites tend to be so much larger than high-density sites precisely because they have fewer target birds in them, and the detections per site increased only slightly as the site boundaries expanded (average detection rate increased 0.002 territories for each additional hectare of sampling area; Appendix C, Section 1.8). Therefore, although comparing detections/site bias the results slightly in favor of low-density sites, no adjustment for the boundary change was included.

The following discussion compares detection rates among the three major land designations and does not involve trend analysis, and so the detection rates given are non-weighted means.

In each year of the study, the central reserve CAGN detection rate (mean detections/site) was substantially greater than the coastal reserve rate (1.6 times greater in 1999; 2.6 times greater in 2000; 1.6 times greater in 2001).

From 1999 to 2001, the three-year mean CAGN detection rate across the NROC (n=40 sites) was 3.22 detections/site. Breaking this down by major land designations:

- The mean detection rate at core sites (n=19) was 0.80 detections/site.
- The mean detection rate at edge sites (n=15) was 4.24 detections/site (5.3 times greater than the rate at core sites).
- The mean detection rate at fragment sites (n=6) was 8.43 detections/site (10.5 times greater than the rate at core sites).

Each of the following factors (but especially the first two) probably contribute to the CAGN's edge-heavy distribution in the NROC:

- Core sites tend to be steeper and higher than edge and fragment sites, and CAGN tend to favor shallower slopes at lower elevations.
- Chaparral is generally unsuitable for CAGN, and the reserve core supports a higher proportion of chaparral than do edge and fragment sites.
- Over half of the NROC has burned since 1993, with a net effect of driving CAGN from core areas into unburned habitat along reserve edges and in fragments.
- The NROC design is "biased" by nature, in that some habitat fragments and areas along reserve edges were included or excluded from the NROC based on target bird distribution.

Chart 1 – California Gnatcatcher Detection Rates in the Central Reserve, 1999-2001

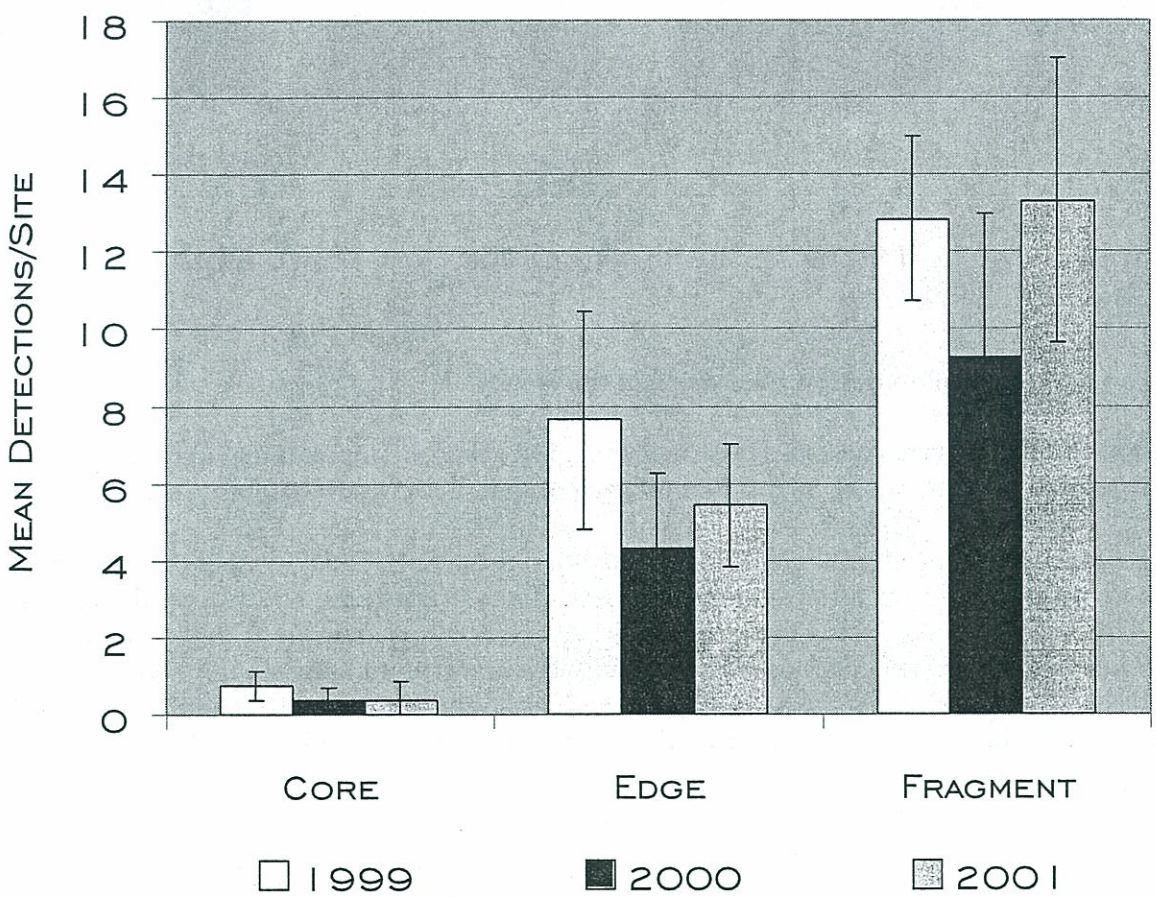
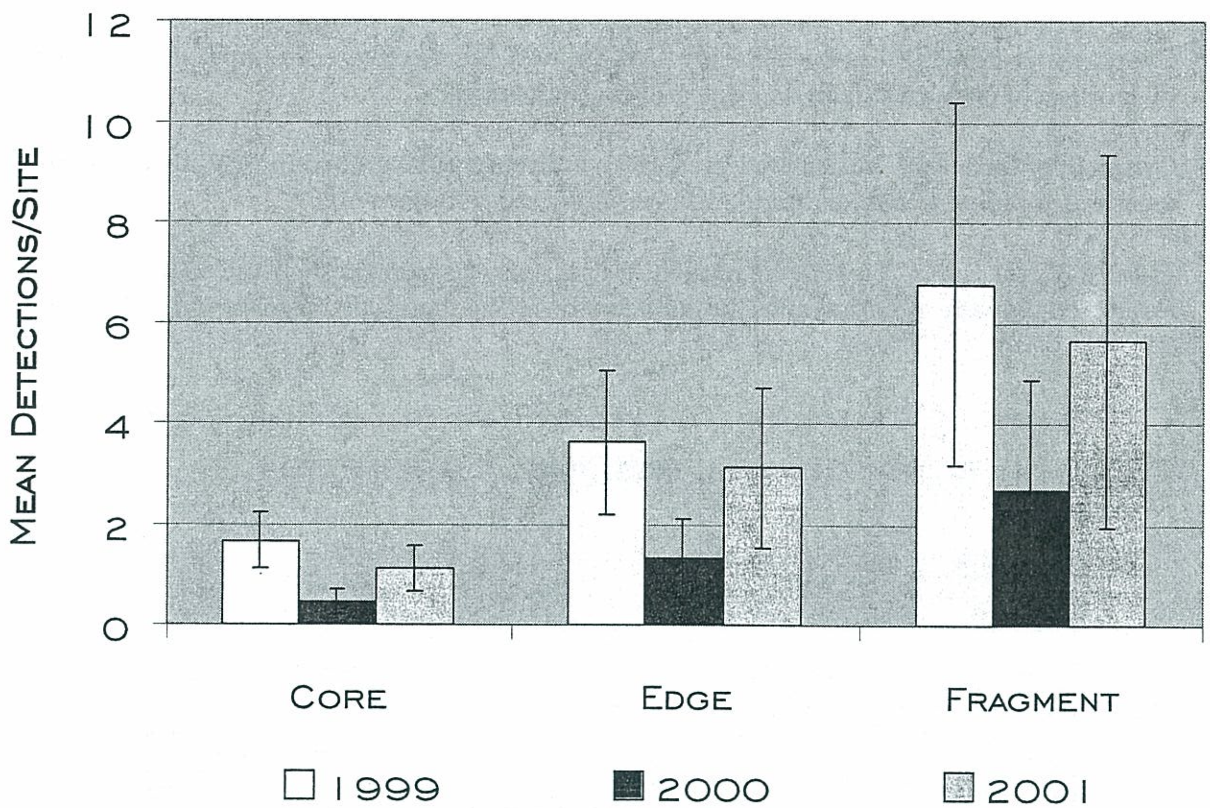


Chart 2 – California Gnatcatcher Detection Rates in the Coastal Reserve, 1999-2001



California Gnatcatcher Population Dynamics in the NROC

An important goal of this study should be to help elucidate the local population dynamics at work for the target bird populations occurring within each of the NROC's subregional reserves.

In order to start examining CAGN population dynamics in the NROC, two classes of monitoring site were identified based on the results of the 1999 surveys (when the NROC population last peaked): "high density" sites were those with at least five territory detections (n=11), and "low density" sites with fewer detections (n=29). Although the break point between the two classes of site is based on raw counts, and the following Table T lists only raw counts, the trend analyses at the bottom of the table reflect weighted mean detection rates, consistent with the other target bird trend analyses in this report.

TABLE T – CALIFORNIA GNATCATCHER DETECTION RATES AT "HIGH DENSITY" AND "LOW DENSITY" SITES, 1999-2001

Table T shows two-visit CAGN counts at each site for each year of the study; two-visit data projected from single-visit data are indicated in italics (see Page 12). Eleven sites that were vacant during all three years of the study have been excluded from this analysis, as these areas may not include habitat that is regularly used by CAGN.

Site	Sub-Stratum	2-Visit Counts 1999	2000	2001
High Density Sites				
1	Residential Edge	*6.42*	*1.07*	1
3	Mixed Edge (Fragment)	*14.98*	16	28
6	Mixed Edge	*14.98*	11	8
12	Road Edge	*20.33*	12	18
14	Road Edge	*7.49*	4	5
19	Mixed Edge (Fragment)	*8.56*	*3.21*	6
20	Mixed Edge (Fragment)	*14.98*	*8.56*	6
21	Mixed Edge	*8.56*	*4.28*	12
26	Road Edge	*10.7*	*5.35*	8
33	Mixed Edge (Fragment)	*13.91*	7	13
39	Core	*5.35*	2	4
	Total - High Density	**126.26**	**74.47**	**109**
Low Density Sites				
5	Road Edge	*2.14*	*0*	4
11	Core	*3.21*	3	2
15	Core	*2.14*	1	2
16	Core	*2.14*	0	0
18	Residential Edge	*2.14*	2	2
22	Residential Edge	*3.21*	0	1
23	Core	*3.21*	*0*	1
24	Core	*1.07*	1	0
25	Residential Edge	*3.21*	0	3
27	Road Edge	*3.21*	*0*	0
28	Road Edge (Fragment)	*2.14*	1	3
29	Core	*1.07*	*0*	2
30	Residential Edge (Fragment)	*4.28*	*0*	1
31	Residential Edge	*0*	1	1
32	Core	*1.07*	0	0
35	Core	*2.14*	*1.07*	0
37	Core	*1.07*	0	1
38	Core	*0*	0	2
	Total - Low Density	37.45	10.07	25
	Total - NROC	163.71	84.54	134

Percent Change (Weighted Mean Detections/Site)

Site Class	1999-2000	2000-2001	1999-2001
High Density	-42% ± 18%	+46% ± 57%	-16% ± 28%
Low Density	-73% ± 50%	+152% ± 80%	-33% ± 80%

As only three years of data are available, and the results are not statistically significant, the following discussions should be treated as tentative. Nonetheless, a few preliminary observations warrant mention.

Table T shows that the number of unoccupied low density sites varied considerably from year to year (two in 1999; 12 in 2000; four in 2001), while none of the high density sites was unoccupied in any of the three years.

Note also that a solid majority of the CAGN territory detections have occurred at high density sites during each year of the study (from raw counts: 77% in 1999; 88% in 2000; 81% in 2001) even though high density sites account for only 38% of the 29 occupied monitoring sites.

The proportion of CAGN territories found in low density habitat was greater during favorable years (23% of detections in 1999; 19% of detections in 2001) and lower during the crash of 2000, when only 12% of detections were in low density habitat.

The preliminary results suggest that low-density CAGN populations are considerably more volatile than are high-density populations, and that from 1999 to 2001, low-density populations may have declined twice as much as high-density populations did.

Proposed Demographic Model for CAGN in the NROC

The term "metapopulation," introduced by Richard Levins (1969), refers to a generalized concept of species existing in sets of local populations that are largely independent, but connected by periodic migration of individuals. California Gnatcatcher dispersal between the central and coastal subregional reserves remains unconfirmed (i.e., through recaptures or sightings of banded birds), and CAGN exchange between these reserves is probably rare due to the large expanses of urbanized or otherwise unsuitable habitat separating them. Unless contrary evidence emerges, it is reasonable to assume that CAGN populations in the subregional reserves are essentially isolated from each other. Taking a wider view, the central reserve is functionally contiguous with a large expanse of occupied habitat to the southeast (i.e., the southern NCCP planning area), and smaller numbers of CAGN to the north in the lower Santa Ana Mountains. By contrast, CAGN movement into and out of the coastal reserve is probably limited to more occasional interchange with coastal populations to the northwest (e.g., the West Newport Oil property and Fairview and Talbert parks) and in Laguna Niguel to the south (cf. Atwood et al. 1998b:22). Because of its less robust connections to other natural reserve systems, the coastal reserve appears to be more vulnerable to extirpation of CAGN and other native species than is the central reserve.

Within each of the NROC's subregional reserves, most CAGN occupy "high density" habitat areas. As described previously, these areas tend to occur along reserve edges, where coastal sage scrub grows on relatively shallow slopes and is dominated by favored shrubs, especially California Sagebrush (*Artemisia californica*). The intervening scrub and chaparral communities, which account for most of the NROC's total area, are either unoccupied by CAGN, or occupied at much lower density. This arrangement has some characteristics of a "classic" or "Levins" metapopulation, but the relative continuity of suitable habitat that is occupied at low levels suggests that the term "patchy population" (Harrison and Taylor 1997) may be more appropriate.

In demographic studies conducted starting in the early-to-mid 1990s, CAGN survivorship has been found to "vary substantially among years, usually at regional scale suggestive of widespread causes, such as weather effects" (Atwood and Bontrager 2001: 20). Productivity, however, has not been found to vary significantly from year to year in southern California (Atwood and Bontrager 2001), although lack of a prolonged regional drought during this period has precluded determination of whether productivity may be higher in certain areas under drought conditions (cf. Atwood et al. 1998b).

Bearing the above information in mind, it is hypothesized that the NROC's high density habitat patches are, in certain important respects (e.g., topography, elevation, vegetation, micro-climate), ecologically favorable to CAGN survival. If this hypothesis is correct, these areas may be termed "high quality habitat" or "source" habitat. Such areas tend to remain occupied at relatively high densities even during times of ecological stress (e.g., drought, severe winters), when gnatcatchers in less favorable areas ("low quality habitat" or "sink" habitat) perish at higher rates. During environmentally benign periods (e.g., mild winters that nonetheless provide rainfall adequate to rejuvenate scrub habitat in time for nesting), many juveniles that disperse into low quality habitat areas survive to breed successfully. Even during these boom periods, population densities and absolute numbers of CAGN in the low quality areas are hypothesized to generally remain well below the densities and numbers found in high quality habitat. Nonetheless, given that low quality habitat predominates in the NROC, the *proportion* of birds occupying low-quality habitat increases substantially during ecologically favorable periods. Inevitably, large-scale ecological stress again concentrates the birds into higher quality habitat areas that are more conducive to CAGN survival, and the cycle repeats.

With respect to this type of simplified "source/sink" demographic model, Van Horne (1983:901) warned:

> We need to be much more careful in identifying high-quality or critical habitat and not assume simple density-habitat quality relationships without the demographic data to support them.

Although the NROC study does not collect the type of demographic data recommended by this author, the hypothesis offered above is, at least, consistent with the growing body of published and unpublished CAGN research.

Van Horne (1983:896) further postulated:

> Because the juveniles are subdominant, there is no social interaction factor to prevent high densities in the sink habitats, which is in contrast to the adult-dominated high-quality or source habitats. Densities in the lower-quality habitat may thus actually be greater at times than in the high-quality habitat.

In the NROC study, high density and low density sites were defined based entirely on survey results from 1999, when reserve-wide gnatcatcher density is believed to have peaked, and the species was present at many sites from which it vanished in 2000 (most such areas were re-colonized in 2001). Thus, 1999 was a year when CAGN densities in low-quality habitat could have approached or exceeded densities in high-quality habitat—i.e., causing some low-quality habitat areas to be erroneously identified as high density ("source") habitat areas. If Van Horne's hypothesis pertained to CAGN in the NROC, many low density sites should have outperformed high density sites in 2000 and 2001. But examination of Table T shows that this clearly was not the case. With the possible exception of Site 1, CAGN populations at high density monitoring sites have responded to environmental stresses consistent with expectations for birds in high-quality "source" habitat. And CAGN populations at low density monitoring sites have, without exception, behaved as hypothesized for birds in low-quality "sink" habitat.

Thus, preliminary results of this study suggest that the most favorable habitat patches play a disproportionately important role in maintaining viable CAGN populations in each subregional reserve. Since nearly all of these high density habitat areas exist near reserve edges, where human disturbances are likely to be greatest, this finding may have implications for long-term management of the reserve.

Low density habitat areas presumably comprise important habitat connections between CAGN population centers, and scrub habitats occupied at low densities may play other important roles in maintaining the NROC's overall CAGN populations—roles that cannot be easily observed or anticipated, such as providing adequate habitat for species that may control populations of CAGN antagonists. Some of these areas may also become high density sites over time, and vice-versa, e.g., due to post-fire vegetative succession or long-term climate change.

Ongoing monitoring, including tracking of results obtained at the high density and low density sites identified herein, will permit tracking of potential shifts in CAGN population centers over time. Upon completion of planned assessments of slope, elevation, vegetation, fire history, and other physical characteristics of each site, it should be possible to obtain a reasonably precise understanding of the site characteristics that determine whether a given patch of habitat in the NROC is occupied by gnatcatchers at low or high density. Ultimately, it may be possible to incorporate such information into a detailed model of reserve-wide CAGN distribution and population dynamics, so that managers may, for example, compare the relative contribution of different habitat areas to the CAGN population in a given subregional reserve, or predict how major events such as wildfires may affect a given population (cf. Pulliam and Danielson 1991).

California Gnatcatcher Habitat Composition

Relative Abundance of Shrub Species in California Gnatcatcher Territories

Consistent with the findings of many other southern California researchers (as summarized by Atwood and Bontrager 2001), California Sagebrush (*Artemisia californica*) is the most prevalent shrub species in CAGN territories in each subregional reserve (see Table I; Charts 3 and 4). California Buckwheat (*Eriogonum fasciculatum*) has ranked a distant second followed by Black Sage (*Salvia mellifera*), a species particularly abundant in CAGN territories in the central reserve. Bontrager (1991) and Weaver (1998) mentioned a frequent lack of CAGN in Black Sage-dominated scrub in southern Orange County and northwestern San Diego County, respectively, although Braden and Powell (1994, as reported by Atwood and Bontrager 2001) showed greater use of Black Sage farther inland. Notably, Black Sage consistently ranks as one of the two most prevalent shrub species in CAGN territories at Peters Canyon Regional Park, the site with highest gnatcatcher density in the NROC. We continue to collect standardized data in order to obtain a fuller picture of CAGN-occupied habitat in the coastal and central reserves over time.

Chart 3 – California Gnatcatcher Habitat Composition in the Central Reserve, 1999-2001

Scientific names abbreviated; please refer to Table N for complete names.

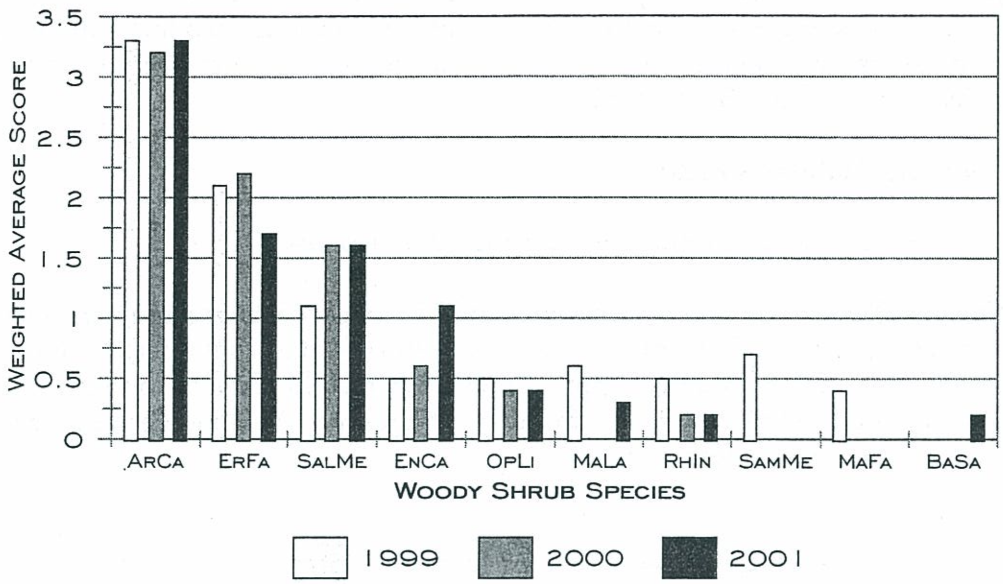
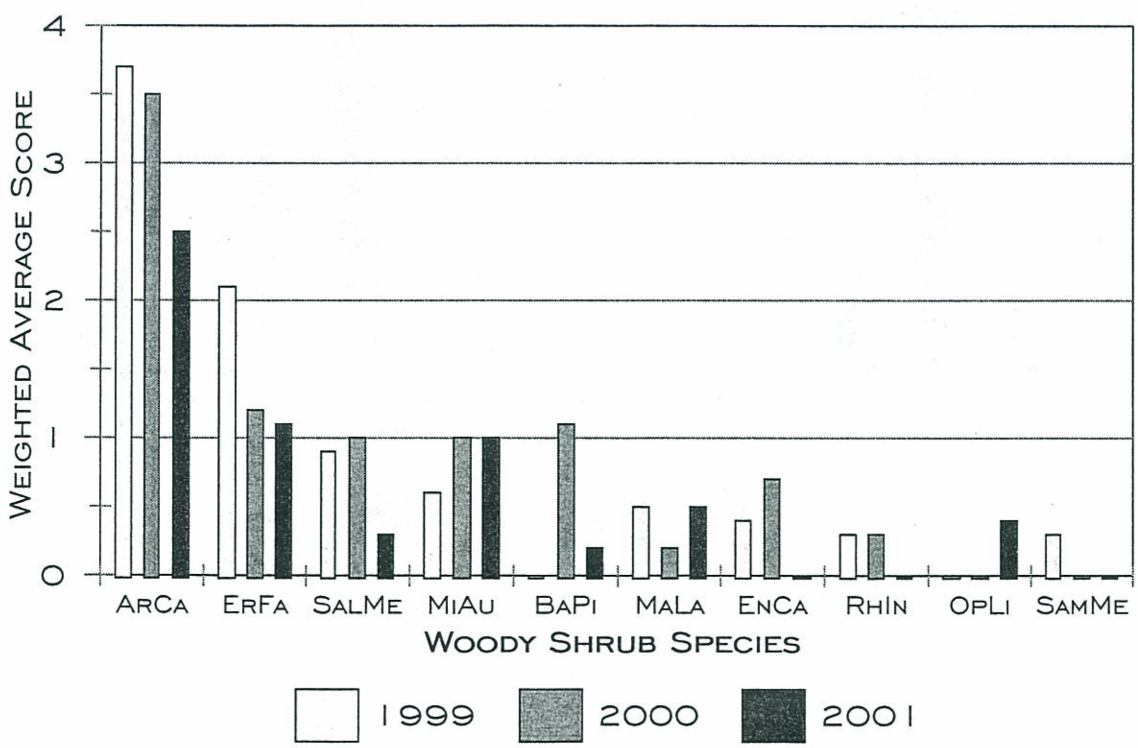


Chart 4 – California Gnatcatcher Habitat Composition in the Coastal Reserve, 1999-2001

Scientific names abbreviated; please refer to Table N for complete names.



CACTUS COVER IN CALIFORNIA GNATCATCHER TERRITORIES

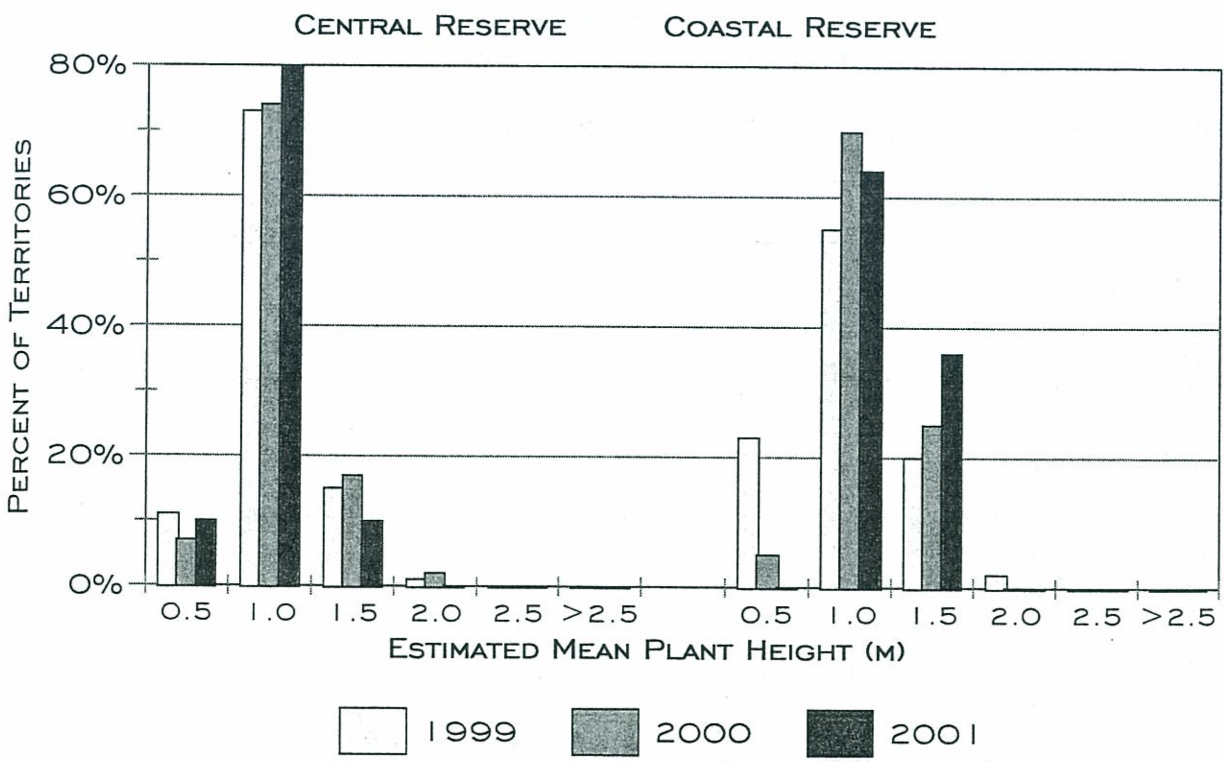
In 2001, the only year this variable was assessed for CAGN, 49% of territories in the central reserve and 62% of territories in the coastal reserve were in scrub judged to have 0% cactus cover (see Table K). The 1993 Laguna Beach Fire greatly reduced the area occupied by cactus in the coastal reserve, presumably contributing to the greater proportion of cactus-free territories there. Nonetheless, these preliminary results suggest that CAGN in the NROC tend to select scrub habitats with few or no cactus patches, presumably to avoid CACWs, which are reported to prey on and otherwise antagonize CAGNs (Atwood and Bontrager 2001).

California Gnatcatcher Habitat Structure

WOODY VEGETATION HEIGHT IN CALIFORNIA GNATCATCHER TERRITORIES

From 1999 to 2001, 73-80% of central reserve territories and 55-70% of coastal reserve territories have been in scrub habitat approximately 1.0 m tall (see Table L and Chart 5). In the coastal reserve, 20-36% of territories have been in scrub habitat approximately 1.5 m tall, a greater proportion than the 10-17% of territories found in this cover class in the central reserve. Much lower proportions of CAGN have selected taller or shorter scrub.

CHART 5 – MEAN WOODY VEGETATION HEIGHT IN CALIFORNIA GNATCATCHER TERRITORIES, 1999-2001

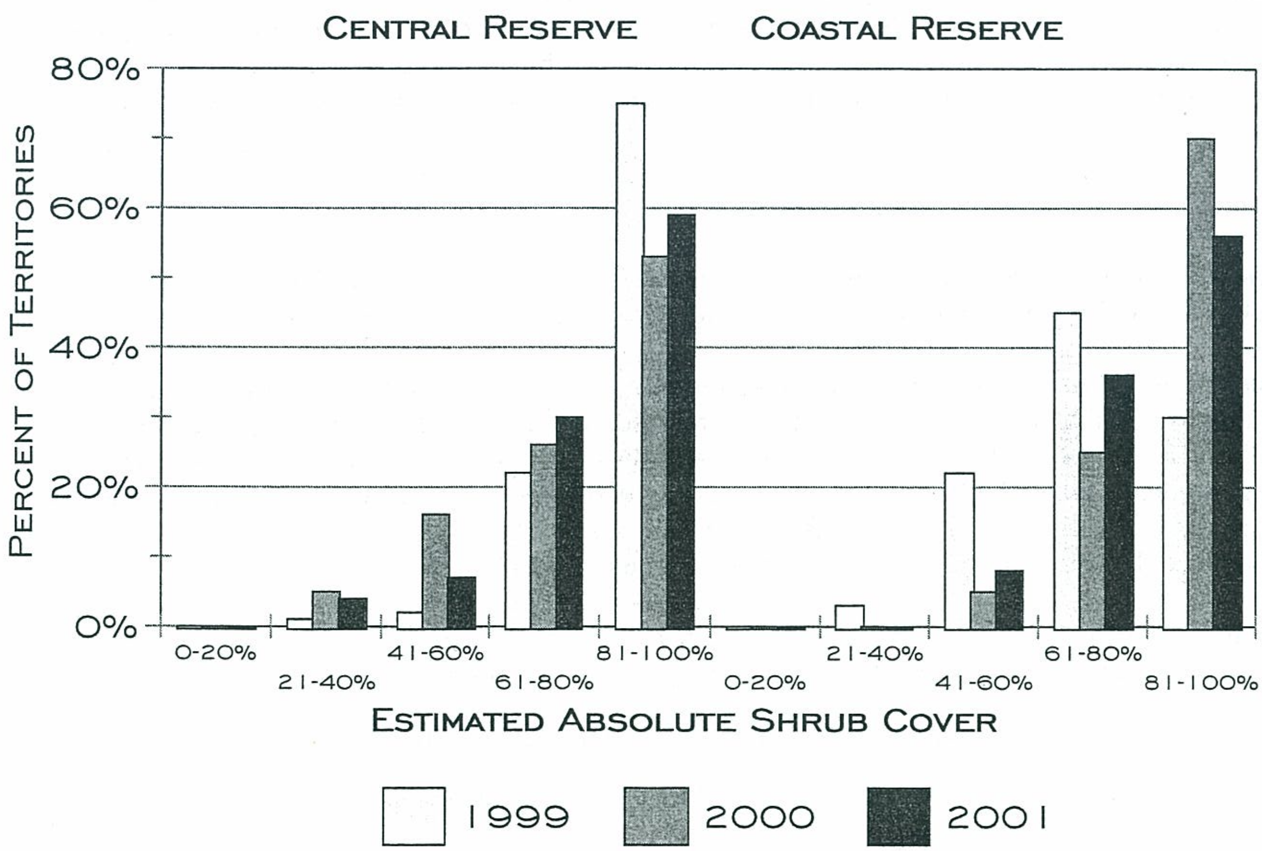


Shrub Cover in California Gnatcatcher Territories

As indicated in Table N and Chart 6, observations to date have suggested a preference for relatively dense scrub habitat. Whereas no CAGN territory has been in scrub with 0-20% shrub cover, and very few have been in scrub with 21-40% cover, 79-97% of central reserve territories and 75-95% of coastal reserve territories have been in habitat with absolute shrub cover estimated at 61-100%, with a majority of territories being in the 81-100% cover class.

In contrast to these results, Atwood and Bontrager (2001) summarized several southern California studies reporting that CAGN mainly occupy scrub with perennial cover of 23-56%. Such results probably reflect methodological differences. In particular, the NROC estimations of perennial cover have been made during brief periods of observation, a method that tends to focus on the presumed main area of habitat use while excluding marginal areas that may be used regularly, if infrequently. Other studies have involved mapping the movements of birds over long periods of time, a method that would be expected to yield lower overall estimates of shrub cover in CAGN territories due to inclusion of marginal areas. Additional years of data collection, combined with analysis of physical site characteristics and fire history, should be valuable in assessing CAGN habitat preferences in the NROC.

Chart 6 – Absolute Woody Vegetation Cover in California Gnatcatcher Territories, 1999-2001



Cactus Wren Short-term Population Trends

The following analyses compare weighted mean territories detected/site (see Tables E, F, G) with the 95% confidence interval given in parentheses.

From 1999 to 2000, the overall CACW population declined 13% (36% decrease to 10% increase). The central reserve decline was 8% (29% decrease to 14% increase), and the coastal reserve decline was 33% (124% decrease to 59% increase).

From 2000 to 2001, the overall CACW population remained constant (8% decrease to 8% increase). The central reserve population declined 5% (13% decrease to 4% increase), and the coastal reserve population increased 25% (17% decrease to 68% increase).

From 1999 to 2001, the overall CACW population declined 13% (42% decrease to 17% increase). The central reserve decrease was 12% (38% decrease to 15% increase), and the coastal reserve decrease was 13% (42% decrease to 17% increase).

The approximate 13% reserve-wide decline in detections/site from 1999 to 2000 is substantially less than the 35% reserve-wide decline among scrub-dwelling passerines estimated through constant-effort mist netting (see preceding discussion of MAPS results). As discussed previously, it seems likely that several months of unusually dry conditions in 1999/2000, followed by two weeks of relatively intense winter rains in February 2000, contributed to short-term declines of scrub-dwelling bird populations. This study suggests that CACW generally weathered these conditions better than did most other species. The 1999/2000 decline in the coastal reserve was apparently comparable to the overall 35% decrease estimated by MAPS, although the confidence interval for this change is very large due to the small number of CACW territories detected at coastal reserve monitoring sites.

Cactus Wren Patterns of Distribution

The following discussion compares detection rates among the three major land designations and does not involve trend analysis, and so the detection rates given are non-weighted means.

In each year of the study, the CACW detection rate (mean detections/site) for the central reserve was substantially greater than that of the coastal reserve (4.1 times greater in 1999; 5.5 times greater in 2000; 4.3 times greater in 2001). These differences appear to be largely attributable to the 1993 Laguna Beach Fire, which burned 75% of the coastal reserve and consumed cactus patches across large swaths of the San Joaquin Hills (the 1998 Santiago Canyon Fire burned 38% of the central reserve and left larger areas of intact cactus scrub usable by CACW).

From 1999 to 2001, the three-year mean CACW detection rate across the NROC (n=40 sites) was 2.18 detections/site. Breaking this down by major land designations:

- The mean detection rate at core sites (n=19) was 2.11 detections/site.
- The mean detection rate at edge sites (n=15) was 2.61 detections/site.
- The mean detection rate at fragment sites (n=6) was 2.16 detections/site.

Chart 7 – Cactus Wren Detection Rates in the Central Reserve, 1999-2001

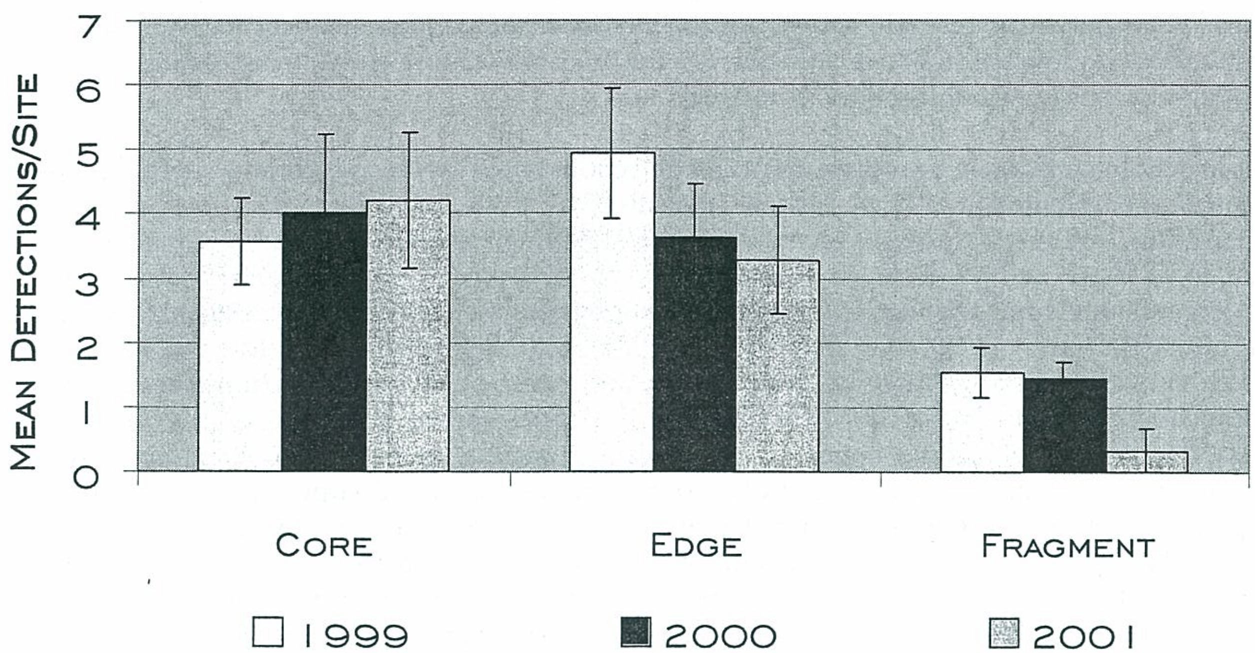
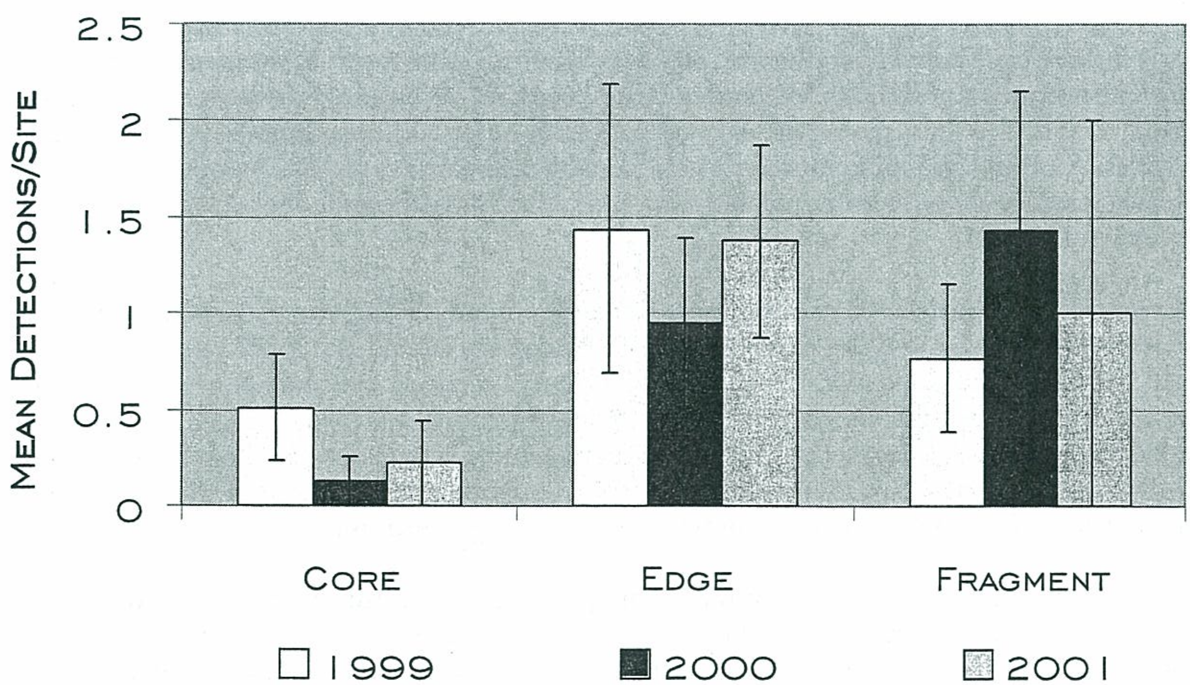


Chart 8 – Cactus Wren Detection Rates in the Coastal Reserve, 1999-2001



Relatively uniform CACW distribution across the three sampling strata appears to reflect the distribution of suitably developed cactus scrub habitat. The 1991/92 surveys of the NROC lands (Jones and Stokes 1993) also showed CACW to be distributed more uniformly across the two subregional reserves compared with CAGN. In a recent study of CACW nest-site selection in the Chino Hills of northern Orange County, Flaagan (1999) found that nest-containing patches were at least 90 cm tall, and averaged 1.4 m tall, and that the birds showed a preference for cactus patches with a relatively low percent cover and average height of shrubs (presumably because tall shrubs provide a means for ground predators to access nests).

The approximate 13% one-year drop in CACW detections NROC-wide in 2000, and the 8% decline measured in the central reserve, were smaller than the 35% decline among scrub-dwelling passerines in the NROC estimated through constant-effort mist netting (see preceding discussion of MAPS results), although the 33% decline measured in the coastal reserve was comparable. Cactus Wrens are larger-bodied birds than are CAGNs, and the wrens build enclosed brood nests that provide warmth and shelter during cold winter weather. As such, they are probably less vulnerable to weather-related mortality than are gnatcatchers and some other scrub-dwelling species. The unexpectedly large decline in CACW numbers in the coastal reserve, which mirrored a very large CAGN decline in that reserve, appears to have been augmented by factors unrelated to weather conditions. For example, recent fires may have forced some CACW to occupy relatively small and fragmented patches of cactus scrub habitat, which could leave them unusually vulnerable to short-term declines. The data are decidedly mixed, however, and do not point to any definite conclusions. The 77% decline in the central reserve's fragment sites from 2000 to 2001 appears drastic, but those few sites were never heavily occupied. Moreover, see the following discussion of low density versus high density CACW populations, which suggests that low density sites actually outperformed high density sites from 1999 to 2001.

Cactus Wren Population Dynamics in the NROC

As discussed previously, the distribution of CACW in the NROC closely mirrors that of mature cactus scrub. Since cactus scrub is not uniformly distributed through the NROC, CACW populations in each subregional reserve are naturally patchy (and, therefore, possess some qualities typically associated with metapopulations).

Cactus Wren dispersal between the central and coastal subregional reserves remains unconfirmed (i.e., through recaptures or sightings of banded birds), and CACW exchange between these reserves is probably rare due to the large expanses of urbanized or otherwise unsuitable habitat separating them. Unless contrary evidence emerges, it is reasonable to assume that CACW populations in the subregional reserves are essentially isolated from each other (please refer to the previous discussion of this topic for CAGN).

In order to start examining CACW population dynamics in the NROC, two classes of monitoring site were identified based on the results of the 1999 surveys (when the NROC population last peaked): "high density" sites were those with at least five territory detections (n=11), and "low density" sites with fewer detections (n=19), with 10 sites excluded due to lack of CACW detections during all three years. Although the break point between the two classes of site is based on raw counts, and Table U lists only raw counts, the trend analyses at the bottom of the table reflect weighted mean detection rates, consistent with the other target bird trend analyses in this report.

As described previously, 1999 detection rates were projected by multiplying Round 1 detections by a factor of 1.15. Detection rates for the 16 sites covered only once in 2000 were projected by multiplying Round 1 detections by a factor of 1.15. The projected data are indicated in *italics*.

Table U – Cactus Wren Detection Rates at "High Density" and "Low Density" Sites, 1999-2001

Table U shows two-visit CACW counts at each site for each year of the study; two-visit data projected from single-visit data are indicated in italics (see Page 12). Ten sites that were vacant during all three years of the study have been excluded from this analysis, as these areas may not include habitat that is regularly used by CACW.

Site	Sub-Stratum	2-Visit Counts 1999	2000	2001
High Density Sites				
1	Residential Edge	*4.6*	*1.15*	1
6	Mixed Edge	*5.75*	4	3
7	Core	*4.6*	2	3
9	Core	*6.9*	10	8
11	Core	*5.75*	7	6
12	Road Edge	*6.9*	6	7
16	Core	*5.75*	9	9
17	Mixed Edge	*4.6*	2	4
18	Residential Edge	*9.2*	7	5
25	Residential Edge	*5.75*	2	2
	Total – High Density	**59.8**	**50.15**	**48**
Low Density Sites				
2	Core	*1.15*	*0*	0
3	Mixed Edge (Fragment)	*1.15*	2	0
4	Core	*1.15*	1	2
5	Road Edge	*1.15*	*2.3*	1
8	Core	*2.3*	*1.15*	2
10	Core	*1.15*	*0*	0
13	Core	*3.45*	*6.9*	4
14	Road Edge	*2.3*	3	2
15	Core	*3.45*	3	8
19	Mixed Edge (Fragment)	*1.15*	*1.15*	0
20	Mixed Edge (Fragment)	*2.3*	*1.15*	1
21	Mixed Edge	*3.45*	*3.45*	4
22	Residential Edge	*1.15*	1	2
23	Core	*1.15*	*0*	0
24	Core	*1.15*	0	0
26	Road Edge	*0*	*1.15*	2
27	Road Edge	*1.15*	*0*	1
28	Road Edge (Fragment)	*1.15*	2	0
30	Residential Edge (Fragment)	*1.15*	*2.3*	3
35	Core	*2.3*	*1.15*	2
	Total – Low Density	**33.35**	**32.70**	**34**
	Total – NROC	**93.15**	**82.85**	**82**

Percent Change (Weighted Mean Detections/Site)

Site Class	1999-2000	2000-2001	1999-2001
High Density	-17% ± 18%	-4% ± 5%	-21% ± 31%
Low Density	-4% ± 27%	+7% ± 28%	+2% ± 20%

As only three years of data are available, and the results are not statistically significant, the following discussions should be treated as tentative.

To date, CACW population dynamics in the NROC have differed from those of the CAGN. For example, CAGN numbers declined dramatically from 1999 to 2000 and then partially rebounded in 2001, whereas CACW numbers decreased moderately from 1999 to 2000 and then remained steady in 2001. As discussed below, the interspecific differences extend to the short-term population trends at high density versus low density sites.

As described elsewhere in this report, CACW are substantially larger than CAGN, and employ somewhat different strategies for surviving the winter months (most notably, constructing brood nests). The two species also select different vegetation and geographic cues for their preferred habitats, and those habitats are recovering at different rates from recent major fires. So it is perhaps to be expected that CACW and CAGN populations in the NROC will behave somewhat differently as environmental conditions change from year to year.

Table U shows that the number of unoccupied low density sites varied from year to year (one in 1999; four in 2000; seven in 2001), while none of the high density sites was unoccupied in any of the three years. Year to year variance in the number of empty sites was lower than observed for CAGN, however.

Note also that most of the detections have occurred at high density sites during each year of the study (from raw counts: 64% in 1999;61% in 2000; 59% in 2001) even though high density sites account for only 33% of the 30 occupied monitoring sites. But the proportion of CACW territories found in low density habitat has increased slightly each year, as CACW numbers at low-density sites remained essentially static during a period when the numbers at high density sites decreased by approximately 21% (although wide confidence intervals indicate that these differences are not close to being significant). At this early point, no indications exist that low density CACW populations are as prone to dramatic fluctuations as CAGN populations appear to be.

All ten sites excluded from this analysis due to lack of CACW sightings are numbered in the range of 29 to 40. Since the numbering of sites generally proceeded from inland sites and moved toward the coast, these sites are all located fairly near the coast. Surveys of the coastal reserve in1991/92 (Jones and Stokes 1993) found the greatest concentrations of CACW at least two miles from the coast, but they also turned up numerous territories near the immediate coast. The lack of detections at these ten sites indicate that very little cactus scrub habitat suitable for use by CACW exists close to the coast eight years after the Laguna Beach Fire.

Bontrager et al. (1995) conducted spring 1994 surveys throughout the Laguna Beach Fire area, revealing 79 pairs of CACW and just 12 pairs of CAGN within the perimeter of the burn—28% and 9%, respectively, of 1992 survey results for the same area. We noted that Laguna Canyon and other coastal canyons had burned hotter and more completely than areas on the north and west flanks of the fire, and consequently experienced greater loss of vegetation. Most of our 1994 CACW and CAGN detections were in the less severely burned areas away from the immediate coast. Finally, we cautioned that CACW outnumbering CAGN by approximately seven to one within the burn perimeter should not be taken as an indication that the CACW population was closer to full recovery. Cactus wrens generally require cactus scrub that is at least one meter tall, a height that is not quickly attained by these relatively slow-growing plants.

Smith and Peacock (1999) investigated the concept that colonization of habitat patches by dispersing individuals "may be profoundly influenced by the presence of conspecifics on neighboring patches, leading to a colonization process that may be much more deterministic than was previously believed." They provided evidence that certain reptiles, birds, and mammals "can and do assess habitat quality indirectly by cuing on the presence of conspecifics," with potentially important implications for managing populations in fragmented habitats (e.g., reintroduction of a species to a fragmented area may be more successful if individuals are grouped in colonies rather than scattering them throughout the reserve area). Although our study has not attempted to research this issue, anecdotal observations of CACW in the NROC and elsewhere, and the observations of others, suggest that CACW may tend to settle selectively in habitat patches near patches already occupied by CACW (but see the preceding discussion of low-density vs. high-density populations). If the presence of other CACW proves to be an important factor determining whether dispersing CACW settle a given area, then burned cactus scrub habitat near the coast could be slowed even further (beyond the time it takes for cactus to regrow) by the scarcity of CACW in that area. Furthermore, the potential relevance of this phenomenon should at least be considered as part of any proposal to restore cactus scrub in the NROC.

Ongoing monitoring and more detailed analysis of the results from high density and low density sites (including comprehensive assessment of slope, elevation, fire history, and other physical characteristics of each site) will give a more complete understanding of the CACW population dynamics in the NROC.

Cactus Wren Habitat Composition

Relative Abundance of Shrub Species in Cactus Wren Territories

In 2000 and 2001[1], Coastal Prickly-Pear (*Opuntia littoralis*) ranked as the most abundant shrub species in CACW territories throughout the NROC, but note the much stronger dominance of this species in the central reserve compared with the coastal reserve. This difference appears to reflect slow cactus recovery in the coastal reserve after the 1993 Laguna Canyon Fire, and it is expected that cactus will become incrementally more dominant in the coastal reserve as recovery progresses.

Other relatively abundant plants in CACW territories include California Buckwheat, Laurel Sumac (*Malosma laurina*), and Lemonade Berry (*Rhus integrifolia*). Although Mexican Elderberry (*Sambucus mexicana*) is frequently found in CACW territories, and it may provide important high perches and foraging habitat, the low ranking of this species in 2000 and 2001 suggest that Mexican Elderberry covers relatively little area compared with other shrub species dominant in CACW territories.

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[1]Results from 1999 are excluded because the habitat data was collected using different methods than in subsequent years. The 2001 results exclude 18 of the 60 territories detected in Round 1 because these habitat data were mistakenly collected according to the 1999 methodology.

Chart 9 – Cactus Wren Habitat Composition in the Central Reserve, 1999-2001

Scientific names abbreviated; please refer to Table J for complete names.

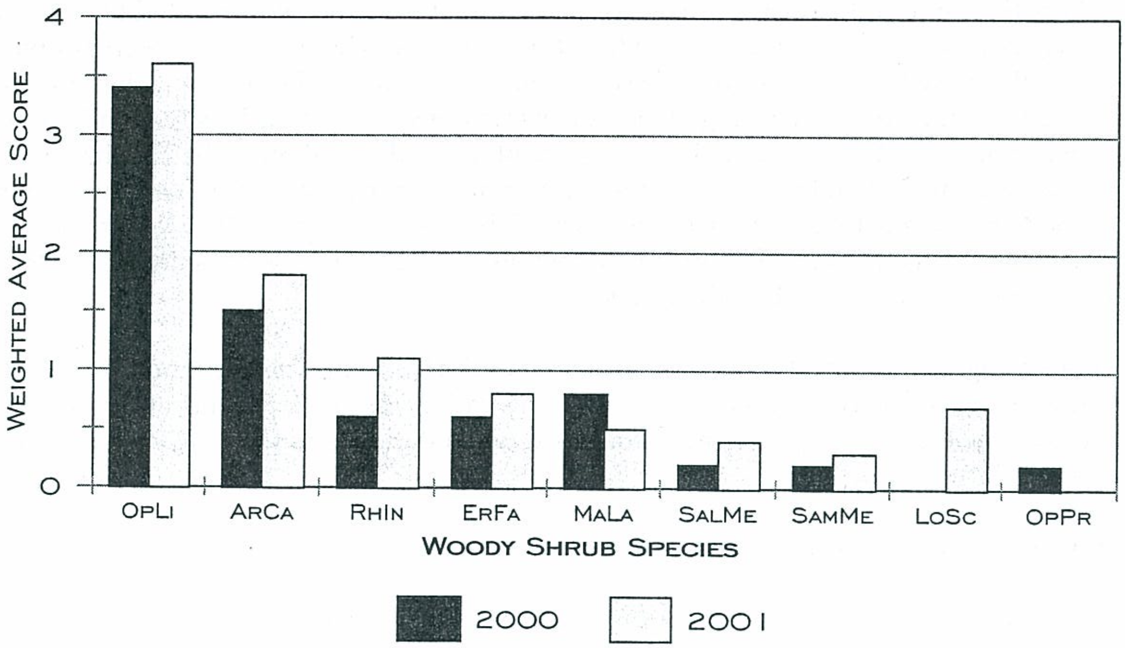
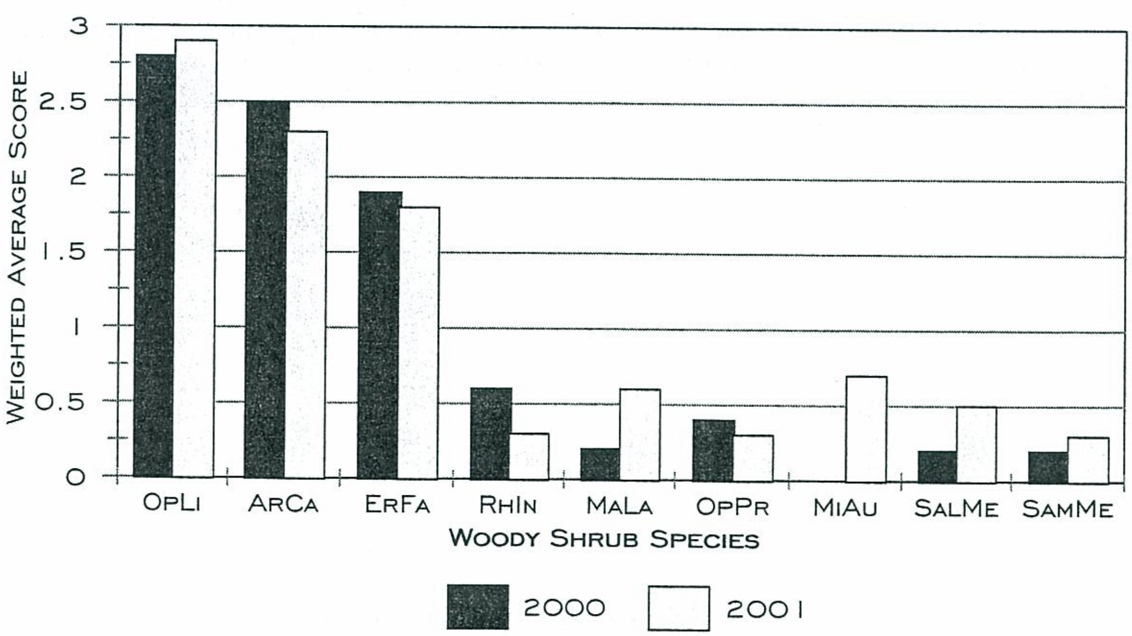


Chart 10 – Cactus Wren Habitat Composition in the Coastal Reserve, 1999-2001

Scientific names abbreviated; please refer to Table J for complete names.



Cactus Cover in Cactus Wren Territories

In the central reserve, 66% of CACW territories were in scrub with 1-25% estimated cactus cover, with an additional 32% in scrub with 25-50% estimated cactus cover, and 2% (one territory) in scrub with 51-75% estimated cactus cover.

In the coastal reserve, 93% of CACW territories were in scrub with 1-25% estimated cactus cover, with 7% (one territory) in scrub with 25-50% estimated cactus cover. This result provides additional evidence of the relative lack of cactus in the coastal reserve, and suggests that CACW near the coast may be forced into inadequate habitat.

In contrast to these findings, Wheeler (1997, as reported by Solek and Szijj 1999) found that cover of Coastal Prickly-Pear ranged from 27-63% at CACW territories at four sites in Los Angeles County. This apparent difference could result from particularities of the sites selected in Los Angeles, or from differences in estimating/measuring cactus cover.

Additional years of study are needed to reach useful conclusions about relative cactus cover in CACW territories in the two subregional reserves, and between the NROC and other areas.

Habitat Structure

Woody Vegetation Height in Cactus Wren Territories

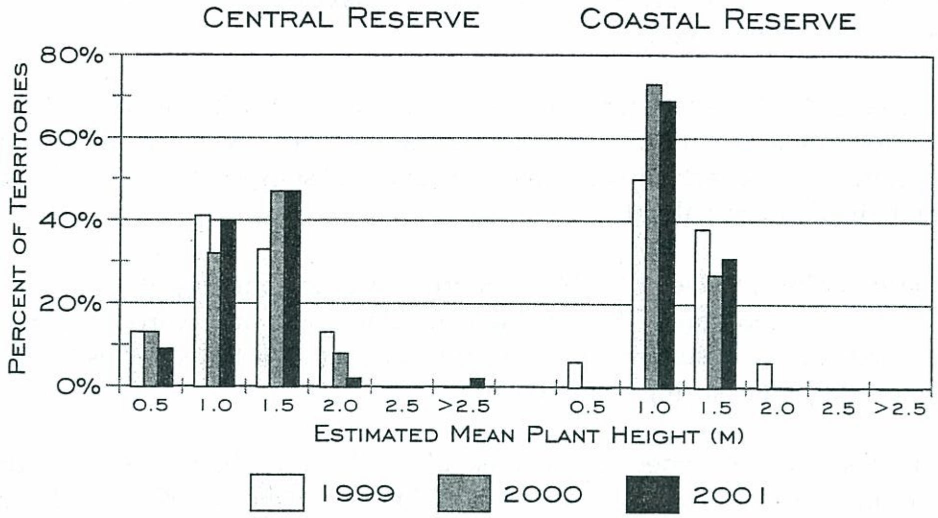
From 1999 to 2001, 32-40% of central reserve territories and 50-73% of coastal reserve territories have been in scrub habitat approximately 1.0 m tall (see Table M and Chart 11).

In the central reserve, 33-47% of territories have been in scrub habitat approximately 1.5 m tall, a slightly greater proportion than the 27-38% of territories found in this cover class in the central reserve.

In the central reserve, 9-13% of CACW have utilized scrub approximately 0.5 m tall each year, while CACW in the coastal reserve almost never occupy such low scrub. Territories in this cover class typically indicate partially burned (but still suitable) scrub or cactus patches surrounded by grassland. Such situations are very rare in the coastal reserve, less so in the central.

Territories estimated to have mean vegetation height of 2.0 m or greater typically include significant chaparral elements, such as Mexican Elderberry, Lemonade Berry, and Laurel Sumac, which naturally occur more commonly in the central reserve.

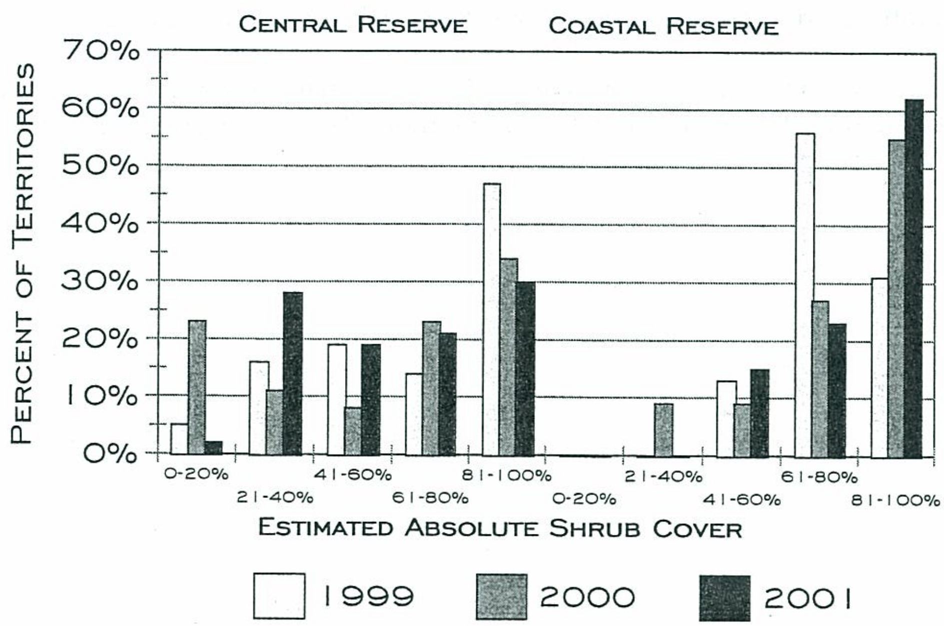
Chart 11 – Mean Woody Vegetation Height in Cactus Wren Territories, 1999-2001



Shrub Cover in Cactus Wren Territories

As indicated in Table O and Chart 12, most CACW have occupied dense scrub from 1999-2001. This tendency has been more pronounced in the coastal reserve, where 82-87% of territories have occurred in habitat with shrub cover estimated at >60%, compared with 51-61% of territories in the central reserve. Most of the sparsely vegetated territories in the central reserve were in recently burned scrub or in limited patches of cactus surrounded by grasslands, situations that are relatively rare in the coastal reserve.

Chart 12 – Absolute Woody Vegetation Cover in Cactus Wren Territories, 1999-2001



Brown-headed Cowbird Sampling, 1999-2001
Robert A. Hamilton

In the three years of this study, only seven Brown-headed Cowbirds have been recorded in the NROC: five in 1999, two in 2000, and none in 2001. These results provide evidence that cowbird trapping efforts across the NROC appear to be achieving positive results for species outside of the riparian areas where the traps are concentrated.

As noted previously, BHCO monitoring is not a required element of the NROC's monitoring program and is not a primary objective of this study. If detections were to increase markedly in future years of this study, further analysis of BHCO data, and possibly other actions, could be warranted at that time.

VI. Recommendations

Statistical Analysis of Pilot Data for Years 1-5

The NROC should retain an experienced biometrician to review data collected during the first five years of pilot monitoring (1999-2003) and recommend any adjustments necessary to meet the project's stated objectives. These analyses should be completed in time to modify the study design prior to commencement of the sixth season of data collection on 1 March 2004. The following analyses were recommended by Dr. Tyson Holmes prior to initiation of the study. They are discussed by Dr. Messer in light of the current data analysis.

Linear Contrast Analysis

Initial Proposal

For each hypothesis, a linear contrast should be calculated on the temporal sequence of detection rates for each site (Gurevitch and Chester 1986) These contrast values will then be used to estimate mean trend and its variance for the NROC with a stratified-sampling estimator (Thompson 1992). The study designers shall determine the most relevant combinations of strata to be considered (coastal and central reserve; core, edge, and fragment land designations; core, road edge, residential edge, and mixed edge sub-designations). Estimates of the mean and its variance will be used to construct a 90%-confidence interval for each hypothesis. A linear trend in mean detection rate will be indicated where a confidence interval does not include zero.

Discussion

As presented in the methods section and Appendix C, a stratified Poisson model incorporating the number of visits to each site probably represents the best approach. The strata are determined by the study design as given in the Methods section. A smooth linear trend should not be expected; it may be more appropriate to consider time series models as more data is collected.

Analyses of Sample Size and Sampling Rate

A sample-size analysis will be performed for each of the two target species. A desirable objective would be to estimate, grossly, how large sample sizes should be each year in order to obtain estimates of the total that are within at least ±20% of the true total with 90% confidence[1]. However, sample sizes for estimating the total number of territories may be much larger that those required to estimate the change in territories. Please see the discussion below and in Section 1.15 in the Appendix C. Dr. Holmes expected that these estimates would be made using normal theory (Thompson 1992) or studentized bootstraps (Efron and Tibshirani 1993).

A biometrician should examine the results of the first five years of this study, and work with the TAC and resource agencies to determine an appropriate sampling strategy for future years of this study.

Monte Carlo Simulations of Sample Size

Initial Proposal

For each hypothesis, Monte Carlo simulations on data from the third through sixth years will be used to determine appropriate sample sizes and schedules for the long term (cf. Mac Nally 1997). Three effect sizes should be explored in each analysis: 1) a drastic 20% change between a pair of consecutive years, 2) 5% linear trend over five years, and 3) 10% linear trend over five years. Each of these changes will be simulated as an increase and a decrease. Each iteration of the 20% effect size will be examined for each pair of consecutive years from data collected in the second through sixth years. For each pair the mean for the second year will be adjusted upward or downward by 20% relative to the mean for the first year and separate sampling simulations will be conducted for a range of studentized-bootstrapped sampling rates (Efron and Tibshirani 1993). For the 5% and 10% effect sizes, a straight line will be fitted to the five-year sequence of annual means and the resultant set of five residuals will be added in their original order to each simulated five-year linear trend to preserve any original autocorrelation structure. For these five-year effect sizes, separate sampling simulations will be conducted across a range of bootstrapped sampling rates for two schedules: 1) sampling conducted each year and 2) sampling conducted every other year. For all three effect sizes, any relationship between the mean and the variance will be preserved in simulated data by appropriately scaling the set of residuals about each annual mean. Hypothesis testing will be as described above. Target power should be 80% and false-alarm rates should be 10% for all simulations (cf. Kendall et al 1992, Zielinski and Stauffer 1996).

Discussion

To estimate changes in population totals, Dr. Messer has carried out a preliminary bootstrap sample size and power computation, utilizing the linear trend model (see Appendix C, Sections 1.15 and 2.6). For CAGN, this analysis indicates that the present study design has 90% or more power to detect a decline of 16 territories per year over five years, at 90% confidence. Reserve managers and the resource agencies will have to determine whether this power level is adequate. Note that this estimate is valid at the current population levels only; a more sophisticated analysis based on a stratified Poisson model would take into account varying population levels.

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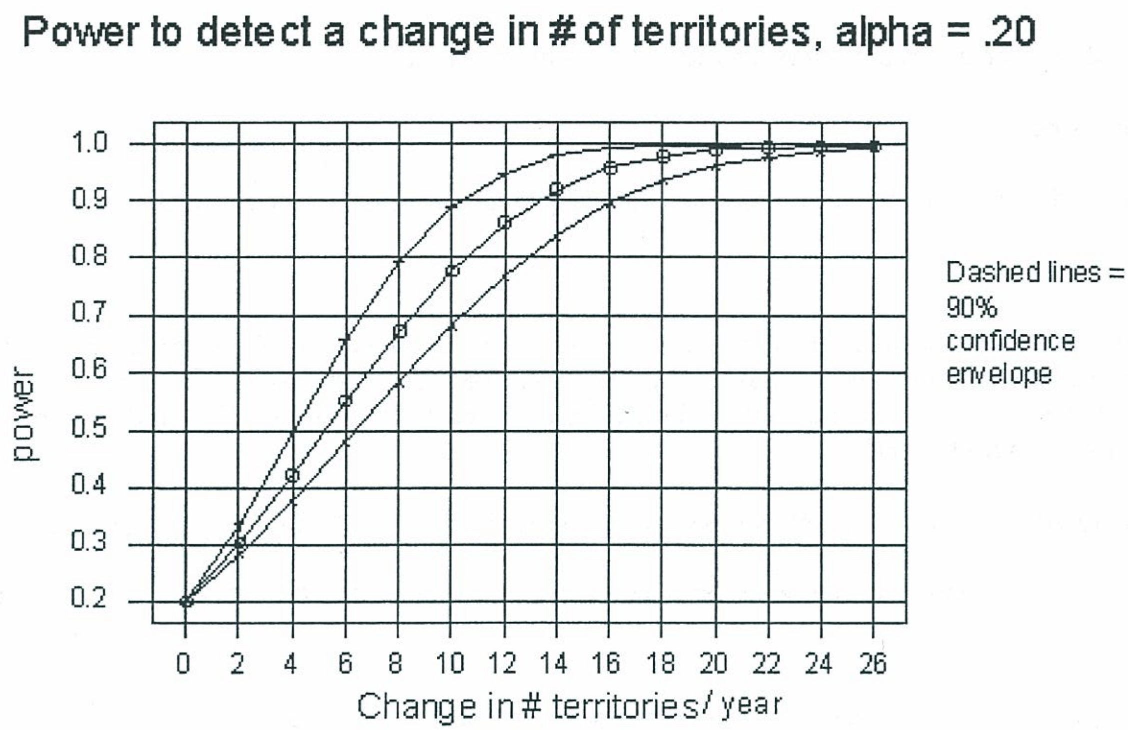
[1] It is recognized that dispersion within the data for the first five years may not be representative of dispersion in subsequent years; but, these are the best data that will be available for this purpose.

With respect to estimating population totals in a given year, Dr. Messer's preliminary discussion shows that the existing sample size is inadequate, if the target is to estimate the total number of CAGN to within ± 20 territories at 90% confidence. Several sampling schemes are discussed in Appendix C, where the best current suggestion would add 10 sampling sites in a nearly optimal design to nearly achieve the desired power. The existing sample is closer to adequate for CACW. Please see the discussion in Appendix C, Section 1.16. It is suggested that rotating panel designs, which build upon the existing information, be considered for the future.

Chart 13 – Power Curve, California Gnatcatcher Territories



Development of Weighted Poisson Regression

After reviewing and analyzing the first three years of pilot data, Dr. Karen Messer has advised the NROC to program a weighted version of Poisson regression to obtain more accurate and narrower confidence intervals.

Employ GIS to Capture Geographic Information from Each Site

Eventually, the NROC's GIS capabilities should be used to characterize the following physical site characteristics:

Area of Site

This should be given in hectares, rounded to the nearest tenth.

Distance to Nearest Four-Lane Road

Measurement in meters from the closest survey boundary to the nearest four-lane (or greater) road, rounded to the nearest 10m.

Distance to Nearest Residential Edge

Measurement in meters from the closest survey boundary to the edge of the nearest residential development, rounded to the nearest 10m.

Minimum and Maximum Site Elevations

These should be given in meters, rounded to the nearest meter.

Mean Slope

A composite angle of the site's major slopes will provide a measure of overall steepness.

Fire History

The site's fire history should be characterized by the percentage of the site burned within one or more of five categories: (0-2 years), (3-7 years), (8-12 years), (13-20 years), and (21+ years). The percentages of sites in each category should be rounded to the nearest 10% and sum of these categories should be 100%.

The following fictitious example shows recommended physical site data in a summary table.

Table V – Example of Recommended Physical Site Data Table

							Fire History				
Site No.	Area (ha)	Nearest Road	Nearest House	Min. Elev.	Max. Elev.	Mean Slope	0-2 yrs.	3-7 yrs.	8-12 yrs.	13-20 yrs.	>20 yrs.
41	22.5	150m	320 m	1,102 m	1,143 m	13°	0%	20%	0%	40%	40%
42	33.6	520 m	710 m	251 m	286 m	21°	80%	0%	0%	0%	20%

Update and Incorporate Plant Community Information

Future years of this study should incorporate information on the plant communities and sub-communities present on each site, within each sampling stratum, etc. This was not completed in 2000 because the site boundaries were not yet finalized and because the existing plant community mapping is inaccurate in some parts of the NROC. Over the long term, detailed plant community mapping should be completed at each monitoring site using methods and community definitions that will be used to re-map the entire NROC. At such a time, it should be possible to characterize the vegetative composition of the monitoring sites for use in analyzing target bird monitoring data.

Develop Data-Filtering Programs

Once the basic data analyses to be conducted during each year of the monitoring program have been determined, the NROC should consult with a relational database programmer to develop code that will perform each year's standard analyses, including comparisons with previous years' data. This would likely save substantial time and resources over the long term, and yield more standardized and reliable results, versus manual filtering and analysis of each year's data.

VII. Report Preparers

This report was authored by Robert Hamilton, with statistical analysis by Karen Messer. Appendix C was authored by Dr. Messer.

VIII. Acknowledgments

This monitoring study and annual report benefitted from discussions with many people, including Richard Erickson, Kurt Campbell, Michael Patten, Trish Smith, Tyson Holmes, Robert Fisher, Will Miller, and Paul Doherty. Thanks also to Al Lucero, Gary Medeiros, and Doug Barrett at the County of Orange/NROC for their excellent work with the maps and management of the database, and to Kathy Keane, Mike San Miguel and Kathy Molina for collection of field data.

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Appendix A
Maps Of Study Sites

The following two maps show the boundaries of the 40 long-term monitoring sites, as they were for the 2001 survey season (boundary modifications were made during the 1999, 2000, and 2001 survey efforts). The 2001 boundaries of the Nature Reserve of Orange County are shown in red.

Appendix B
Monitoring Site Areas 1999-2001
by Land Designation & Sub-Designation

The following five tables specify the hectares covered by each monitoring site during each year from 1999 to 2001. Many monitoring site boundaries expanded between 1999 and 2000, and a smaller number of changes were made in 2001; a few site boundaries contracted, as well. The following tables indicate the area covered by each monitoring site during each year of the study to date.

Table B1 – Breakdown of Core Sites

Site	Descriptive Name	Land Designation	Land Sub-Designation	Hectares 1999	2000	2001
Central Reserve Sites						
2	Weir Canyon Core	core	core	43.4	53.8	53.8
4	Limestone North	core	core	46.4	46.4	46.4
7	Limestone Southwest	core	core	21.4	21.4	21.4
8	Limestone Southeast	core	core	40.6	40.6	42.7
9	Cactus Wren Canyon	core	core	26.6	30.4	45.2
10	Hangman East	core	core	25.0	25.3	25.3
11	Round Canyon	core	core	36.5	36.5	36.5
13	Mustard Road	core	core	52.1	52.1	52.1
15	Upper Agua Chinon	core	core	47.8	47.8	47.8
16	Whiting North	core	core	29.1	29.1	29.1
			Subtotal	**368.9**	**383.4**	**400.3**
Coastal Reserve Sites						
23	Camarillo Spur	core	core	65.7	65.7	65.7
24	Shady Canyon South	core	core	25.8	25.8	25.8
29	Laurel Canyon	core	core	47.2	47.2	47.2
32	Upper Emerald Canyon	core	core	64.8	64.8	64.8
34	Bommer Ridge	core	core	135.8	139.7	140.5
35	Upper Wood Canyon	core	core	26.2	25.5	25.5
37	Lag. Wild. Park East Edge	core	core	22.1	34.4	34.4
38	Moro Ridge	core	core	38.8	50.6	55.6
39	El Moro Ranger Station	core	core	23.6	49.1	48.8
			Subtotal	**449.9**	**502.8**	**508.3**
			Grand Total	**818.8**	**886.2**	**908.6**

Table B2 – Breakdown of Edge Sites

Site	Descriptive Name	Land Designation	Land Sub-Designation	Hectares 1999	2000	2001
Central Reserve Sites						
1	Upper Weir Canyon	edge	residential edge	24.0	28.0	28.0
5	Hicks Canyon North	edge	road edge	31.4	31.4	31.4
6	Rattlesnake Canyon	edge	mixed edge	18.9	33.4	33.4
12	Siphon East	edge	road edge	26.0	26.0	26.0
14	ETC Toll Plaza	edge	road edge	26.6	26.6	25.7
17	Portola South	edge	mixed edge	18.5	18.5	18.5
18	Whiting South	edge	residential edge	18.0	18.0	18.0
			Subtotal	**163.4**	**181.9**	**181.0**
Coastal Reserve Sites						
21	Laguna Laurel North	edge	mixed edge	30.2	31.6	31.6
22	Shady Canyon North	edge	residential edge	31.8	49.1	49.1
25	Bommer Canyon West	edge	residential edge	20.4	29.7	29.7
26	Bommer Canyon North	edge	road edge	25.3	35.3	35.3
27	Laguna Laurel Southwest	edge	road edge	44.4	44.4	44.4
31	No Name Ridge	edge	residential edge	20.1	33.3	36.5
36	Lag. Wild. Park East Edge	edge	road edge	16.8	57.8	57.8
40	Alta Laguna	edge	residential edge	36.5	41.8	41.8
			Subtotal	**225.4**	**323.0**	**326.2**
			Grand Total	**388.8**	**504.9**	**507.2**

Table B3 – Breakdown of Fragment Sites

Site	Descriptive Name	Land Designation	Land Sub-Designation	Hectares 1999	2000	2001
Central Reserve Sites						
3	Peters Canyon	fragment	mixed edge	28.1	29.0	29.0
19	El Toro West	fragment	mixed edge	28.9	41.7	41.7
20	El Toro South	fragment	mixed edge	17.5	19.0	19.0
			Subtotal	**74.5**	**89.7**	**89.7**
Coastal Reserve Sites						
28	Northwest Sycamore Hills	fragment	road edge	23.1	39.5	39.5
30	Southeast Sycamore Hills	fragment	residential edge	29.6	60.2	60.2
33	Crystal Cove Shelf	fragment	mixed edge	19.5	20.1	20.1
			Subtotal	**72.2**	**119.8**	**119.8**
			Grand Total	**146.7**	**209.5**	**209.5**

Table B4 – Breakdown of Road Edge Sites

Site	Descriptive Name	Land Designation	Land Sub-Designation	Hectares 1999	2000	2001
Central Reserve Sites						
5	Hicks Canyon North	edge	road edge	31.4	31.4	31.4
12	Siphon East	edge	road edge	26.0	26.0	26.0
14	ETC Toll Plaza	edge	road edge	26.6	26.6	25.7
			Subtotal	**84.0**	**84.0**	**83.1**
Coastal Reserve Sites						
26	Bommer Canyon North	edge	road edge	25.3	35.3	35.3
27	Laguna Laurel Southwest	edge	road edge	44.4	44.4	44.4
28	Northwest Sycamore Hills	fragment	road edge	23.1	39.5	39.5
36	Lag. Wild. Park East Edge	edge	road edge	16.8	57.8	57.8
			Subtotal	**109.6**	**177.0**	**177.0**
			Grand Total	**193.6**	**261.0**	**260.1**

Table B5 – Breakdown of Residential Edge Sites

Site	Descriptive Name	Land Designation	Land Sub-Designation	Hectares 1999	2000	2001
Central Reserve Sites						
1	Upper Weir Canyon	edge	residential edge	24.0	28.0	28.0
18	Whiting South	edge	residential edge	18.0	18.0	18.0
			Subtotal	**42.0**	**46.0**	**46.0**
Coastal Reserve Sites						
22	Shady Canyon North	edge	residential edge	31.8	49.1	49.1
25	Bommer Canyon West	edge	residential edge	20.4	29.7	29.7
30	Southeast Sycamore Hills	fragment	residential edge	29.6	60.2	60.2
31	No Name Ridge	edge	residential edge	20.1	33.3	36.5
40	Alta Laguna	edge	residential edge	36.5	41.8	41.8
			Subtotal	**138.4**	**214.1**	**217.3**
			Grand Total	**180.4**	**260.1**	**263.3**

Table B6 – Breakdown of Mixed Edge Sites

Site	Descriptive Name	Land Designation	Land Sub-Designation	Hectares 1999	2000	2001
Central Reserve Sites						
3	Peters Canyon	fragment	mixed edge	28.1	29.0	29.0
6	Rattlesnake Canyon	edge	mixed edge	18.9	33.4	33.4
17	Portola South	edge	mixed edge	18.5	18.5	18.5
19	El Toro West	fragment	mixed edge	28.9	41.7	41.7
20	El Toro South	fragment	mixed edge	17.5	19.0	19.0
			Subtotal	**111.9**	**141.6**	**141.6**
Coastal Reserve Sites						
21	Laguna Laurel North	edge	mixed edge	30.2	31.6	31.6
33	Crystal Cove Shelf	fragment	mixed edge	19.5	20.1	20.1
			Subtotal	**49.7**	**51.7**	**51.7**
			GRAND TOTAL	**161.6**	**193.3**	**193.3**

Appendix C

Statistical Appendix by Karen Messer, Ph. D.