

TARGET BIRD MONITORING STUDY
NATURE RESERVE OF ORANGE COUNTY
2004

PREPARED FOR:



THE NATURE RESERVE OF ORANGE COUNTY
300 N. FLOWER STREET
SANTA ANA, CA 92703

CONTACT: LYN MCAFEE, EXECUTIVE DIRECTOR

PREPARED BY:

ROBERT A. HAMILTON
CONSULTING BIOLOGIST
34 RIVO ALTO CANAL
LONG BEACH, CA 90803

STATISTICAL ANALYSIS BY:

MARTHA WHITE, PH. D.
AND
KAREN MESSER, PH. D.

NOVEMBER 3, 2004

2257 B1 N29

RECEIVED

NOV 08 2004

USFWS
CARLSBAD FIELD OFFICE, CA

TABLE OF CONTENTS

Executive Summary	iv
I. Introduction	1
Nature Reserve of Orange County History	1
The NROC Biological Monitoring Program	1
II. Purpose and Objectives	2
Hypotheses to be Tested	2
III. Methods	3
Sampling Design	3
Sampling Period	5
Survey Personnel	5
Survey Methods	5
Data Adjustment Methods	6
IV. Results	10
Target Bird Territory Counts	10
Target Bird Territory Detection Rates	10
Brown-headed Cowbird Detections	25
Target Bird Habitat Composition & Structure	26
V. Discussion	33
Recent NROC Fire History	33
Analysis of Target Bird Population Levels as Related to Weather	33
Monitoring Avian Productivity and Survivorship (MAPS) Program, 1998-2003	
The Institute for Bird Populations	38
California Gnatcatcher and Cactus Wren Sampling	
Robert A. Hamilton	42
Brown-headed Cowbird Sampling	
Robert A. Hamilton	56
VI. Recommendations	56
Focused Evaluation of Coastal Reserve CACW Population	56
Statistical Analysis of Pilot Data for Years 1-6	57
Employ GIS to Capture Geographic Information from Each Site	59
Update and Incorporate Plant Community Information	60
Develop Data-Filtering Programs	60
VII. Report Preparers	61
VIII. Acknowledgments	61
IX. Literature Cited	61

LIST OF TABLES

A	Sampling Fractions	4
B	California Gnatcatcher Full & Partial Territories, 1999-2004	8
C	Cactus Wren Full & Partial Territories, 1999-2004	9
D	California Gnatcatcher Territory Detections, Sites 1-40, 1999-2004	11
E	Cactus Wren Territory Detections, Sites 1-40, 1999-2004	11
F	California Gnatcatcher Detection Rates, 1999	13
G	California Gnatcatcher Detection Rates, 2000	14
H	California Gnatcatcher Detection Rates, 2001	15
I	California Gnatcatcher Detection Rates, 2002	16
J	California Gnatcatcher Detection Rates, 2003	17
K	California Gnatcatcher Detection Rates, 2004	18
L	Cactus Wren Detection Rates, 1999	19
M	Cactus Wren Detection Rates, 2000	20
N	Cactus Wren Detection Rates, 2001	21
O	Cactus Wren Detection Rates, 2002	22
P	Cactus Wren Detection Rates, 2003	23
Q	Cactus Wren Detection Rates, 2004	24
R	Summary of Brown-headed Cowbird Detections, 1999-2004	25
S	Ranking of Dominant Plant Species in California Gnatcatcher Territories, 1999-2004 ...	27
T	Ranking of Dominant Plant Species in Cactus Wren Territories, 2000-2004	27
U	Estimated Cactus Cover in California Gnatcatcher & Cactus Wren Territories, 2002-2004	28
V	Mean Woody Vegetation Height in California Gnatcatcher Territories, 1999-2004	28
W	Mean Woody Vegetation Height in Cactus Wren Territories, 1999-2004	29
X	Absolute Woody Vegetation Cover in California Gnatcatcher Territories, 1999-2004 ...	29
Y	Absolute Woody Vegetation Cover in Cactus Wren Territories, 1999-2004	30
Z	California Gnatcatcher Territories Detected at 22 Three-visit Sites, 2000-2004	31
AA	Cactus Wren Territories Detected at 22 Three-visit Sites, 2000-2004	32
BB	Centimeters of Precipitation at Costa Mesa Station #165, 1998/99 to 2003/04	35
CC	California Gnatcatcher Detection Rates at "High Density" & "Low Density" Sites, 1999-2004	47
DD	Cactus Wren Detection Rates at "High Density" and "Low Density" Sites, 1999-2004 ...	54
EE	Example of Recommended Physical Site Data Table	59

LIST OF CHARTS

1	Power Curve, California Gnatcatcher Territories	59
---	---	----

APPENDICES

Appendix A Areal Breakdown of Monitoring Sites by Land Designation & Sub-Designation

Appendix B Statistical Appendix by Karen Messer, Ph. D.

EXECUTIVE SUMMARY

This report presents the methods, results, and analysis of the fifth year of ongoing monitoring of California Gnatcatcher (CAGN) and Cactus Wren (CACW) populations in the Nature Reserve of Orange County (NROC). The monitoring is conducted to satisfy the requirements of the Implementation Agreement for the Natural Communities Conservation Plan (NCCP) for Central and Coastal Orange County; it is funded by the NROC's monitoring endowment.

In the following summaries, the 95% confidence interval is given in parentheses.

CALIFORNIA GNATCATCHER RESULTS

It is estimated that the overall CAGN population increased 19% (14–25%) between 2003 and 2004. For the central reserve, the estimated one-year increase was 22% (14–30%), and for the coastal reserve the estimated one-year increase was 16% (7–26%). These increases are in line with the expectation, expressed in the Executive Summary to last year's annual report, that "CAGN populations should rebound strongly in spring 2004 (especially in high density habitat areas)."

From 1999 to 2004, it is estimated that the overall CAGN population declined 26% (17–35%). For the central reserve the estimated decrease was 33% (18–47%), and for the coastal reserve the estimate decrease was 17% (4–30%). These medium-term declines appear to be drought-related, as rainfall during the six years of this study has averaged 30% below the 47-year average, including a two-year drought (1998/99 and 1999/00) and the driest winter in recent memory (2001/02).

Extreme drought conditions led to very low productivity of scrub-dwelling passerines across the NROC in spring 2002 (DeSante et al. 2003a), and this caused the CAGN population to drop an estimated 30% (20–38%) between 2002 and 2003. With normal rainfall in 2002/03, productivity of scrub-dwelling passerines rebounded in 2003 (DeSante et al. 2003b), leading to the reserve-wide CAGN population increase documented herein.

The reserve-wide 2002/03 decline was concentrated in high-density populations, where raw territory counts dropped 35%, compared with a 14% decline in low density populations (95% confidence intervals not available for these estimates of population change). In 2004, CAGN territory counts increased by 25% in high density areas and only 12% in low density areas.

Precipitation in 2003/04 was 47% below average, and anecdotal observations of relatively few CAGN juveniles in spring 2004 lead to a prediction that CAGN populations across the NROC will be considerably lower in 2005 than in 2004. The magnitude of decline should depend, in part, on weather conditions in 2004/2005 (severe storms such as those already experienced in October 2004 may result in high adult mortality, particularly in the marginally suitable habitat areas that support CAGN at low density).

CACTUS WREN RESULTS

Following an estimated decline of 40% (35–44%) from 2002 to 2003, it is estimated that the overall CACW population increased 15% (13–18%) in 2004. This overall increase was comprised of an estimated 25% increase (21–30%) in the central reserve population and a 26% decrease (23–28%) in the coastal reserve population.

From 1999 to 2004, it is estimated that the overall CACW population declined 33% (28–37%).

The estimated decline in the central reserve was 26% (19–33%), while the coastal reserve's estimate decrease was 59% (54–63%). As discussed for CAGN, these general declines appear to be drought-related, although the very high rate of decline in the coastal reserve cannot be readily explained by drought effects alone.

The 2002/03 declines were similar in high-density and low-density populations (-37% and -43%, respectively). In 2004, CACW territory counts increased by 26% in high density areas but just 4% in low density areas. Unlike the seemingly explicable year-to-year patterns of change seen in the NROC's high-density and low-density CAGN populations, the changes in high-density and low-density CACW populations have not followed predictable patterns. This may be because any such patterns are being swamped by the coastal reserve's widespread decline.

The Laguna Beach Fire burned 75% of the coastal reserve. Surveys within the fire perimeter conducted in 1994 by Bontrager et al. (1995) revealed 72% fewer CACW pairs than were known from pre-fire surveys in 1992, and cactus scrub has not yet recovered significantly in the fire perimeter. It is possible that CACW are occupying fire-damaged cactus patches that are less than optimal for the species' survival and reproduction. If this is a relevant factor in the species' six-year decline, the situation should tend to improve over a period of many years as the cactus slowly recovers.

As reported above, the estimated number of CACW pairs in the coastal reserve has declined 59% since 1999, and from 2003 to 2004 the estimated population size declined 25% when a population increase had been expected (such single-year increases were recorded for CACW in the central reserve and for CAGN in both subregional reserves).

Finally, precipitation in 2003/04 was 47% below average, and anecdotal observations of relatively few CACW juveniles in spring 2004 lead to a prediction that CACW populations across the NROC will be lower in 2005 than in 2004. The magnitude of decline may depend, to some degree, on weather conditions in 2004/2005 (CACW are probably less vulnerable to winter weather than CAGN are, due to their larger body size and habit of building enclosed roost nests).

For the reasons outlined above, the coastal reserve CACW population is now considered to be of potential conservation concern. It is recommended that the NROC, USFWS, and CDFG survey the entire coastal reserve in spring 2005 to determine the actual number of CACW territories in the reserve, to identify the most heavily populated habitat areas, to closely evaluate the characteristics of occupied and unoccupied cactus scrub habitat areas, and to start developing a conservation strategy that will help to ensure the long-term viability of this vulnerable NROC target bird population.

BROWN-HEADED COWBIRD RESULTS

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 BHCO were detected during the 2004 monitoring effort, a result consistent with the previous years of this study, which have produced zero to few observations each year.

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 2004.

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 1999-2001 monitoring report reviewed the history of this monitoring effort back to its 1997 inception, when only six monitoring sites were monitored.

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 summarized 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 is in the range of 5-27%. 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	FRACTION OF TOTAL POPULATION	SITES RANDOMLY SELECTED (N)	SAMPLING RATE
CENTRAL	CORE	87	23.3%	10	11.5%
	EDGE	67	18.0%	7	10.4%
	FRAGMENT	20	5.4%	3	15.0%
COASTAL	CORE	101	27.1%	9	8.9%
	EDGE	73	19.6%	8	11.0%
	FRAGMENT	25	6.7%	3	12.0%

373

From 1999 to 2002, the boundaries of the selected sites were adjusted in the field to ensure (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) that 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)

The boundaries of Site No. 7 were almost completely revised in 2003 due to the unanticipated grading of a large part of this site by the County of Orange in order to stabilize landslides threatening the Frank Bowerman Landfill.

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 by Hamilton (2003a; Appendix B, 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 number of monitoring sites may be changed depending on the results of sample size analyses conducted at some point after the fifth year of data collection.

SAMPLING PERIOD

The sampling period extends from 1 March to 30 June.

SURVEY PERSONNEL

The 2004 surveys were conducted by Robert Hamilton and Mike San Miguel, who have conducted these surveys since 1999. 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.

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

Surveys are 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. Locations of all target bird sightings are mapped, and information on gender and group size (single, pair, or family group) and nesting stage (e.g., nest-building, nestlings, fledglings) is noted where possible. Standardized information is also taken on the vegetative composition of occupied habitat areas. Microsoft Access files, available from the lead author upon request, specify survey dates, areas, times and weather conditions for each survey.

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.

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.

NUMBER OF SURVEYS PER SITE

During the initial years of this study, the number of surveys conducted per site varied from year to year:

- ▶ In 1999, all 40 monitoring sites were visited once.
- ▶ In 2000, 16 sites were visited once, and the remaining 24 sites were visited thrice. Sites were chosen at random to be included in the three-visit protocol.
- ▶ In 2001, all sites were covered at least twice, and the 24 sites covered thrice in 2000 were again surveyed three times in 2001.
- ▶ In 2002 the same protocol was used as in 2001. However, since no target birds were detected at Sites 34 and 36 during the years 1999–2001, they were visited only twice in 2002; the third visit was shifted to Sites 20 and 30.
- ▶ In 2003 and 2004, survey coverage was identical to that in 2002.

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. Since this study uses two-visit data for computing target bird population trends, we have derived two-visit estimates for the sites visited only once 1999 and 2000; the methods for deriving these estimates are discussed subsequently.

DATA ADJUSTMENT METHODS

As addressed in the 1999–2001 report, we estimated that on average, at 95% confidence, the first two visits to a site will detect 90% of the territories that would be detected at three visits. Hence a two-visit data shall be used where available, with counts adjusted upward if only one visit occurred (i.e., for 1999 and 2000). 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.

Methods for Estimating Two-Round Counts – 1999 Data

In 1999, all 40 monitoring sites were visited once. Hamilton and San Miguel, who have completed most of the surveys during each year of the study, consider it likely that Round 1 detection rates were comparable (relatively high) in 1999 and 2000. Therefore, in order to permit comparisons between the 1999 detection rates and the two-visit rates obtained in later years of the study, we estimated Round 2 detection rates using a multiplier derived from the results of multiple-visit surveys conducted at 24 of the 40 sites in 2000.

For CAGN 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 CAGN detection rates for 1999 data.

For CACW 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 CACW detection rates for 1999 data.

Methods for Estimating Two-Round Counts – 2000 Data

In 2000, 24 sites were surveyed three times and the remaining 16 sites were surveyed once. We have used the 2000 data from the 24 multiple-visit sites to estimate Round 2 detection rates for the 16 sites that were covered only once during that year. As discussed in the previous section, this yields a 1.07 multiplier for CAGN and a 1.15 multiplier for CACW.

Methods for Estimating Population Sizes

In order to estimate numbers of target bird territories in each subregion, it is necessary to apply an adjustment factor to account for partial territories, which would be double-counted if monitoring sites were adjacent to each other. To accomplish this, Hamilton and San Miguel reviewed all of the data sheets and field maps (1999 to 2004) in August 2004, and assessed whether they considered it likely that each territory would be double-counted on a hypothetical adjacent sampling site. In future years of this study, this assessment will be made in the field at the time of the sighting. Partial territories count as 0.5 territory.

Whether this assessment is made at the time of the sighting or at a later time, the result is necessarily subjective and imprecise. This is because each pair would have to be followed for many hours on multiple days throughout the nesting season in order to map its full territory. Such an effort would be prohibitively expensive, and territory mapping is not required to address this study's population trend hypotheses, which were specified above. Nonetheless, reserve-wide estimates of target bird population sizes are desired, and adjusting for partial territories will increase the accuracy of these estimates. We have made our best effort at deriving a single, standardized "partial territory adjustment factor" for CAGN territories and another for CACW territories based on the cumulative results from 1999 to 2004 (see Tables B and C). Given that the basic determination of "full" or "partial" territories is unavoidably imprecise and subjective, more detailed adjustments – e.g., applying each year's adjustment factor separately – would not be appropriate.

METHODS FOR MAKING STATISTICALLY VALIDATED COMPARISONS

In years when statistical analyses are performed, a Poisson model is employed to make statistically validated comparisons between the results from 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.

In Tables F through Q, the final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS.

TABLE B – CALIFORNIA GNATCATCHER FULL & PARTIAL TERRITORIES, 1999–2004

These numbers represent two-round totals except for sites that were covered only once (all 40 sites in 1999; 16 sites in 2000).

			GROSS NUMBER OF TERRITORIES DETECTED													
RESERVE	LAND DESIGNATION (STRATUM)	NUMBER OF SITES SAMPLED	1999		2000		2001		2002		2003		2004		TOTAL	
			FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL
CENTRAL	CORE	10	1	6	1	3	0	3	1	4	1	2	1	2	5	20
	EDGE	7	36	14	25	5	29	8	37	12	24	5	27	10	178	54
	FRAGMENT	3	31	5	23	4	34	6	28	7	19	4	19	8	154	34
	TOTAL	20	68	25	49	12	63	17	66	23	44	11	47	20	337	108
COASTAL	CORE	9	8	6	2	2	5	5	5	6	4	10	7	3	31	32
	EDGE	8	17	10	8	2	14	11	14	8	14	3	21	5	88	39
	FRAGMENT	3	17	2	6	2	13	4	17	6	9	4	14	4	76	22
	TOTAL	20	42	18	16	6	32	20	36	20	27	17	42	12	195	93
GRAND TOTAL		40	110	43	65	18	95	37	102	43	71	28	89	32	532	201

Full territories count 1.0 and partial territories count 0.5.

Combined Six-Year Totals, Central Reserve Sites: 337 full + 108 partial = 445 territories (gross count)
337.0 + 54.0 = 391.0 territories (adjusted count)
391.0 ÷ 445 = 0.88 (adjustment factor for Central Reserve sites)

Combined Six-Year Totals, Coastal Reserve Sites: 195 full + 93 partial = 288 territories (gross count)
195.0 + 46.5 = 241.5 territories (adjusted count)
241.5 ÷ 288 = 0.84 (adjustment factor for Coastal Reserve sites)

Combined Six-Year Totals, all NROC Sites: 532 full + 201 partial = 733 territories (gross count)
532.0 + 101.5 = 633.5 territories (adjusted count)
633.5 ÷ 733 = 0.86 (adjustment factor for all NROC sites combined)

Sample Adjusted Totals for 1999 (using 0.86 as a uniform adjustment factor): Central Reserve = 717 ± 338; Coastal Reserve = 517 ± 256; NROC Total = 1234 ± 409

TABLE C – CACTUS WREN FULL & PARTIAL TERRITORIES, 1999–2004

These numbers represent two-round totals except for sites that were covered only once (all 40 sites in 1999; 16 sites in 2000).

RESERVE	LAND DESIGNATION (STRATUM)	NUMBER OF SITES SAMPLED	GROSS NUMBER OF TERRITORIES DETECTED													
			1999		2000		2001		2002		2003		2004		TOTAL	
			FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL	FULL	PARTIAL
CENTRAL	CORE	10	13	18	16	23	16	26	17	27	13	12	13	18	88	124
	EDGE	7	18	12	13	12	11	12	12	12	8	10	10	11	72	69
	FRAGMENT	3	4	0	4	0	1	0	3	0	1	0	3	1	16	1
	TOTAL	20	35	30	33	35	28	38	32	39	22	22	26	30	176	194
COASTAL	CORE	9	0	4	1	0	0	2	1	3	1	0	1	0	4	9
	EDGE	8	6	4	3	4	5	6	7	3	2	0	3	1	26	18
	FRAGMENT	3	1	1	2	2	3	0	3	3	4	2	3	0	16	8
	TOTAL	20	7	9	6	6	8	8	11	9	7	2	7	1	46	35
GRAND TOTAL		40	42	39	39	41	36	46	43	48	29	24	33	31	222	229

Full territories count 1.0 and partial territories count 0.5.

Combined Six-Year Totals, Central Reserve Sites: 176 full + 194 partial = 370 territories (gross count)
176.0 + 97.0 = 273.0 territories (adjusted count)
273.0 ÷ 370 = 0.74 (adjustment factor for Central Reserve sites)

Combined Six-Year Totals, Coastal Reserve Sites: 46 full + 35 partial = 81 territories (gross count)
46.0 + 17.5 = 63.5 territories (adjusted count)
63.5 ÷ 81 = 0.78 (adjustment factor for Coastal Reserve sites)

Combined Six-Year Totals, all NROC Sites: 222 full + 229 partial = 451 territories (gross count)
222.0 + 114.5 = 336.5 territories (adjusted count)
336.5 ÷ 451 = 0.75 (adjustment factor for all NROC sites combined)

Sample Adjusted Totals for 1999 (using 0.75 as a uniform adjustment factor): Central Reserve = 503 ± 135; Coastal Reserve = 131 ± 93; NROC Total = 634 ± 158

IV. RESULTS

TARGET BIRD TERRITORY COUNTS

Tables D and E specify the two-visit CAGN and CACW counts for each site for each year of the study. These counts form the basis for the analyses presented in this report.

TARGET BIRD TERRITORY DETECTION RATES

Tables F-L indicate the CAGN detection rates for each year from 1999 through 2004.

Tables M-Q specify the CACW detection rates for each year from 1999 through 2004.

TABLE D – CALIFORNIA GNATCATCHER TERRITORY DETECTIONS, SITES 1-40
1999-2004

Table D specifies the two-visit CAGN territory counts for each site for each year of the study; two-visit data projected from single-visit data are indicated in italics (see Pages 6-7).

SITE	SUB-STRATUM	2-VISIT COUNTS					
		1999	2000	2001	2002	2003	2004
CENTRAL RESERVE SITES							
1	RESIDENTIAL EDGE	6.42	1.07	1	2	2	4
2	CORE	0	0	0	1	1	0
3	MIXED EDGE (FRAGMENT)	14.98	16	28	18	12	12
4	CORE	0	0	0	0	0	0
5	ROAD EDGE	2.14	0	4	4	2	3
6	MIXED EDGE	14.98	11	8	11	5	9
7	CORE	0	0	0	0	0	0
8	CORE	0	0	0	0	0	0
9	CORE	0	0	0	0	0	1
10	CORE	0	0	0	0	0	0
11	CORE	3.21	3	2	3	2	1
12	ROAD EDGE	20.33	12	18	23	16	13
13	CORE	0	0	0	0	0	0
14	ROAD EDGE	7.49	4	5	7	4	7
15	CORE	2.14	1	2	1	0	1
16	CORE	2.14	0	0	0	0	0
17	MIXED EDGE	0	0	0	1	0	0
18	RESIDENTIAL EDGE	2.14	2	2	1	1	2
19	MIXED EDGE (FRAGMENT)	8.56	3.21	6	6	4	4
20	MIXED EDGE (FRAGMENT)	14.98	8.56	6	11	6	11
TOTAL - CENTRAL RESERVE		99.51	61.84	82	89	55	68
COASTAL RESERVE SITES							
21	MIXED EDGE	8.56	4.28	12	10	8	12
22	RESIDENTIAL EDGE	3.21	0	1	1	1	0
23	CORE	3.21	0	1	2	3	2
24	CORE	1.07	1	0	0	0	0
25	RESIDENTIAL EDGE	3.21	0	3	3	1	1
26	ROAD EDGE	10.70	5.35	8	6	5	8
27	ROAD EDGE	3.21	0	0	1	1	3
28	ROAD EDGE (FRAGMENT)	2.14	1	3	2	2	4
29	CORE	1.07	0	2	2	0	1
30	RESIDENTIAL EDGE (FRAGMENT)	4.28	0	1	3	2	5
31	RESIDENTIAL EDGE	0	1	1	1	0	1
32	CORE	1.07	0	0	0	0	0
33	MIXED EDGE (FRAGMENT)	13.91	7	13	18	9	9
34	CORE	0	0	0	0	0	0
35	CORE	2.14	1.07	0	1	2	1
36	ROAD EDGE	0	0	0	0	1	0
37	CORE	1.07	0	1	1	2	0
38	CORE	0	0	2	1	3	1
39	CORE	5.35	2	4	4	4	5
40	RESIDENTIAL EDGE	0	0	0	0	1	1
TOTAL - COASTAL RESERVE		64.20	22.70	52	56	45	54
TOTAL - NROC		163.71	84.54	134	145	100	122

TABLE E – CACTUS WREN TERRITORY DETECTIONS, SITES 1-40
1999-2004

Table E specifies the two-visit CACW territory counts for each site for each year of the study; two-visit data projected from single-visit data are indicated in italics (see Pages 6-7).

SITE	SUB-STRATUM	2-VISIT COUNTS					
		1999	2000	2001	2002	2003	2004
CENTRAL RESERVE SITES							
1	RESIDENTIAL EDGE	4.60	1.15	1	2	2	2
2	CORE	1.15	0	0	0	0	0
3	MIXED EDGE (FRAGMENT)	1.15	2	0	0	0	0
4	CORE	1.15	1	2	1	1	1
5	ROAD EDGE	1.15	2.30	1	0	0	1
6	MIXED EDGE	5.75	4	3	4	3	3
7	CORE	4.60	2	3	3	0	3
8	CORE	2.30	1.15	2	4	1	2
9	CORE	6.90	10	8	9	5	6
10	CORE	1.15	0	0	2	0	1
11	CORE	5.75	7	6	6	2	3
12	ROAD EDGE	6.90	6	7	6	4	5
13	CORE	3.45	6.90	4	4	3	3
14	ROAD EDGE	2.30	3	2	2	2	1
15	CORE	3.45	3	8	8	6	5
16	CORE	5.75	9	9	7	6	6
17	MIXED EDGE	4.60	2	4	4	4	5
18	RESIDENTIAL EDGE	9.20	7	5	6	4	5
19	MIXED EDGE (FRAGMENT)	1.15	1.15	0	1	0	2
20	MIXED EDGE (FRAGMENT)	2.30	1.15	1	2	1	2
TOTAL - CENTRAL RESERVE		74.75	69.80	66	71	44	56
COASTAL RESERVE SITES							
21	MIXED EDGE	3.45	3.45	4	4	1	1
22	RESIDENTIAL EDGE	1.15	1	2	2	1	0
23	CORE	1.15	0	0	1	0	0
24	CORE	1.15	0	0	0	0	0
25	RESIDENTIAL EDGE	5.75	2	2	2	1	1
26	ROAD EDGE	0	1.15	2	2	1	2
27	ROAD EDGE	1.15	0	1	0	0	0
28	ROAD EDGE (FRAGMENT)	1.15	2	0	3	2	1
29	CORE	0	0	0	0	0	0
30	RESIDENTIAL EDGE (FRAGMENT)	1.15	2.30	3	3	4	2
31	RESIDENTIAL EDGE	0	0	0	0	0	0
32	CORE	0	0	0	0	0	0
33	MIXED EDGE (FRAGMENT)	0	0	0	0	0	0
34	CORE	0	0	0	0	0	0
35	CORE	2.30	1.15	2	3	1	1
36	ROAD EDGE	0	0	0	0	0	0
37	CORE	0	0	0	0	0	0
38	CORE	0	0	0	0	0	0
39	CORE	0	0	0	0	0	0
40	RESIDENTIAL EDGE	0	0	0	0	0	0
TOTAL - COASTAL RESERVE		18.40	13.05	16	20	11	8
TOTAL - NROC		93.15	82.85	82	91	55	64

TABLE F – 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 (see Page 6).

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

		TERRITORIES			PERCENT OF	MEAN		MEAN TERRITORIES	PARTIAL	
	LAND	DETECTED	NUMBER	NUMBER OF	SUBREGIONAL	TERRITORIES		DETECTED PER SITE,	TERRITORY	ESTIMATED
RESERVE	DESIGNATION	(ROUND 2	OF SITES	20-HA SITES	RESERVE IN	DETECTED		WEIGHTED BY % OF	ADJUSTMENT	TOTAL
	(STRATUM)	PROJECTED)	SAMPLED	IN STRATUM	STRATUM	PER SITE		RESERVE IN STRATUM	FACTOR	TERRITORIES
CENTRAL	CORE	7.49	10	87	50.0%	0.75	65.2	0.37		
	EDGE	53.50	7	67	38.5%	7.64	51.08	2.94		
	FRAGMENT	38.52	3	20	11.5%	12.84	256.8	1.48		
	TOTAL	99.51	20	174	100.0%	4.98	832.98	4.79	0.86	717 ± 338
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	64.20	20	199	100.0%	3.21		3.02	0.86	518 ± 256
TOTAL		163.71	40	373		4.09		3.85	0.86	1235 ± 368

TABLE G – CALIFORNIA GNATCATCHER DETECTION RATES, 2000

These projected Round 2 detection rates should be used when comparing 2000 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 (see Page 7).

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

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	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	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	61.84	20	174	100.0%	3.09	2.92	0.86	437 ± 259
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	0.86	180 ± 141
TOTAL		84.54	40	373		2.11	1.92	0.86	617 ± 251

TABLE H – CALIFORNIA GNATCATCHER DETECTION RATES, 2001

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	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	82	20	174	100.0%	4.10	3.82	0.86	572 ± 365
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	0.86	415 ± 266
TOTAL		134	40	373		3.35	3.08	0.86	987 ± 365

TABLE I – CALIFORNIA GNATCATCHER DETECTION RATES, 2002

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	ESTIMATED TOTAL TERRITORIES
CENTRAL	CORE	5	10	87	50.0%	0.50	0.25		
	EDGE	49	7	67	38.5%	7.00	2.70		
	FRAGMENT	35	3	20	11.5%	11.67	1.34		
	TOTAL	89	20	174	100.0%	4.45	4.29	0.86	641 ± 367
COASTAL	CORE	11	9	101	50.8%	1.22	0.62		
	EDGE	22	8	73	36.7%	2.75	1.01		
	FRAGMENT	23	3	25	12.6%	7.67	0.97		
	TOTAL	56	20	199	100.0%	2.80	2.60	0.86	444 ± 280
TOTAL		145	40	373		3.63	3.38	0.86	1086 ± 383

TABLE J – CALIFORNIA GNATCATCHER DETECTION RATES, 2003

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	ESTIMATED TOTAL TERRITORIES
CENTRAL	CORE	3	10	87	50.0%	0.30	0.15		
	EDGE	30	7	67	38.5%	4.29	1.65		
	FRAGMENT	22	3	20	11.5%	7.33	0.84		
	TOTAL	55	20	174	100.0%	2.75	2.64	0.86	396 ± 252
COASTAL	CORE	14	9	101	50.8%	1.56	0.79		
	EDGE	18	8	73	36.7%	2.25	0.83		
	FRAGMENT	13	3	25	12.6%	4.33	0.55		
	TOTAL	45	20	199	100.0%	2.25	2.16	0.86	370 ± 183
TOTAL		100	40	373		2.50	2.39	0.86	766 ± 248

TABLE K – CALIFORNIA GNATCATCHER DETECTION RATES, 2004

See Page 7 for explanation of the “Partial Territory Adjustment Factor.”

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using “proc surveymeans” in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	ESTIMATED TOTAL TERRITORIES
CENTRAL	CORE	3	10	87	50.0%	0.30	0.15		
	EDGE	38	7	67	38.5%	5.43	2.09		
	FRAGMENT	27	3	20	11.5%	9.00	1.04		
	TOTAL	68	20	174	100.0%	3.40	3.28	0.86	490 ± 204
COASTAL	CORE	10	9	101	50.8%	1.11	0.56		
	EDGE	26	8	73	36.7%	3.25	1.19		
	FRAGMENT	18	3	25	12.6%	6.00	0.76		
	TOTAL	54	20	199	100.0%	2.70	2.51	0.86	430 ± 226
TOTAL		122	40	373		3.05	2.87	0.86	920 ± 269

TABLE L – 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 (see Page 6).

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2 PROJECTED)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	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	0.75	503 ± 135
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	0.75	132 ± 93
TOTAL		93.15	40	373		2.33	2.27	0.75	635 ± 159

TABLE M – CACTUS WREN DETECTION RATES, 2000

These projected Round 2 detection rates should be used when comparing 2000 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 (see Page 7).

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

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	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	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	69.80	20	174	100.0%	3.49	3.57	0.75	466 ± 177
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	0.75	89 ± 59
TOTAL		82.85	40	373		2.07	1.98	0.75	554 ± 168

TABLE N – CACTUS WREN DETECTION RATES, 2001

See Page 7 for explanation of the “Partial Territory Adjustment Factor.”

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using “proc surveymeans” in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	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	66	20	174	100.0%	3.30	3.40	0.75	444 ± 162
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	0.75	111 ± 74
TOTAL		82	40	373		2.05	1.98	0.75	555 ± 162

TABLE O – CACTUS WREN DETECTION RATES, 2002

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	ESTIMATED TOTAL TERRITORIES
CENTRAL	CORE	44	10	87	50.0%	4.40	2.20	0.75	474 ± 151
	EDGE	24	7	67	38.5%	3.43	1.32		
	FRAGMENT	3	3	20	11.5%	1.00	0.12		
	TOTAL	71	20	174	100.0%	3.55	3.64		
COASTAL	CORE	4	9	101	50.8%	0.44	0.23	0.75	140 ± 86
	EDGE	10	8	73	36.7%	1.25	0.46		
	FRAGMENT	6	3	25	12.6%	2.00	0.25		
	TOTAL	20	20	199	100.0%	1.00	0.94		
TOTAL		91	40	373		2.28	2.20	0.75	614 ± 158

TABLE P – CACTUS WREN DETECTION RATES, 2003

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	ESTIMATED TOTAL TERRITORIES
CENTRAL	CORE	24	10	87	50.0%	2.40	1.20		
	EDGE	19	7	67	38.5%	2.71	1.05		
	FRAGMENT	1	3	20	11.5%	0.33	0.04		
	TOTAL	44	20	174	100.0%	2.20	2.28	0.75	298 ± 116
COASTAL	CORE	1	9	101	50.8%	0.11	0.06		
	EDGE	4	8	73	36.7%	0.50	0.18		
	FRAGMENT	6	3	25	12.6%	2.00	0.25		
	TOTAL	11	20	199	100.0%	0.55	0.49	0.75	73 ± 50
TOTAL		55	40	373		1.38	1.33	0.75	371 ± 114

TABLE Q – CACTUS WREN DETECTION RATES, 2004

See Page 7 for explanation of the "Partial Territory Adjustment Factor."

The final column specifies the estimated total territories plus or minus a 95% confidence interval derived from weighted regression using "proc surveymeans" in SAS (see Page 7).

RESERVE	LAND DESIGNATION (STRATUM)	TERRITORIES DETECTED (ROUND 2)	NUMBER OF SITES SAMPLED	NUMBER OF 20-HA SITES IN STRATUM	PERCENT OF SUBREGIONAL RESERVE IN STRATUM	MEAN TERRITORIES DETECTED PER SITE	MEAN TERRITORIES DETECTED PER SITE, WEIGHTED BY % OF RESERVE IN STRATUM	PARTIAL TERRITORY ADJUSTMENT FACTOR	ESTIMATED TOTAL TERRITORIES
CENTRAL	CORE	30	10	87	50.0%	3.00	1.50		
	EDGE	22	7	67	38.5%	3.14	1.21		
	FRAGMENT	4	3	20	11.5%	1.33	0.15		
	TOTAL	56	20	174	100.0%	2.80	2.86	0.75	374 ± 113
COASTAL	CORE	1	9	101	50.8%	0.11	0.06		
	EDGE	4	8	73	36.7%	0.50	0.18		
	FRAGMENT	3	3	25	12.6%	1.00	0.13		
	TOTAL	8	20	199	100.0%	0.40	0.37	0.75	55 ± 40
TOTAL		64	40	373		1.60	1.53	0.75	428 ± 120

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 five years of this study, and this species is not a primary focus of the study, Table R presents these results in summary form. More detailed analyses of Brown-headed Cowbird data may be conducted in future years of this study, but only if the numbers detected increase sharply.

TABLE R – SUMMARY OF BROWN-HEADED COWBIRD DETECTIONS
1999–2004

RESERVE	LAND DESIGNATION/ SUB-DESIGNATION	SITES	99	00	01	02	03	04
CENTRAL	CORE	10	0	1	0	0	0	0
	EDGE & FRAGMENT	10	4	1	0	0	0	0
	ROAD EDGE	[3]	[0]	[0]	[0]	[0]	[0]	[0]
	RESIDENTIAL EDGE	[2]	[1]	[0]	[0]	[0]	[0]	[0]
	MIXED EDGE	[5]	[3]	[1]	[0]	[0]	[0]	[0]
	TOTAL	20	4	2	0	0	0	0
COASTAL	CORE	9	0	0	0	0	0	0
	EDGE & FRAGMENT	11	1	0	0	2	0	0
	ROAD EDGE	[4]	[0]	[0]	[0]	[0]	[0]	[0]
	RESIDENTIAL EDGE	[5]	[0]	[0]	[0]	[1]	[0]	[0]
	MIXED EDGE	[2]	[1]	[0]	[0]	[1]	[0]	[0]
	TOTAL	20	1	0	0	2	0	0
OVERALL	CORE	19	0	1	0	0	0	0
	EDGE & FRAGMENT	21	5	1	0	2	0	0
	ROAD EDGE	[7]	[0]	[0]	[0]	[0]	[0]	[0]
	RESIDENTIAL EDGE	[7]	[1]	[0]	[0]	[0]	[0]	[0]
	MIXED EDGE	[7]	[4]	[1]	[0]	[0]	[0]	[0]
	TOTAL	40	5	2	0	2	0	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 (these results appear to have little practical value and so are not reported here; please refer to the Access data base).

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 S and T list weighted average scores for dominant plant species in CAGN and CACW territories (1999 results are omitted for CACW, as some data were incorrectly collected). Round 1 results are reported for 2004. Species are listed in approximate order of abundance, and species ranking lower than 0.2 for a given year are denoted with "—".

TABLE S – RANKING OF DOMINANT PLANT SPECIES IN
CALIFORNIA GNATCATCHER TERRITORIES, 1999–2004

RESERVE	DOMINANT PLANTS	WEIGHTED AVERAGE SCORE					
		1999	2000	2001	2002	2003	2004
CENTRAL	<i>Artemisia californica</i>	3.3	3.2	3.3	3.6	3.5	3.6
	<i>Eriogonum fasciculatum</i>	2.1	2.2	1.7	2.0	2.3	1.7
	<i>Salvia mellifera</i>	1.1	1.6	1.6	1.4	1.3	1.6
	<i>Encelia californica</i>	0.5	0.6	1.1	0.2	1.1	0.7
	<i>Opuntia littoralis</i>	0.5	0.4	0.4	0.6	0.3	0.3
	<i>Malosma laurina</i>	0.6	—	0.3	0.4	0.2	0.2
	<i>Rhus integrifolia</i>	0.5	0.2	0.2	—	0.2	0.2
	<i>Baccharis salicifolia</i>	—	—	0.2	0.2	—	0.3
	<i>Baccharis pilularis</i>	—	—	—	0.2	—	0.3
	<i>Malacothamnus fasciculatus</i>	0.4	—	—	—	—	0.2
	<i>Sambucus mexicana</i>	0.7	—	—	—	—	—
COASTAL	<i>Artemisia californica</i>	3.7	3.5	2.5	3.5	3.3	3.5
	<i>Eriogonum fasciculatum</i>	2.1	1.2	1.1	1.8	2.1	1.5
	<i>Salvia mellifera</i>	0.9	1.0	0.3	1.0	0.8	0.4
	<i>Baccharis pilularis</i>	—	1.1	0.2	1.0	0.8	0.8
	<i>Mimulus aurantiacus</i>	0.6	1.0	1.0	0.5	0.4	0.6
	<i>Encelia californica</i>	0.4	0.7	—	—	0.9	0.2
	<i>Malosma laurina</i>	0.5	0.2	0.5	0.4	0.4	0.2
	<i>Rhus integrifolia</i>	0.3	0.3	—	0.3	0.3	0.5
	<i>Opuntia littoralis</i>	—	—	0.4	0.2	0.2	0.4
	<i>Sambucus mexicana</i>	0.3	—	—	—	0.2	0.2

TABLE T – RANKING OF DOMINANT PLANT SPECIES
IN CACTUS WREN TERRITORIES, 2000–2004

RESERVE	DOMINANT PLANTS	WEIGHTED AVERAGE SCORE				
		2000	2001	2002	2003	2004
CENTRAL	<i>Opuntia littoralis</i>	3.4	3.6	3.0	3.2	3.0
	<i>Artemisia californica</i>	1.5	1.8	2.0	2.1	2.7
	<i>Rhus integrifolia</i>	0.6	1.1	1.2	1.1	0.8
	<i>Malosma laurina</i>	0.8	0.5	0.6	0.7	0.6
	<i>Eriogonum fasciculatum</i>	0.6	0.8	0.6	0.6	0.6
	<i>Salvia mellifera</i>	0.2	0.4	0.6	0.5	0.6
	<i>Malacothamnus fasciculatus</i>	—	—	0.4	0.5	1.0
	<i>Lotus scoparius</i>	—	0.7	0.5	0.5	—
	<i>Sambucus mexicana</i>	0.2	0.3	0.2	0.4	0.4
	<i>Opuntia prolifera</i>	0.2	—	—	—	—
COASTAL	<i>Opuntia littoralis</i>	2.8	2.9	1.9	2.9	2.9
	<i>Artemisia californica</i>	2.5	2.3	2.6	2.8	3.0
	<i>Eriogonum fasciculatum</i>	1.9	1.8	2.2	1.8	1.8
	<i>Rhus integrifolia</i>	0.6	0.3	0.6	0.4	0.6
	<i>Malosma laurina</i>	0.2	0.6	0.4	0.4	—
	<i>Salvia mellifera</i>	0.2	0.5	0.4	0.4	—
	<i>Sambucus mexicana</i>	0.2	0.3	0.2	0.3	—
	<i>Opuntia prolifera</i>	0.4	0.3	—	—	—
	<i>Mimulus aurantiacus</i>	—	0.7	—	0.6	0.4
	<i>Baccharis pilularis</i>	—	—	—	—	1.1

↑
Final
EVENT?

Estimated Cactus Cover

In 2002–2004, areal cover of cactus in each target territory was attributed to one of five cover classes (0%; 1–10%; 11–25%; 26–50%; >50%). Table U specifies the percentage of territories within each cover class. Round 1 data were used in 2004.

TABLE U – ESTIMATED CACTUS COVER IN
CALIFORNIA GNATCATCHER & CACTUS WREN TERRITORIES, 2002–2004

RESERVE	ESTIMATED CACTUS COVER	CALIFORNIA GNATCATCHER			CACTUS WREN		
		2002	2003	2004	2002	2003	2004
CENTRAL	0%	27%	48%	45%	0%	0%	0%
	1–10%	54%	43%	40%	29%	33%	43%
	11–25%	14%	9%	15%	48%	43%	39%
	26–50%	5%	0%	0%	20%	25%	18%
	>50%	0%	0%	0%	3%	0%	0%
		(n=76)	(n=44)	(n=62)	(n=56)	(n=40)	(n=44)
COASTAL	0%	59%	58%	49%	0%	0%	0%
	1–10%	35%	36%	41%	29%	11%	25%
	11–25%	6%	6%	10%	65%	78%	38%
	26–50%	0%	0%	0%	6%	11%	38%
	>50%	0%	0%	0%	0%	0%	0%
		(n=49)	(n=36)	(n=49)	(n=17)	(n=9)	(n=8)

Mean Woody Vegetation Height

In 1999–2004, mean height of woody plants within each territory was estimated as: 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, or >2.5m. Tables V and W specify the percentage of territories within each cover class. Round 1 data were used in 2004.

TABLE V – MEAN WOODY VEGETATION HEIGHT IN
CALIFORNIA GNATCATCHER TERRITORIES, 1999–2004

RESERVE	ESTIMATED MEAN PLANT HEIGHT (M)	PERCENT OF TERRITORIES					
		1999	2000	2001	2002	2003	2004
CENTRAL	0.5	11%	7%	10%	0%	2%	0%
	1.0	73%	74%	80%	82%	86%	71%
	1.5	15%	17%	10%	18%	11%	29%
	2.0	1%	2%	0%	0%	0%	0%
	2.5	0%	0%	0%	0%	0%	0%
	>2.5	0%	0%	0%	0%	0%	0%
		(n=93)	(n=58)	(n=70)	(n=76)	(n=44)	(n=62)
COASTAL	0.5	23%	5%	0%	0%	0%	0%
	1.0	55%	70%	64%	73%	67%	61%
	1.5	20%	25%	36%	27%	28%	39%
	2.0	2%	0%	0%	0%	3%	0%
	2.5	0%	0%	0%	0%	3%	0%
	>2.5	0%	0%	0%	0%	0%	0%
		(n=60)	(n=20)	(n=39)	(n=49)	(n=36)	(n=49)

TABLE W – MEAN WOODY VEGETATION HEIGHT
IN CACTUS WREN TERRITORIES, 1999–2004

RESERVE	ESTIMATED MEAN PLANT HEIGHT (M)	PERCENT OF TERRITORIES					
		1999	2000	2001	2002	2003	2004
CENTRAL	0.5	13%	13%	9%	4%	3%	2%
	1.0	41%	32%	40%	50%	48%	23%
	1.5	33%	47%	47%	41%	35%	66%
	2.0	13%	8%	2%	2%	15%	7%
	2.5	0%	0%	0%	2%	0%	2%
	>2.5	0%	0%	2%	2%	0%	0%
		(n=64)	(n=60)	(n=47)	(n=56)	(n=40)	(n=44)
COASTAL	0.5	6%	0%	0%	0%	0%	0%
	1.0	50%	73%	69%	71%	78%	50%
	1.5	38%	27%	31%	29%	22%	50%
	2.0	6%	0%	0%	0%	0%	0%
	2.5	0%	0%	0%	0%	0%	0%
	>2.5	0%	0%	0%	0%	0%	0%
		(n=16)	(n=11)	(n=13)	(n=17)	(n=9)	(n=8)

Absolute Vegetative Cover

From 1999–2004, 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 X and Y specify the percentage of territories within each cover class. Round 1 data were used in 2004.

TABLE X – ABSOLUTE WOODY VEGETATION COVER IN
CALIFORNIA GNATCATCHER TERRITORIES, 1999–2004

RESERVE	ESTIMATED WOODY COVER	PERCENT OF TERRITORIES					
		1999	2000	2001	2002	2003	2004
CENTRAL	0–20%	0%	0%	0%	0%	0%	0%
	21–40%	1%	5%	4%	0%	0%	0%
	41–60%	2%	16%	7%	12%	18%	8%
	61–80%	22%	26%	30%	28%	36%	31%
	81–100%	75%	53%	59%	60%	45%	61%
		(n=93)	(n=58)	(n=70)	(n=76)	(n=44)	(n=62)
COASTAL	0–20%	0%	0%	0%	0%	0%	0%
	21–40%	3%	0%	0%	4%	3%	2%
	41–60%	22%	5%	8%	10%	14%	14%
	61–80%	45%	25%	36%	37%	33%	20%
	81–100%	30%	70%	56%	49%	50%	63%
		(n=60)	(n=20)	(n=39)	(n=49)	(n=36)	(n=49)

TABLE Y – ABSOLUTE WOODY VEGETATION COVER
 IN CACTUS WREN TERRITORIES, 1999–2004

RESERVE	ESTIMATED WOODY COVER	PERCENT OF TERRITORIES					
		1999	2000	2001	2002	2003	2004
CENTRAL	0–20%	5%	23%	2%	2%	3%	0%
	21–40%	16%	11%	28%	11%	23%	9%
	41–60%	19%	8%	19%	25%	28%	35%
	61–80%	14%	23%	21%	25%	20%	19%
	81–100%	47%	34%	30%	38%	28%	37%
		(n=64)	(n=61)	(n=47)	(n=56)	(n=40)	(n=43)
COASTAL	0–20%	0%	0%	0%	0%	0%	0%
	21–40%	0%	9%	9%	0%	0%	0%
	41–60%	13%	9%	9%	6%	11%	13%
	61–80%	56%	27%	27%	35%	33%	38%
	81–100%	31%	55%	55%	59%	56%	50%
		(n=16)	(n=11)	(n=11)	(n=17)	(n=9)	(n=8)

RESULTS OF MULTIPLE-VISIT SURVEYS

In 2000, 2001, 2002, 2003, and 2004, three rounds of surveys were conducted at 24 long-term monitoring sites. Tables Z and AA specify the cumulative number of territories detected at 22 of these sites. No target birds were detected at Sites 34 and 36 in 1999 to 2001, so they were visited only twice in 2002; the third visit was shifted to Sites 20 and 30, which were covered only twice in 2000 and 2001.

TABLE Z — CALIFORNIA GNATCATCHER TERRITORIES
DETECTED AT 22 THREE-VISIT SITES, 2000–2004

SITE	ROUND 1 COUNT					ROUND 2 COUNT					ROUND 3 COUNT				
	00	01	02	03	04	00	01	02	03	04	00	01	02	03	04
3	16	24	16	9	12	16	23	14	11	7	16	20	12	7	6
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	11	8	8	5	7	8	5	10	5	8	9	5	7	5	7
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
11	3	2	3	2	0	1	1	2	0	1	2	1	1	1	0
12	11	13	22	16	12	9	18	21	12	13	10	16	21	13	7
14	3	4	4	4	7	4	5	7	3	7	6	3	6	4	8
15	1	1	0	0	1	1	1	1	0	0	1	0	0	0	1
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0
18	2	2	1	0	2	0	1	0	1	1	1	2	0	1	1
22	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0
24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	3	2	1	0	0	0	3	1	1	0	2	2	0	0
28	1	2	0	2	4	0	2	2	2	3	1	1	1	1	1
31	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	6	12	15	7	9	6	13	16	9	8	6	17	13	9	9
37	0	1	1	2	0	0	0	0	1	0	0	0	0	0	0
38	0	1	1	3	1	0	2	1	3	0	0	1	0	3	1
39	2	2	4	4	5	2	3	5	3	4	1	4	6	3	4
Visit Total	57	77	80	56	62	48	75	84	52	53	53	73	71	48	45
% of 3-V. Tot.	88%	79%	80%	90%	91%	74%	77%	84%	84%	78%	82%	74%	71%	77%	66%
Cumul. Tot.	57	77	80	56	62	61	93	97	62	67	65	98	100	62	68
% of 3-V. Tot.	88%	79%	80%	90%	91%	94%	95%	97%	100%	99%	100%	100%	100%	100%	100%

Within a given round of surveys, 66–91% of the three-visit total was detected. Relatively high variance is the main reason why a single-visit protocol is inadequate to meet the study objectives.

By Round 2, 94–100% of the three-visit total was detected. Because a high proportion of CAGN territories is detected with low inter-annual variance, a two-visit protocol appears to be adequate to meet the study objectives (cf. Hamilton 2003a,b).

TABLE AA — CACTUS WREN TERRITORIES
DETECTED AT 22 THREE-VISIT SITES, 2000–2004

SITE	ROUND 1 COUNT					ROUND 2 COUNT					ROUND 3 COUNT				
	00	01	02	03	04	00	01	02	03	04	00	01	02	03	04
3	2	0	0	0	0	2	0	0	0	0	2	0	1	0	0
4	1	2	1	1	1	1	1	1	1	0	1	2	1	1	0
6	4	3	4	3	3	2	3	4	2	3	3	3	3	3	2
7	2	3	3	0	2	2	2	1	0	3	2	2	2	0	1
9	10	7	9	5	5	10	5	7	4	4	9	5	7	4	3
11	6	4	4	1	3	7	5	5	2	2	4	3	4	2	1
12	5	4	6	4	5	6	6	4	4	3	5	6	6	5	4
14	1	1	2	1	0	3	2	1	2	1	2	2	2	1	1
15	2	5	8	5	5	2	7	5	3	4	3	4	5	3	3
16	8	3	7	5	6	9	8	7	6	5	8	5	6	6	5
17	2	2	4	4	5	2	3	4	4	3	3	3	3	4	3
18	6	4	5	4	3	6	5	5	4	5	5	4	5	3	3
22	0	2	2	1	0	1	1	2	1	0	1	1	2	0	0
24	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
25	2	2	2	1	1	2	2	1	1	1	1	2	2	1	1
28	2	0	2	2	1	0	0	3	1	0	1	2	2	1	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total This Visit	53	42	60	37	40	55	50	50	35	34	50	44	51	34	27
% of 3-V. Tot.	85%	66%	92%	86%	89%	89%	78%	77%	81%	76%	81%	69%	78%	79%	60%
Cumul. Tot.	53	42	60	37	40	61	61	63	41	45	62	64	65	43	45
% of 3-V. Tot.	85%	66%	92%	86%	89%	98%	95%	97%	95%	100%	100%	100%	100%	100%	100%

Within a given round of surveys, 60–92% of the three-visit total was detected. Relatively high variance is the main reason why a single-visit protocol is inadequate to meet the study objectives.

By Round 2, 95–100% of the three-visit total was detected. Because a high proportion of territories is detected with low inter-annual variance, a two-visit protocol appears to be adequate to meet the study objectives (cf. Hamilton 2003a,b).

V. DISCUSSION

This section analyzes and discusses data gathered during the first six years of the target bird study, and other relevant information.

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 (see 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. On 12 August 2003 an arsonist set fire to approximately 15 acres of the 72-acre monitoring site at Peters Canyon Regional Park, impacting approximately 20% of the site that has consistently supported the highest density of CAGN (no substantial cactus patches were affected). The effects of recent NROC fires on cactus and coastal sage scrub in general are discussed in later subsections of this report.

ANALYSIS OF TARGET BIRD POPULATION LEVELS AS RELATED TO WEATHER

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 review target bird survey results with reference to weather conditions.

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,

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

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

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 during the "egg-formation period" 30 to 90 days before clutch completion (mean estimated clutch completion date was 6 May $\pm$ 22 days).

DeSante et al. (2001, 2002, 2003a, 2003b) 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 this 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.

Table BB summarizes precipitation at Costa Mesa hydrological station #165. This information is now available by request from the Orange County Public Resources and Facilities Department at <http://www.oc.ca.gov/pfrd/envres/rainfall/intro.asp>; e-mail bryan.pastor@pfrd.ocgov.com. The 1999–2001 report (Hamilton 2003a) included information from Costa Mesa hydrological station #219, which goes back only to 1978/79, whereas data from #165 goes back to 1955/56. It is recommended that data from station #165 be used in the future. Table BB provides monthly totals for each year of the target bird study, and also shows the 6-year and 49-year averages.

In considering the long-term declines in target bird populations over the six years of this study (discussed year-by-year below), note that annual precipitation averaged only 21.60 cm during this period – 30% below the 49-year mean of 30.91 cm. As discussed subsequently, the NROC's MAPS program documented broad declines among most of the NROC's scrub-dwelling bird populations during this period. While the results of this study strongly suggest that this six-year drought has played a major role in the decline of CAGN and CACW populations during this period, it should also be noted that most of the rainfall has been concentrated in Patten and Rotenberry's three-month "egg-formation period" of February–April. The six-year average of 13.42 cm for this period is only 8% below the 49-year average of 14.63 cm. In contrast, the six-year average of 6.89 cm for November–January is 41% below the 49-year average of 13.98 cm. Since February–April rainfall is positively correlated with CAGN (and probably CACW) productivity, and severe winter storms are hypothesized to kill off adult birds, target bird declines might have been even more dramatic if precipitation during this period had occurred more during the coldest winter months and less during the period when birds were forming eggs and feeding young.

TABLE BB – CENTIMETERS OF PRECIPITATION AT COSTA MESA STATION #165
1998/99 TO 2003/04

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

SEASON	MONTH												TOTAL
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	
98/99	0.00	0.00	0.13	0.00	3.12	2.36	2.79	1.75	3.00	3.48	0.00	0.25	16.88
99/00	0.15	0.00	0.00	0.00	0.46	0.00	1.60	8.08	4.78	3.23	0.00	0.00	18.30
00/01	0.00	0.00	0.51	4.47	0.00	0.00	11.00	14.86	1.63	1.32	0.10	0.00	33.89
01/02	0.00	0.00	0.00	0.00	3.12	2.87	1.24	0.89	1.96	0.69	0.08	0.00	10.85
02/03	0.00	0.00	0.00	0.13	3.00	5.66	0.00	10.97	8.64	3.23	1.83	0.00	33.46
03/04	0.15	0.00	0.00	0.00	1.07	2.11	0.89	9.78	1.37	0.86	0.00	0.00	16.23
6-YEAR AVG.	0.05	0.00	0.11	0.77	1.80	2.17	2.92	7.72	3.56	2.14	0.34	0.04	21.60
49- YEAR AVG.	0.05	0.13	0.56	0.69	3.35	4.11	6.52	6.81	5.41	2.41	0.48	0.15	30.91

Weather Effects, 1998/99

The seasonal total of 16.9 cm was just 55% of the station's 49-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 3 cm. February–April rainfall was 44% below the 48-year average, with February–March rainfall being 61% below average.

Below-average rainfall spread evenly through the winter and early spring months, and a lack of severe storms, probably 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 almost certainly contributed to very low productivity of passerine birds using coastal sage in spring/summer 1999 (see the subsequent discussion of 1999 MAPS results).

Weather Effects, 1999/00

The seasonal total of 18.3 cm was just 59% of the station's 49-year average. Only 2.2 cm fell between 1 July and 10 February, and coming on the heels of the previous winter's drought 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 season's total (7.8 cm) fell 11–24 February, including 5.1 cm during the period 21–24 February; rainfall during the February–April egg-formation period was 10% above average.

The culling of adult populations in winter 1999/00 combined with slightly above-average rainfall February–April probably combined to produce better-than-average nesting conditions for the surviving birds. Indeed, as discussed subsequently, the MAPS program documented a 256%

increase in productivity of coastal sage scrub bird species (proportion of young in the catch) at the four bird-banding stations operated in 1999 and 2000.

Weather Effects, 2000/01

The seasonal total of 33.9 cm was 110% of the 49-year average. November and December were dry, while January–February rainfall represented 186% of the average, with three fairly heavy storms: 9–13 January (8.6 cm), 10–14 February (7.6 cm), and 23–28 February (6.9 cm). It seems likely that some storm-related mortality of CAGN occurred during these events, which would have offset to some degree the relatively high productivity of scrub-nesting birds in spring/summer 2000 (documented by the MAPS program). Also, 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.

Rainfall during the February–April 2001 egg-formation period was 21% 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. As discussed subsequently, bird-banding at six MAPS stations documented a 13% increase in productivity of coastal sage scrub bird species (proportion of young in the catch) in 2001 vs. 2000.

Weather Effects, 2001/02

With total rainfall measuring just 10.8 cm, 2001/02 ranks as the driest year in four decades (9.5 cm was recorded at station #165 in 1960/61). Precipitation for the year was 35% of the 49-year average, and 3.5 cm recorded during the February–April egg-formation period was just 24% of average. No severe winter storms occurred (the heaviest, 30–31 December, brought only 1.3 cm), meaning that little or no storm-related mortality was likely to have occurred. Thus, following two years of relatively high productivity for coastal sage scrub birds in the NROC, and presumably low winter mortality in 2001/02, songbird populations in spring/summer 2002 were expected to be somewhat higher than they were in spring/summer 2001. The results reported here for CAGN and CACW populations in the NROC are consistent with this prediction.

As reported subsequently, the 2002 MAPS report (DeSante et al. 2003a) found that the NROC's coastal sage scrub bird populations experienced >95% reduction in productivity (proportion of young in the catch) in 2002 compared with 2001. Near-total reproductive failure was also reported among monitored populations of coastal sage scrub birds in San Diego County (Michael A. Patten, pers. comm.).

In the target bird study, numbers of juvenile CAGN and CACW have been recorded when they are detected, but no special effort has been made to obtain accurate counts of the numbers of young in each family group. As a gross measure of the magnitude of target bird population declension, 24 juvenile CAGN and 3 juvenile CACW were detected in 2002 compared with 90 juvenile CAGN and 33 juvenile CACW in 2001 (includes all survey days). Thus, the count of juvenile CAGN decreased by 77% and the count of juvenile CACW decreased by 91% even as the estimated reserve-wide adult populations of these species experienced modest increases.

Weather Effects, 2002/03

Owing to the dramatic productivity crash discussed above, the 2003 target bird populations were predicted to be considerably lower than in 2002 (Hamilton 2003b), and this was indeed the case. The total of 33.5 cm in 2002/03 was 108% of the 49-year average, with the heaviest storms dropping 6.5 cm (11–13 February) and 8.2 cm (23 March). While these storms were moderately heavy (especially the latter one), rainfall was generally well distributed through the rainy season (26 October–11 May). A more severe winter on top of such a poor reproductive effort could have resulted in greater mortality, and hence a more serious nadir in the populations of both target bird species.

As noted previously, numbers of juvenile CAGN and CACW have been recorded when they are detected, but no special effort has been made to obtain accurate counts of the numbers of young in each family group. As a gross measure of the rebounding of target bird productivity, 72 juvenile CAGN and 30 juvenile CACW were detected in 2003 compared with 24 juvenile CAGN and 3 juvenile CACW in 2002 (includes all survey days). Thus, the count of juvenile CAGN increased by 300% and the count of juvenile CACW increased by 1000% even as the estimated reserve-wide adult populations of these species declined by 29% and 40%, respectively.

Weather Effects, 2003/04

The seasonal total of 16.23 cm was 53% of the 49-year average, with virtually all of the precipitation occurring 1 November–18 April. The season's only major storm (6.0 cm on 26 February) dropped 37% of the year's total. It is expected that severe storms kill off some target birds, but the substantial reserve-wide increase of CAGN from 2003 to 2004 indicates that large numbers of even the smallest birds were able to survive. Compared with CAGN, CACW should be relatively well equipped to withstand bad weather due to the latter species' larger body size and habit of building enclosed roost nests that offer protection from rain and cold.

After above-average precipitation in 2002/03 led to a rebounding of productivity for the NROC's scrub-dwelling birds in spring 2003 (DeSante et al. 2003b), populations of both CAGN and CACW were expected to rebound strongly in spring 2004 (Hamilton 2003c). This expectation was realized across the NROC for CAGN (22% adult population increase in the central reserve, 16% increase in the coastal reserve) and for CACW in the central reserve (26% increase). The coastal reserve CACW population, however, continued its long-term decline, dropping an estimated 25% from 2003 to 2004. Given (a) that the estimated size of the central reserve CACW population increased 26% from 2003 to 2004, and (b) that CAGN populations increased across the NROC reserve system from 2003 to 2004, CACW in the coastal reserve appear to comprise a population of conservation concern.

As reported by DeSante (2003b), and as summarized on page 42 of this report, populations of 13 of 15 scrub-dwelling bird species have undergone decline across the NROC over the past several years. Since 1999, the population estimate for CAGN has declined 33% in the central reserve and 17% in the coastal reserve. Over the same period, the population estimate for CACW has decreased 26% in the central reserve and 59% in the coastal reserve. Thus, over the past six years, the coastal reserve CACW population is estimated to have declined at more than double the rate of decline for the central reserve CACW population, and at a rate two to three times greater than CAGN populations in these reserves. This is another piece of evidence indicating that this population warrants focused attention from reserve managers.

Rainfall during the February–April egg-formation period was 18% below average. The combined total for March and April was 71% below average for these two critical months, and no rain fell in May or June (mean May/June precipitation is 0.63 cm over the past 49 years). From these precipitation figures, one could predict that target bird productivity was again depressed in 2004, a situation that normally leads to declines in adult counts the following spring. As noted previously, numbers of juvenile CAGN and CACW have been recorded when they are detected, but no special effort has been made to obtain accurate counts of the numbers of young in each family group. As a gross measure of the single-year decline in target bird productivity, 66 juvenile CAGN and 11 juvenile CACW were detected in 2004 compared with 72 juvenile CAGN and 30 juvenile CACW in 2003 (includes all survey days). Thus, the count of juvenile CAGN decreased by 8% and the count of juvenile CACW decreased by 43% even as the estimated reserve-wide adult populations of these species increased by 19% and 15%, respectively. For this reason, it is expected that populations of CAGN and especially CACW will be lower in 2005 than in 2004, with the magnitude of decline depending in part on weather conditions in 2004/2005.

MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP (MAPS) PROGRAM, 1998–2003 THE INSTITUTE FOR BIRD POPULATIONS

Two MAPS constant-effort mist-netting 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 in the NROC. Four more were added in 2001 and 2002, for a total of 10 stations, but these were dropped back in 2003, when only six stations were operated, and the program was suspended for the 2004 nesting season. The original monitoring goal had been to operate 12 stations in the NROC.

Although CAGN and CACW are captured at very low rates at the NROC's MAPS stations, it was useful to compare target bird population trends determined by the target bird monitoring study with productivity and survivorship data that the MAPS program collected for a suite of scrub-dwelling passerines from 1998 to 2003. 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 2003, see DeSante et al. (2003b).

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 fol-

lowed 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.

2002 MAPS Results

The following information is summarized from the 2002 annual report prepared by DeSante et al. (2003a).

Overshadowing all other results in 2002 was documentation of a nearly complete reproductive failure at the NROC MAPS stations, the likes of which have not been recorded within the MAPS program since its inception in 1989. No young were captured at any of the ten NROC MAPS stations for 29 of 39 species for which at least one adult was captured. Furthermore, only 54 young birds were captured at all stations combined in 2002 (compared to 983 in 2001), and 25 of these 54 were young House Finches. Mean productivity for all stations combined was just 0.04, the lowest ever recorded at a MAPS location, and ranged from 0.00 at Irvine Park to 0.09 at Upper Weir Canyon. Thus, this reproductive failure was both region wide and species wide.

Examination of weather data indicates that the extremely dry conditions experienced in southern California during the winter and early spring were likely related to this reproductive failure. Only 0.93 inches of rain fell at the San Diego Airport during December 2001–February 2002, representing the lowest such 3-month total in the past 100 years. Such extremely dry conditions prohibit growth of vegetative matter and result in a paucity of insect and other vegetative and invertebrate prey resources that landbirds need to feed their young. Adults were also likely to have been in poor reproductive condition due to the lack of food.

According to multivariate analyses including terms for year, geographic location, landscape, and station, there was little variation in numbers of adults captured by year, although for Bush-tit and Wrentit adults captured in 2002 were significantly higher than those captured in 2000. Numbers of adults captured also did not vary greatly by geographic location, except for expected differences; e.g., inland species such as Bewick's Wren, House Wren, Rufous-crowned Sparrow showed higher breeding populations in the central reserve and coastal species such as Orange-crowned Warbler, Common Yellowthroat, Spotted Towhee, and Song Sparrow showed higher breeding populations in the coastal reserve. There was also only slight variation in adults captured according to landscape (core, road-edge, and housing development stations), and differences among stations were also generally slight, and largely reflected differences in geographic location and/or landscape.

Adult population sizes have generally declined during 1999–2002 at NROC. Population trends for 11 of 14 species showed declines. For nine species and all species pooled, population trends showed substantial decreases, with those of Spotted Towhee, Orange-crowned Warbler, and Song Sparrow showing significant or near-significant declines. By contrast, only three species showed increases, and these were all non-substantial. Populations generally drop after years of poor productivity so it is likely that these declines will become more widespread and severe with the inclusion of 2003 data. Four-year productivity trends generally showed erratic fluctuations, but no substantial trend. Many species showed lower productivity in 1999, higher productivity in 2000 and 2001, and extremely low productivity in 2002, thus showing overall declines.

Between-year changes in adult breeding populations and productivity generally followed the opposite pattern during the period 1999–2002 in the NROC, culminating in significant increase in breeding populations in 2002 but a highly significant decrease in productivity. This alternating population dynamic has been noted at other MAPS stations, and we believe it relates to density-dependent effects on productivity and recruitment along with lower productivity of first-time breeders. Of concern is that this pattern has also been superimposed upon a general decline in populations, which will very likely become more widespread and severe in 2003 based on the reproductive failure of 2002. Disruptions of this alternating cycle at other MAPS stations have generally appeared to be related to unusually favorable or unfavorable weather or to pronounced changes in the environment. In this respect we might expect the severe drought conditions of the winter of 2001–2002 at NROC to disrupt this cycle, although the resultant poor

productivity occurred during a year (2002) when low productivity was already expected based on higher breeding populations. Based on both rainfall totals and the above-described population dynamic, we can now predict better productivity in 2003, which will hopefully cause breeding populations eventually to rebound at NROC.

2003 MAPS Results

The following information is summarized from the 2003 annual report prepared by DeSante et al. (2003b).

Instead of 10 MAPS stations, as in 2002, IBP operated six MAPS stations on NROC in 2003, at the same locations where they were operated during the previous four (4 stations) or three (2 stations) years. A total of 2043 captures of 51 species was recorded in 2003 during 3234.2 net-hours of operation. Following the nearly complete, region-wide and species-wide reproductive failure at NROC during 2002, the 2003 season was notable in two respects: adult population sizes declined significantly, and productivity rebounded dramatically. The decline in breeding populations was especially severe among permanent resident species that likely experience less recruitment from more distant sources than do migratory species. The 2003 decline resulted in 13 of 15 species showing 5-year population declines, of which those for six species and all species pooled were substantial. The 2003 increase in productivity was also region-wide and species-wide, and again occurred most dramatically in resident species. It resulted in 11 of 15 species showing positive 5-year productivity trends, although most were widely fluctuating rather than substantial.

Using five years of data, IBP obtained survival estimates for eight target species from modified CJS mark-recapture analyses using a transient model. They noted a substantial improvement in precision of the survival-rate estimates using five, rather than four, years of data, and an increase in the number of species for which survival could be estimated with reasonable precision. Except for Orange-crowned Warbler and Spotted Towhee, which were found to have low survival that IBP recommended for careful monitoring in future years, survival-rate estimates from NROC appeared to be about as high, or possibly even higher, than those from other western locations.

The authors emphasized that their population and productivity trends and survival estimates were based on only five years of data, and may not be representative of the longer-term population dynamics. With additional years of data, however, they expected to be able to undertake further analyses to identify the factors causing the declines that they were documenting, analyses that could potentially lead to the formulation of management strategies for reversing those declines. Information on a broad spectrum of both permanent resident and migratory breeding species would also provide increased understanding of the manner in which various biotic and abiotic factors affect the NROC's target bird populations. The authors recommended continuing operation of at least the six currently active MAPS stations in future years, but this recommendation was not taken in 2004.

CALIFORNIA GNATCATCHER AND CACTUS WREN SAMPLING 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 has been covered

at least twice per year since 2001, and it is recommended that two-rounds of surveys be conducted at each site in future years of this study.

As discussed under Methods, and at greater length by Hamilton (2003a, Appendix B), 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 Population Estimates

Following an estimated decline of 30% (20–38%) from 2002 to 2003, it is estimated that the overall CAGN population increased 19% (14–25%) from 2003 to 2004. For the central reserve, the estimated increase was 22% (14–30%), and for the coastal reserve the estimated increase was 16% (7–26%).

From 1999 to 2004, it is estimated that the overall CAGN population declined 26% (17–35%). For the central reserve, the estimated decrease was 33% (18–47%), and for the coastal reserve the estimate decrease was 17% (4–30%).

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; Hamilton 2003a). Therefore, although comparing detections/site biases 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 all six years of the study, the central reserve CAGN detection rate (mean detections/site) has been greater than the coastal reserve rate (1.6 times greater in 1999; 2.6 times greater in 2000; 1.6 times greater in 2001; 1.6 times greater in 2002; 1.2 times greater in 2003; 1.3 times greater in 2004).

In 2004, the mean CAGN detection rate across the NROC (n=40 sites) was 2.87 detections/site. Breaking this down by major land designations:

- The mean detection rate at core sites (n=19) was 0.68 territories/site (24% lower than the 2003 detection rate of 0.89 territories/site).

- ▶ The mean detection rate at edge sites (n=15) was 4.27 territories/site (33% higher than the 2003 detection rate of 3.20 territories/site).
- ▶ The mean detection rate at fragment sites (n=6) was 7.50 territories/site (29% higher than the 2003 detection rate of 5.83 territories/site).

The 2004 results reverse those from 2003, when the edge and fragment detection rates declined sharply even as the detection rate in the sparsely occupied core stratum increased slightly. These patterns are analyzed in the subsequent section entitled, "California Gnatcatcher Population Dynamics in the NROC."

As in each year of this study, CAGN were distributed primarily along reserve edges. The following reasons help to explain this pattern of distribution, with the first two likely being more important than the last two:

- ▶ 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.

California Gnatcatcher Habitat Composition

RELATIVE ABUNDANCE OF SHRUB SPECIES IN CALIFORNIA GNATCATCHER TERRITORIES

Table S presents these results for 1999–2004. As in previous years of this study, California Sagebrush (*Artemisia californica*) ranked as the prevalent shrub species in CAGN territories in each subregional reserve, followed distantly by California Buckwheat (*Eriogonum fasciculatum*) and Black Sage (*Salvia mellifera*). Once again, Black Sage was more prevalent in central reserve CAGN territories versus those in the coastal reserve. In spring 2002, California Sunflower (*Encelia californica*) suffered extensive withering due to lack of rainfall, and was recorded at very low levels in both reserves, but with the return to normal rainfall its prevalence in both central and coastal reserve territories substantially increased in 2003. With the return of drought conditions in 2004, California Sunflower's prevalence in CAGN territories again declined. 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.

CACTUS COVER IN CALIFORNIA GNATCATCHER TERRITORIES

Table U presents these results for 2002–2004. In each year and in each reserve, CAGN overwhelmingly occupied scrub with 0–10% cactus cover. This tendency has been somewhat stronger in the coastal reserve, probably reflecting the sparse distribution of cactus in coastal reserve since the 1993 Laguna Beach Fire. These results suggest that CAGN in the NROC tend to select

scrub habitats with few or no cactus patches, possibly to avoid CACW, which are reported to prey on and otherwise antagonize CAGN (see Atwood and Bontrager 2001).

California Gnatcatcher Habitat Structure

WOODY VEGETATION HEIGHT IN CALIFORNIA GNATCATCHER TERRITORIES

Table V presents these results for 1999–2004, with the 2004 data reinforcing the pattern of CAGN selecting habitat close to 1.0 m tall. In 2004, 71% of central reserve territories and 61% of coastal reserve territories were in scrub habitat in this height range, with the remaining territories being in habitat estimated to be approximately 1.5 m tall.

SHRUB COVER IN CALIFORNIA GNATCATCHER TERRITORIES

Table X presents these results for 1999–2004. As in previous years of this study, CAGN showed a preference for relatively dense scrub habitat. Almost no CAGN were found in scrub estimated to have shrub cover lower than 40%, while 92% of central reserve territories and 83% of coastal reserve territories were in habitat with absolute shrub cover estimated at 61–100%, with the 81–100% cover class claiming more territories than any other 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.

California Gnatcatcher Population Dynamics in the NROC

An important goal of this study should be to use annual monitoring data to better understand the basic ecological principles affecting the target bird populations occurring within each of the NROC's subregional reserves. Toward this end, two classes of CAGN 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 CAGN territory detections ($n=11$), and "low density" sites with fewer detections ($n=23$). Six sites that have not supported CAGN during any year of the study are excluded from this analysis, as they may not provide suitable habitat for CAGN (but note that this number is down from nine in 2002, as new territories were established in habitat that had been vacant during the previous years).

As reported on Page 43, mean detection rates in the core, edge, and fragment sampling strata form the basis for reserve-wide CAGN population trend analyses. In Table CC, raw counts are used instead of mean detection rates. This is because the division of the NROC into "high density" and "low density" areas is purely conceptual (e.g., the division does not conform to the core, edge, and fragment sampling strata). The following year-to-year comparisons of detection rates at high-density vs. low-density sites are intended only as a means of conceptualizing and assessing ecological factors that appear to influence CAGN population dynamics in the NROC.

TABLE CC – CALIFORNIA GNATCATCHER DETECTION RATES
AT “HIGH DENSITY” AND “LOW DENSITY” SITES, 1999-2004

Table CC 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 Pages 6-7). Six sites that remained vacant during all years of the study have been excluded from this analysis, as these areas may not include habitat that is regularly used by CAGN.

		2-VISIT RAW COUNTS					
SITE	SUB-STRATUM	1999	2000	2001	2002	2003	2004
HIGH DENSITY SITES							
1	RESIDENTIAL EDGE	6.42	1.07	1	2	2	4
3	MIXED EDGE (FRAGMENT)	14.98	16	28	18	12	12
6	MIXED EDGE	14.98	11	8	11	5	9
12	ROAD EDGE	20.33	12	18	23	16	12
14	ROAD EDGE	7.49	4	5	7	4	7
19	MIXED EDGE (FRAGMENT)	8.56	3.21	6	6	4	4
20	MIXED EDGE (FRAGMENT)	14.98	8.56	6	11	6	11
21	MIXED EDGE	8.56	4.28	12	10	8	12
26	ROAD EDGE	10.7	5.35	8	6	5	8
33	MIXED EDGE (FRAGMENT)	13.91	7	13	18	9	9
39	CORE	5.35	2	4	4	4	5
TOTAL - HIGH DENSITY		126.26	74.47	109	116	75	93
LOW DENSITY SITES							
2	CORE	0	0	0	1	1	0
5	ROAD EDGE	2.14	0	4	4	2	3
9	CORE	0	0	0	0	0	1
11	CORE	3.21	3	2	3	2	1
15	CORE	2.14	1	2	1	0	1
16	CORE	2.14	0	0	0	0	0
17	MIXED EDGE	0	0	0	1	0	0
18	RESIDENTIAL EDGE	2.14	2	2	1	1	2
22	RESIDENTIAL EDGE	3.21	0	1	1	1	0
23	CORE	3.21	0	1	2	3	2
24	CORE	1.07	1	0	0	0	0
25	RESIDENTIAL EDGE	3.21	0	3	3	1	1
27	ROAD EDGE	3.21	0	0	1	1	3
28	ROAD EDGE (FRAGMENT)	2.14	1	3	2	2	4
29	CORE	1.07	0	2	2	0	1
30	RESIDENTIAL EDGE (FRAGMENT)	4.28	0	1	3	2	5
31	RESIDENTIAL EDGE	0	1	1	1	0	1
32	CORE	1.07	0	0	0	0	0
35	CORE	2.14	1.07	0	1	2	1
36	ROAD EDGE	0	0	0	0	1	0
37	CORE	1.07	0	1	1	2	0
38	CORE	0	0	2	1	3	1
40	RESIDENTIAL EDGE	0	0	0	0	1	1
TOTAL - LOW DENSITY		37.45	10.07	25	29	25	28

PERCENT CHANGE (DETECTIONS/SITE)						
SITE CLASS	99-00	00-01	01-02	02-03	03-04	99-04
HIGH DENSITY	-41%	+46%	+6%	-35%	+25%	-26%
LOW DENSITY	-73%	+148%	+16%	-14%	+12%	-25%

Table CC shows that the number of unoccupied low density sites varied considerably from year to year (six in 1999; 15 in 2000; nine in 2001; five in 2002; seven in 2003; eight in 2004), while no high density site has been unoccupied in any year. As noted previously, six sites were excluded from this analysis because they were vacant during each year of the study. A solid majority of CAGN territories (75–88%) have been found at high density sites during each year of the study despite the high density sites accounting for only one-third of the 34 occupied monitoring sites.

From 1999 to 2001, territory counts at low-density CAGN sites declined about twice as fast as the counts at high-density sites, but by the end of 2004 both high and low density CAGN populations had declined approximately 25% from their 1999 levels. As reviewed in the following paragraphs, different mechanisms appear to be responsible for partially asynchronous declension of the NROC's low and high density populations.

In demographic studies that started in the early-to-mid 1990s, CAGN survivorship was found to "vary substantially among years, usually at regional scale suggestive of widespread causes, such as weather effects" (Atwood and Bontrager 2001: 20). Specifically, mild winters – with a general lack of heavy storms, and exclusive of multi-year drought conditions – appear to promote overwinter survival by CAGN. Consistent with this notion, and with the proposition that low density populations occupy habitat that is of relatively low quality for the species (see the next section, entitled "Current Demographic Model for CAGN in the NROC"), the proportion of territories found at low density monitoring sites has been greatest in springs that followed mild winters: 25% of detections in 2003; 23% of detections in 1999 and 2004. Note that only 12% of territories were found at low density sites in spring 2000 – on the heels of a two-year drought that was broken by a series of fairly heavy storms in February and March 2000. As noted above, 15 of the 23 low density sites were, in fact, vacant in 2000 – many more than in any other year of the study to date. Thus, the six years of data from the NROC target bird study suggest a correlation between overwinter survival and the relative abundance of CAGN in lower quality habitat during the following spring.

In contrast to survivorship, Atwood and Bontrager (2001) reported that regional CAGN productivity tends to remain fairly constant from year to year. But this finding was made during the early-to-mid 1990s, a period not marked by regional drought of particular consequence (Atwood et al. 1998b), and it appears that the more recent drought conditions have affected productivity considerably, at least during certain years. In particular, productivity of all of the NROC's coastal sage scrub bird populations appeared to be profoundly affected in spring 2002, as well documented at the NROC's MAPS stations (DeSante et al. 2003a, summarized on Pages 40–42). That very dry rainy season was followed by a relatively mild winter with near-average rainfall¹, affording an opportunity to evaluate the relationship between low CAGN productivity and potential shifts in the species' distribution across the NROC. In 2003, the predicted single-year decline occurred primarily in high density populations, which dropped 35% from 2002 levels, compared with a 14% decline in low density populations. Examining these results, some logical – if speculative – explanatory mechanisms emerged.

As Table CC shows, the higher the territory count in 2002, the greater the decline registered in 2003. Nine of the 11 high density sites (82%) registered single-year declines in 2003, and the two high density sites that remained constant from 2002 to 2003 had the lowest territory counts in 2002. Conversely, only eight of the 23 low density sites (36%) registered single-year declines in

¹This was in contrast to the situation in 1999, when apparently low productivity was followed by conditions that were not conducive to overwinter survivorship, making it impossible to tease apart the effects of low productivity from the effects of low overwinter survivorship.

2003 while six sites (27%) actually registered increases. Such striking short-term demographic shifts almost certainly reflect basic ecological processes that follow directly from the productivity crash of 2002. Comprehensive, standardized data on CAGN productivity, survivorship, and perhaps dispersal would be required to demonstrate the mechanism(s) responsible for these patterns, but in the absence of such detailed information it is reasonable to explore the likely causes for these demographic shifts:

- ▶ First, it is safe to conclude that most or all of the gnatcatchers that fledged in 2002 encountered environmentally stressful conditions (in both high density and low density populations) and were forced to compete with adults and other young gnatcatchers for scarce food resources.
- ▶ Under such conditions, it is reasonable to hypothesize that adults already established in high density areas would vigorously harass subdominant juveniles, causing them to disperse into sparsely occupied or unoccupied scrub (indeed, CAGN pairs were recorded in 2003 at two of nine monitoring sites that had been vacant each year from 1999 to 2002).
- ▶ It is also possible that juveniles actually require little "encouragement" to disperse long distances out of natal territories that offer scarce food resources, which could lead to the same result (preferential settlement of low-density areas).
- ▶ Finally, and not exclusive of the potential dispersal mechanisms outlined above, CAGN nesting success may have been relatively high in sparsely occupied habitat, where both adult and juvenile birds would be capable of foraging over wider areas due to lower levels of competition from nearby gnatcatchers.

The 2004 results were not as dramatic as the 2003 results, but they nonetheless tend to support the developing demographic model outlined below.

Current Demographic Model for CAGN in the NROC

Previous NROC target bird reports (Hamilton 2001a, 2001c) have addressed this topic, which has been evolving to incorporate and accommodate each year's CAGN population data. The current demographic model seems to be useful in helping to explain each year's results through 2004.

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 Orange County 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 to the south in Laguna Niguel (see 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 sedentary species, such as CAGN and CACW, compared with 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.

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., prolonged drought, severe winter storms), 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 initiate insect flights needed for CAGN survival), many gnatcatchers that settle in low quality habitat areas are able to survive and may breed successfully. During such periods, and even in years like 2003 when CAGN populations in high quality habitat experience short-term declines greater than those in low quality habitat, the densities and absolute numbers in high quality areas appear to generally remain well above the densities and numbers in low quality areas (see the data in Table CC).

Nonetheless, the *proportion* of birds occupying low-quality habitat is relatively high during periods that favor overwinter survivorship, especially during the year after a severe, reserve-wide drop in productivity. But inevitably, severe winter storms or prolonged drought conditions can be expected to eliminate relatively large numbers of gnatcatchers from low quality habitat areas, so that the proportion of birds in high density areas again increases.

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.

The NROC study has not collected the type of demographic data on CAGN recommended by this author, but nothing in the six years of NROC data suggest that any low density habitat areas should be considered high quality habitat for CAGN, or vice-versa (with the possible exception of Site No. 1, which has been occupied at low density since 2000). Moreover, the NROC results are consistent with a growing body of published and unpublished research indicating that CAGN density tends to be correlated with habitat quality for this species.

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

ity 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 when the species was present at many sites from which it vanished in 2000 (most such areas were recolonized in 2001 and in later years). 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-quality (“source”) habitat areas. If Van Horne’s hypothesis pertained to CAGN in the NROC, many low density sites should have outperformed high density sites at some point during the next five years, but examination of Table CC shows that this clearly was not the case (Site 30 did register five territories in 2004, but counts at this site have fluctuated greatly over the years, and two of the five territories in 2004 were partials). Even in 2003, when high-density populations decreased 35% from 2002 levels and low-density populations decreased only 14%, 10 of the 11 high density sites maintained four to 16 CAGN territories while none of the 22 low density sites supported more than three CAGN territories. Thus, with the possible exception of Site 1, CAGN populations occupying high density monitoring sites have responded to environmental stresses consistent with expectations for birds in high-quality “source” habitat. And, with the possible exception of Site 30, CAGN populations at low density monitoring sites have behaved as hypothesized for birds in low-quality “sink” habitat.

Thus, results of this study to date 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 important implications for long-term management of the reserve.

Low density habitat areas, which comprise most of the NROC, presumably provide important habitat connections between CAGN population centers, and may play other key roles in maintaining the NROC’s overall CAGN populations—roles that cannot be easily observed or anticipated, such as providing habitat for species that may control populations of CAGN antagonists. The surprising stability of low-density populations in 2003, a year when high-density populations declined markedly, also speaks to the importance of appreciating the subtle complexity of certain landscape-level ecological processes, some of which may only become evident after long periods of study. Finally, some low-density areas may 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 high density and low density sites, will permit tracking of potential shifts in CAGN population centers over time. Upon completion of anticipated 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 scrub in the NROC provides relatively low or relatively high habitat values for CAGN. Ultimately, it may be possible to incorporate such information into a detailed model of reserve-wide CAGN distribution and population dynamics. This could allow managers to, for example, compare the relative contributions of different habitat areas to the viability of the CAGN population in a given geographical area, or anticipate the likely short-term and long-term effects of major stochastic events, such as wildfires or prolonged drought (see Pulliam and Danielson 1991).

Cactus Wren Population Estimates

Following an estimated decline of 40% (35–44%) from 2002 to 2003, it is estimated that the overall CACW population increased 15% (13–18%) in 2004. This overall increase was comprised of an estimated 25% increase (21–30%) in the central reserve population and a 26% decrease (23–28%) in the coastal reserve population.

From 1999 to 2004, it is estimated that the overall CACW population declined 33% (28–37%). The estimated decline in the central reserve was 26% (19–33%), while the coastal reserve's estimate decrease was 59% (54–63%).

Cactus Wren Patterns of Distribution

In all six years of the study, the CACW detection rate (mean detections/site) for the central reserve has been substantially greater than that for the coastal reserve (4.1 times greater in 1999; 5.5 times greater in 2000; 4.3 times greater in 2001; 3.6 times greater in 2002; 4.0 times greater in 2003; 7.7 times greater in 2004). 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).

In 2004, the mean CACW detection rate across the NROC (n=40 sites) was 1.53 detections/site. Breaking this down by major land designations:

- ▶ The mean detection rate at core sites (n=19) was 1.63 territories/site (44% higher than the 2003 rate of 1.32 territories/site in the reserve core).
- ▶ The mean detection rate at edge sites (n=15) was 1.73 territories/site (13% higher than the 2003 rate of 1.53 territories/site on the reserve edges).
- ▶ The mean detection rate at fragment sites (n=6) was 1.16 territories/site (approximately the same as the 2003 rate of 1.17 territories/site in reserve fragments).

From 2002 to 2003, the core detection rate decreased the most (48%), followed by the edge rate (30%) and the fragment rate (22%). Thus, as observed for CAGN, the 2004 results reversed the previous year's pattern.

The relatively uniform distribution of CACW across the three sampling strata, observed in all years of this study, 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 shrub cover and low average height of shrubs (presumably because abundant tall shrubs allow ground predators to more readily access nests placed in otherwise well-protected cactus plants).

Cactus Wren Habitat Composition

RELATIVE ABUNDANCE OF SHRUB SPECIES IN CACTUS WREN TERRITORIES

Table T presents these results. For each of the five years this information has been recorded, Coastal Prickly-Pear has been more dominant in the central reserve than in the coastal reserve, and in 2004 this species again ranked first in the central reserve. In 2002, it had been supplanted by both California Sagebrush and California Buckwheat in the coastal reserve, and in 2004 California Sagebrush was again slightly more prevalent in this part of the NROC. The differing prevalence of cactus in the two reserves appears to reflect slow cactus recovery in the coastal reserve after the 1993 Laguna Beach Fire, and it is expected that cactus will become incrementally more dominant in the coastal reserve as recovery progresses (Hamilton 2003a, b). In 2004, Coyote Brush (*Baccharis pilularis*) was unexpectedly prevalent in coastal reserve territories, receiving a fairly high ranking of "1.1" after five years of rankings lower than "0.2." In the central reserve, Lax-flowered Bushmallow (*Malacothamnus fasciculatus*) ranked high at "1.0" after five years of lower rankings. Other relatively abundant plants in CACW territories include Laurel Sumac (*Malosma laurina*) and Lemonade Berry (*Rhus integrifolia*). Mexican Elderberry (*Sambucus mexicana*) is frequently found in CACW territories, and it may provide important high perches and foraging habitat, but it continues to receive low rankings as it covers relatively little area compared with other shrub species dominant in CACW territories.

CACTUS COVER IN CACTUS WREN TERRITORIES

Table U presents these results. In 2004, 57% of CACW territories in the central reserve and 76% of CACW territories in the coastal reserve were judged to have >10% cactus cover. The remaining territories were judged to have 1–10% cactus cover. In the central reserve, 18% of CACW territories were judged to have >25% cactus cover, comparable to 20% of territories in 2002 and 25% of territories in 2003.

In the coastal reserve 38% of CACW territories were judged to have >25% cactus cover, up from 6% in 2002 and 11% in 2003. Given that the coastal reserve population estimate dropped 25% from 2003 to 2004, the increased proportion of CACW occupying scrub with >25% cactus cover (during Round 1 surveys) could reflect concentration of birds in the highest quality cactus scrub. Note, however, that the sample size is very small ($n=8$ for Round 1 detections), and that all four Round 2 CACW detections were in scrub with cactus cover estimated at 11–25%.

Cactus Wren Habitat Structure

WOODY VEGETATION HEIGHT IN CACTUS WREN TERRITORIES

Table W presents these results. In 2004, as in previous years, the overwhelming majority of CACW territories (89% in the central reserve and 100% in the coastal reserve) were in scrub habitat approximately 1.0 to 1.5 m tall.

SHRUB COVER IN CACTUS WREN TERRITORIES

Table Y presents these results. In 2004, as in previous years, CACW territories were primarily found in dense scrub, although this tendency was once again more pronounced in the coastal reserve, where 88% of territories were in habitat with shrub cover estimated at >60%, compared with only 56% of territories in the central reserve. Many sparsely vegetated territories in the central reserve (i.e., those estimated at <41% shrub cover) were in recently burned scrub or in

limited patches of cactus surrounded by grasslands, situations that are relatively rare in the coastal reserve.

Cactus Wren Population Dynamics in the NROC

To better understand the basic ecological principles affecting the CACW populations in the NROC's subregional reserves, 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 four CACW territory detections (n=10), and "low density" sites with fewer detections (n=20). Ten sites that did not support CACW during any year of the study have been excluded from this analysis, as they may not provide suitable habitat for this species.

As reported on Page 51, mean detection rates in the core, edge, and fragment sampling strata form the basis for reserve-wide CACW population trend analyses. In Table DD, raw counts are used instead of mean detection rates. This is because the division of the NROC into "high density" and "low density" areas is purely conceptual (e.g., these divisions do not conform to core, edge, and fragment sampling strata). The following year-to-year comparisons of detection rates at high-density vs. low-density sites are intended only as a means of conceptualizing and assessing ecological factors that appear to influence CACW population dynamics in the NROC.

To date, year-to-year fluctuations in the NROC's CACW populations have not consistently mirrored those of the reserve's CAGN populations. Cactus Wrens 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. Nonetheless, by spring 2003 the reserve-wide populations of both species were approximately 40% below their 1999 levels.

Table DD shows that the number of unoccupied low density sites varied from year to year (one in 1999; four in 2000; seven in 2001; four in 2002; eight in 2003; six in 2004), while only a single high density site was vacant during any of the five years (Site No. 7 in 2003). As noted previously, ten sites were excluded from this analysis because they were vacant during each year of the study. Note also that most of the CACW detections have occurred at high density sites during each year of the study (64% in 1999; 61% in 2000; 59% in 2001; 53% in 2002; 56% in 2003; 61% in 2004) despite the high density sites accounting for only one-third of the 30 occupied monitoring sites.

Counts at high density sites declined 20% from 1999–2001 as the counts at low density sites remained constant. From 2001 to 2002 high density populations increased by just 2% while low-density populations registered a 24% increase. Following the productivity crash of 2002, however, both sets of populations dropped precipitously in 2003, with high density sites shedding 37% of the 2002 territories and low density sites shedding 43%. In 2004, the high density sites rebounded by 26% while low density sites remained nearly flat, with just a 4% increase¹.

¹ It should be noted that only one of the ten high density sites is in the coastal reserve, while nine of the 20 low density sites are in the coastal reserve; the coastal reserve CACW population posted an unanticipated 25% single-year decline in 2004.

TABLE DD – CACTUS WREN DETECTION RATES
AT “HIGH DENSITY” AND “LOW DENSITY” SITES, 1999-2004

Table DD 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 Pages 6–7). Ten sites that were vacant during all five 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	2002	2003	2004
HIGH DENSITY SITES							
1	RESIDENTIAL EDGE	4.60	1.15	1	2	2	2
6	MIXED EDGE	5.75	4	3	4	3	3
7	CORE	4.60	2	3	3	0	3
9	CORE	6.90	10	8	9	5	6
11	CORE	5.75	7	6	6	2	3
12	ROAD EDGE	6.90	6	7	6	4	5
16	CORE	5.75	9	9	7	6	6
17	MIXED EDGE	4.60	2	4	4	4	5
18	RESIDENTIAL EDGE	9.20	7	5	6	4	5
25	RESIDENTIAL EDGE	5.75	2	2	2	1	1
TOTAL – HIGH DENSITY		59.80	50.15	48	49	31	39
LOW DENSITY SITES							
2	CORE	1.15	0	0	0	0	0
3	MIXED EDGE (FRAGMENT)	1.15	2	0	0	0	0
4	CORE	1.15	1	2	1	1	1
5	ROAD EDGE	1.15	2.30	1	0	0	1
8	CORE	2.30	1.15	2	4	1	2
10	CORE	1.15	0	0	2	0	1
13	CORE	3.45	6.90	4	4	3	3
14	ROAD EDGE	2.30	3	2	2	2	1
15	CORE	3.45	3	8	8	6	5
19	MIXED EDGE (FRAGMENT)	1.15	1.15	0	1	0	2
20	MIXED EDGE (FRAGMENT)	2.30	1.15	1	2	1	2
21	MIXED EDGE	3.45	3.45	4	4	1	1
22	RESIDENTIAL EDGE	1.15	1	2	2	1	0
23	CORE	1.15	0	0	1	0	0
24	CORE	1.15	0	0	0	0	0
26	ROAD EDGE	0	1.15	2	2	1	2
27	ROAD EDGE	1.15	0	1	0	0	0
28	ROAD EDGE (FRAGMENT)	1.15	2	0	3	2	1
30	RESIDENTIAL EDGE (FRAGMENT)	1.15	2.30	3	3	4	2
35	CORE	2.30	1.15	2	3	1	1
TOTAL – LOW DENSITY		33.35	32.70	34	42	24	25

PERCENT CHANGE (DETECTIONS/SITE)						
SITE CLASS	99-00	00-01	01-02	02-03	03-04	99-04
HIGH DENSITY	-16%	-4%	+2%	-37%	+26%	-35%
LOW DENSITY	-2%	+4%	+24%	-43%	+4%	-25%

Examining the six-year trend from 1999–2004, high density populations declined 35% while low density populations declined 25%. The following paragraphs review some factors that may help to explain these downward trends.

It was noted previously that mild winters—with a general lack of heavy storms, and exclusive of multi-year drought conditions—appear to promote overwinter survival by CAGN. In contrast, the data to date suggest that CACW better survive cold, wet weather, as expected for a relatively large species that builds enclosed brood nests for warmth and shelter during cold, rainy winter weather. This life history trait helps to level out the difference between high quality habitat and lower quality habitat that may offer less natural protection from the elements (a difference hypothesized to play a role in CAGN population dynamics). For example, CACW detections at low density sites declined only 4% from 1999 to 2000 despite low productivity in 1999 and very poor survival conditions in winter 1999. The 18% decline at high density sites in 2000 may reflect the rigors of greater competition in high density areas (with possible dispersal of juveniles to low density habitat) more than weather-related declines in overwinter survival. Were overwinter survival an important factor, one would expect low density sites to have posted a larger decline. The only major, NROC-wide, single-year CACW decline was registered in 2003, following a spring with record-low productivity and a winter with average rainfall and just one heavy storm, and both high density and low density populations were greatly affected. This suggests that productivity is generally more important to CACW population viability than is overwinter survival.

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 in 1991/92 (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 ten 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

in the NROC and elsewhere, and the observations of others, suggest that CACW may tend to settle selectively in habitat patches near areas already occupied by CACW. If this is the case, analysis of low density vs. high density populations in the NROC should provide evidence of this, as cactus scrub recovers over a period of decades. If the presence of 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 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 anticipated 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.

BROWN-HEADED COWBIRD SAMPLING ROBERT A. HAMILTON

Table R presents these results. In the six years of this study, we have recorded only nine Brown-headed Cowbirds in the NROC: five in 1999; two in 2000; none in 2001; two in 2002; none in 2003 or 2004 (all Round 1 counts; BHCO are not monitored in Rounds 2 or 3). It should be noted, however, that in 2004 we detected BHCO parasitism of two nests at Site 33 (on the coastal shelf of Crystal Cove State Park). Overall, our 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 could be warranted at that time.

VI. RECOMMENDATIONS

FOCUSED EVALUATION OF COASTAL RESERVE CACW POPULATION

Due to the following considerations, the coastal reserve CACW population is of potential conservation concern:

- ▶ The Laguna Beach Fire burned 75% of the coastal reserve. Surveys within the fire perimeter conducted in 1994 by Bontrager et al. (1995) revealed 72% fewer CACW pairs than were known from pre-fire surveys in 1992, and cactus scrub has not yet recovered significantly in the fire perimeter.
- ▶ The estimated number of CACW pairs in the coastal reserve has declined 59% (54–63%) since 1999, and from 2003 to 2004 the estimated population size declined 25% (23–28%) when a population increase had been expected (such single-year increases were recorded for CACW in the central reserve and for CAGN in both subregional reserves).
- ▶ Precipitation in 2003/04 was 47% below average, and anecdotal observations of relatively few CACW juveniles in spring 2004 lead to a prediction that CACW populations across the NROC will be lower in 2005.

It is recommended that the NROC, USFWS, and CDFG survey the entire coastal reserve in spring 2005 to determine the actual of CACW in the reserve, to identify the most heavily populated habitat areas, to more closely evaluate the characteristics of occupied cactus scrub habitat, and to start developing a conservation strategy that will help to ensure the long-term viability of this vulnerable NROC target bird population.

STATISTICAL ANALYSIS OF PILOT DATA FOR YEARS 1–6

This section repeats input from Dr. Karen Messer concerning statistical analyses that should be performed in future years of the target bird study. These recommendations are essentially the same as those presented by Hamilton (2003a,b,c), although the statistical analysis of pilot data was originally recommended for 2003. These analyses have not been completed to date, as it is anticipated that the USFWS and CDFG will want to provide further guidance in this respect.

The NROC should retain an experienced biometrician to review data collected during the first six years of pilot monitoring (1999–2004) 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 seventh season of data collection on 1 March 2005. The following analyses were recommended by Dr. Tyson Holmes prior to initiation of the study and later modified by Dr. Messer.

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 B, 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 $\pm 20\%$ of the true total with 90% confidence⁵.

⁵ 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.

However, sample sizes for estimating the total number of territories may be much larger than those required to estimate the change in territories. Please see the discussion below and in Section 1.15 in the Appendix B. 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 six years of this study, and work with the NROC, USFWS, and CDFG to determine an appropriate sampling strategy for future years of this study.

Monte Carlo Simulations of Sample Size

INITIAL PROPOSAL

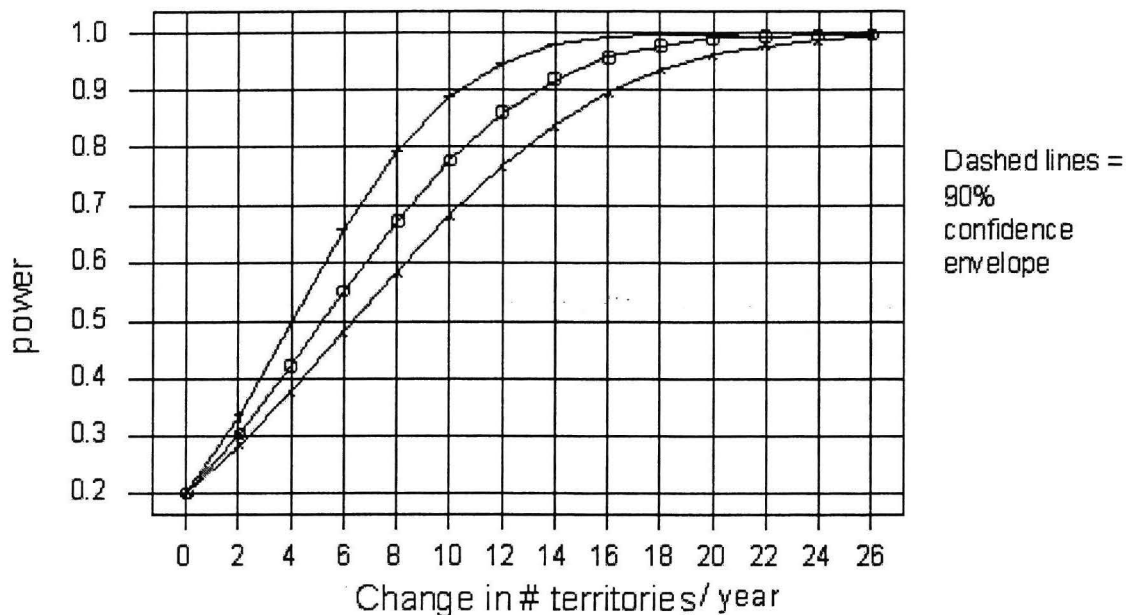
For each hypothesis, Monte Carlo simulations on data from the third through sixth years will be used to determine appropriate sample sizes and schedules for the long term (see Mac Nally 1997). Three effect sizes should be explored in each analysis: 1) a drastic 20% change between a pair of consecutive 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 (see 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 B, 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.

CHART 1 – POWER CURVE, CALIFORNIA GNATCATCHER TERRITORIES

Power to detect a change in # of territories, $\alpha = .20$



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 B, 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 B, Section 1.16. It is suggested that rotating panel designs, which build upon the existing information, be considered for the future.

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 EE – EXAMPLE OF RECOMMENDED PHYSICAL SITE DATA TABLE

SITE NO.	AREA (HA)	NEAREST ROAD	NEAREST HOUSE	MIN. ELEV.	MAX. ELEV.	MEAN SLOPE	FIRE HISTORY				
							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. Statistical analyses and recommendations in this report were made by Drs. Karen Messer and Martha White.

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 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.

IX. LITERATURE CITED

- Atwood, J.L., D.R. Bontrager, and A.L. Gorospe. 1998a. Use of refugia by California Gnatcatchers displaced by habitat loss. *Western Birds* 29:406-412.
- Atwood, J.L., D.R. Bontrager, R. Hirsch, D. Kamada, M. Madden, and P.A. Bowler. 1998b. Population dynamics, dispersal and demography of California Gnatcatchers in Orange Co., California (1998 progress report). Unpublished report, Manomet Center for Conservation Sciences, Manomet, MA, and University of California, Irvine.
- Atwood, J.L., and D.R. Bontrager. 2001. California Gnatcatcher (*Poliophtila californica*). In *The Birds of North America*, No. 574 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Bontrager, D.R., R.A. Erickson, and R.A. Hamilton. 1995. Impacts of the October 1993 Laguna fire on California Gnatcatchers and Cactus Wrens. in J.E. Keeley and T.A. Scott (editors). *Wildfires in California Brushlands: Ecology and Resource Management*. International Association of Wildland Fire, Fairfield, Washington.
- DeSante, D.F., P. Pyle, and D. O'Grady. 2001. The 2000 Annual Report of the Monitoring Avian Productivity and Survivorship (MAPS) Program at the Nature Reserve of Orange County. Report dated 18 April 2001 prepared for the NROC by the Institute for Bird Populations.
- DeSante, D.F., N. Michel, and D. O'Grady. 2002. The 2001 Annual Report of the Monitoring Avian Productivity and Survivorship (MAPS) Program at the Nature Reserve of Orange County. Report dated 5 June 2002 prepared for the NROC by the Institute for Bird Populations.
- DeSante, D.F., P. Pyle, N. Michel, and D. O'Grady. 2003a. The 2002 Annual Report of the Monitoring Avian Productivity and Survivorship (MAPS) Program at the Nature Reserve of Orange County. Report dated 5 May 2003 prepared for the NROC by the Institute for Bird Populations.
- DeSante, D.F., P. Pyle, and D. Kaschube. 2003b. The 2003 Annual Report of the Monitoring Avian Productivity and Survivorship (MAPS) Program at the Nature Reserve of Orange County. Report dated 30 September prepared for the NROC by the Institute for Bird Populations.
- Efron, B. and R.J. Tibshirani. 1993. *An Introduction to the Bootstrap*. Chapman and Hall, New York.
- Erickson, R.A., and K.L. Miner. 1998. Six years of synchronous California Gnatcatcher population fluctuations at two locations in coastal Orange County, California. *Western Birds* 29:333-339.
- Flaagan, K.J. 1999. Nest-site selection of the coastal cactus wren, *Campylorhynchus brunneicapillus*, in Chino Hills State Park, California. unpubl. masters thesis, Calif. State Univ., Fullerton.
- Gessaman, J.A. and G.L. Worthen. 1982. The effects of weather on avian mortality. Unpublished annotated

bibliography available from J. A. Gessaman, UMC 53, Department of Biology, Utah State University, Logan, UT 84322.

- Gurevitch, J. and S.T. Chester. 1986. Analysis of repeated measures experiments. *Ecology* 67:251-255.
- Hamilton, R.A. 2003a. Target Bird Monitoring Study, Nature Reserve of Orange County, Combined Report, 1999-2001. Report, dated 11 March 2003, prepared for the Nature Reserve of Orange County, Santa Ana, CA.
- Hamilton, R.A. 2003b. Target Bird Monitoring Study, Nature Reserve of Orange County, Combined Report, 2002. Report, dated 21 March 2003, prepared for the Nature Reserve of Orange County, Santa Ana, CA.
- Hamilton, R.A. 2003c. Target Bird Monitoring Study, Nature Reserve of Orange County, 2003. Report, dated 12 December 2003, prepared for the Nature Reserve of Orange County, Santa Ana, CA.
- Jones & Stokes Assoc. 1993. Field study methods for conducting surveys of California Gnatcatchers (*Poliophtila californica*), cactus wrens (*Campylorhynchus brunneicapillus*), and other special-status species at the Irvine Ranch, Orange County, California. Unpublished report prepared for The Irvine Company (available from Wilson Ornithol. Soc., Mus. Zool. Univ. of Mich., Ann Arbor, MI 48109-1079).
- Kendall, K.C., L.H. Metzgar, D.A. Patterson, and B.M. Steele. 1992. Power of sign surveys to monitor population trends. *Ecological Applications* 2:422-430.
- Lustick, S.A. and J. Adams. 1977. Seasonal variation in the effects of wetting on the energetics and survival of starlings (*Sturnus vulgaris*). *Comp. Biochem. Physiol.* 56A:173-177.
- Mac Nally, R. 1997. Monitoring forest bird communities for impact assessment: the influence of sampling intensity and spatial scale. *Biological Conservation* 82:355-367.
- Mock, P.J. 1998. Energetic constraints to the distribution and abundance of the California Gnatcatcher. *Western Birds* 29:413-420.
- Mock, P.J., B.L. Jones, and J. Konecny. 1990. California Gnatcatcher Survey Guidelines. Unpublished report prepared by Environmental and Energy Services Company. San Diego, CA.
- Patten, M.A. and J.T. Rotenberry. 1999. The proximate effects of rainfall on clutch size of the California Gnatcatcher. *Condor* 101:876-880.
- Root, T. 1988. Energy constraints on avian distributions and abundances. *Ecology* 69:330-339.
- Smith, A.T. and M.M. Peacock. 1990. Conspecific attraction and the determination of metapopulation colonization rates. *Conservation Biology* 4:321-323.
- Thompson, S.K. 1992. *Sampling*. John Wiley and Sons, Inc., New York.
- Zielinski, W.J. and H.B. Stauffer. 1996. Monitoring Marten populations in California: survey design and power analysis. *Ecological Applications* 6:1254-1267.

APPENDIX A
2003 MONITORING SITE AREAS
BY LAND DESIGNATION & SUB-DESIGNATION

After large changes to the monitoring site boundaries in 1999 and 2000 (see Hamilton 2003), several relatively minor changes were made in 2001 and 2002. The following tables indicate the area covered by each monitoring site in 2003.

TABLE A I – BREAKDOWN OF CORE SITES, 2003

SITE	DESCRIPTIVE NAME	LAND DESIGNATION	LAND SUB-DESIGNATION	HECTARES
Central Reserve Sites				
2	Weir Canyon Core	core	core	53.8
4	Limestone North	core	core	46.4
7	Limestone Southwest	core	core	21.4
8	Limestone Southeast	core	core	42.7
9	Cactus Wren Canyon	core	core	45.2
10	Hangman East	core	core	25.3
11	Round Canyon	core	core	36.5
13	Mustard Road	core	core	52.1
15	Upper Agua Chinon	core	core	47.8
16	Whiting North	core	core	29.1
SUBTOTAL				400.3
Coastal Reserve Sites				
23	Camarillo Spur	core	core	65.7
24	Shady Canyon South	core	core	25.8
29	Laurel Canyon	core	core	47.2
32	Upper Emerald Canyon	core	core	64.8
34	Bommer Ridge	core	core	140.5
35	Upper Wood Canyon	core	core	42.3
37	Lag. Wild. Park East Core	core	core	34.4
38	Moro Ridge	core	core	55.6
39	El Moro Ranger Station	core	core	48.8
SUBTOTAL				525.1
GRAND TOTAL				925.4

TABLE A2 – BREAKDOWN OF EDGE SITES, 2003

SITE	DESCRIPTIVE NAME	LAND DESIGNATION	LAND SUB-DESIGNATION	HECTARES
Central Reserve Sites				
1	Upper Weir Canyon	edge	residential edge	28.0
5	Hicks Canyon North	edge	road edge	31.4
6	Rattlesnake Canyon	edge	mixed edge	32.8
12	Siphon East	edge	road edge	25.9
14	ETC Toll Plaza	edge	road edge	25.7
17	Portola South	edge	mixed edge	18.5
18	Whiting South	edge	residential edge	18.0
SUBTOTAL				180.3
Coastal Reserve Sites				
21	Laguna Laurel North	edge	mixed edge	31.6
22	Shady Canyon North	edge	residential edge	49.1
25	Bommer Canyon West	edge	residential edge	29.7
26	Bommer Canyon North	edge	road edge	35.3
27	Laguna Laurel Southwest	edge	road edge	44.4
31	No Name Ridge	edge	residential edge	36.5
36	Lag. Wild. Park East Edge	edge	road edge	56.7
40	Alta Laguna	edge	residential edge	41.8
SUBTOTAL				325.1
GRAND TOTAL				505.4

TABLE A3 – BREAKDOWN OF FRAGMENT SITES, 2003

SITE	DESCRIPTIVE NAME	LAND DESIGNATION	LAND SUB-DESIGNATION	HECTARES
Central Reserve Sites				
3	Peters Canyon	fragment	mixed edge	29.0
19	El Toro West	fragment	mixed edge	41.7
20	El Toro South	fragment	mixed edge	19.5
SUBTOTAL				90.2
Coastal Reserve Sites				
28	Northwest Sycamore Hills	fragment	road edge	39.5
30	Southeast Sycamore Hills	fragment	residential edge	55.4
33	Crystal Cove Shelf	fragment	mixed edge	20.1
SUBTOTAL				115.0
GRAND TOTAL				205.2

TABLE A4 – BREAKDOWN OF ROAD EDGE SITES, 2003

SITE	DESCRIPTIVE NAME	LAND DESIGNATION	LAND SUB-DESIGNATION	HECTARES
Central Reserve Sites				
5	Hicks Canyon North	edge	road edge	31.4
12	Siphon East	edge	road edge	25.9
14	ETC Toll Plaza	edge	road edge	25.7
SUBTOTAL				83.0
Coastal Reserve Sites				
26	Bommer Canyon North	edge	road edge	35.3
27	Laguna Laurel Southwest	edge	road edge	44.4
28	Northwest Sycamore Hills	fragment	road edge	39.5
36	Lag. Wild. Park East Edge	edge	road edge	56.7
SUBTOTAL				175.9
GRAND TOTAL				258.9

TABLE A5 – BREAKDOWN OF RESIDENTIAL EDGE SITES, 2003

SITE	DESCRIPTIVE NAME	LAND DESIGNATION	LAND SUB-DESIGNATION	HECTARES
Central Reserve Sites				
1	Upper Weir Canyon	edge	residential edge	28.0
18	Whiting South	edge	residential edge	18.0
SUBTOTAL				46.0
Coastal Reserve Sites				
22	Shady Canyon North	edge	residential edge	49.1
25	Bommer Canyon West	edge	residential edge	29.7
30	Southeast Sycamore Hills	fragment	residential edge	55.4
31	No Name Ridge	edge	residential edge	36.5
40	Alta Laguna	edge	residential edge	41.8
SUBTOTAL				212.5
GRAND TOTAL				258.5

TABLE A6 – BREAKDOWN OF MIXED EDGE SITES, 2003

SITE	DESCRIPTIVE NAME	LAND DESIGNATION	LAND SUB-DESIGNATION	HECTARES
Central Reserve Sites				
3	Peters Canyon	fragment	mixed edge	29.0
6	Rattlesnake Canyon	edge	mixed edge	32.8
17	Portola South	edge	mixed edge	18.5
19	El Toro West	fragment	mixed edge	41.7
20	El Toro South	fragment	mixed edge	19.5
SUBTOTAL				141.5
Coastal Reserve Sites				
21	Laguna Laurel North	edge	mixed edge	31.6
33	Crystal Cove Shelf	fragment	mixed edge	20.1
SUBTOTAL				51.7
GRAND TOTAL				193.2

APPENDIX B

STATISTICAL APPENDIX BY KAREN MESSER, PH.D.

STATISTICAL APPENDIX TO
TARGET BIRD MONITORING STUDY,
COMBINED REPORT 1999-2001
NATURE RESERVE OF ORANGE COUNTY
2-AUG-02

Prepared by :

Karen Messer, Ph. D
Department of Mathematics
California State University Fullerton
Fullerton, CA 92834
Phone: 760 434 4966
email: messer@fullerton.edu

PREFACE

To facilitate communication with other monitoring projects, we have attempted to present the rationale behind our approach to various questions in this appendix. Hence much of this material will not be of interest to the non-statistician. This analysis was prepared using SAS v. 8.1. Questions or comments should be addressed to Karen Messer, Dept. of Mathematics, California State University Fullerton (messer@fullerton.edu).

TABLE OF CONTENTS

1	CAGN ANALYSIS	4
1.1	Sampling design.....	4
1.2	Stratum information	4
1.3	Number of visits to each site.....	5
1.4	Example Computation of weighted estimates.....	7
1.4.1	Comparison of weighted and unweighted estimates	8
1.5	Boxplots of adjusted counts by stratum and year	9
1.6	Weighted estimates of totals, means, by year.....	10
1.6.1	Total territories by year	10
1.6.2	Total territories By reserve	10
1.6.3	Total territories by land use designation.....	11
1.7	Weighted estimates of change, by year.....	12
1.7.1	Overall change, by year.....	12
1.7.2	Change By reserve and year.....	12
1.7.3	Change by land use designation. and year.....	13
1.8	Estimate of % changes from stratified estimator, 95% CI.....	14
1.9	Changes in site boundaries	15
1.10	Poisson models of change in CAGN counts over time.....	17
1.11	Poisson Estimates of decrease/increase each year over baseline (1999).	18
1.11.1	Fit a linear time trend:	18
1.12	Normal Estimates of decrease/increase each year over baseline (1999)	19
1.13	Analysis of number of visits per site	20
1.14	Bootstrap estimates of number of visits per site	21
1.15	Stratifying by area or land designation.....	23
1.16	Sample size Estimates.....	25
1.16.1	For a Confidence interval on change in # cagn.....	25
1.16.2	For a Confidence interval on total # cagn.	26
1.17	sample size computations for estimating total # CAGN.....	27
1.17.1	For a CHANGE in CAGN, sample sizes may be adequate	27

1.17.2	For estimating T otal Cagn, existing sample sizes are not adequate.	27
1.17.3	TOTAL CAGN: Comparison of SRS ,Proportional , and optimal sampling	27
1.18	Supporting computations and sas output.....	29
2	CACW ANALYSIS.....	34
2.1	CACW counts	34
2.1.1	CACW counts, no. visits, by site and year.	35
2.2	Adjustment of visit1 data.....	37
2.3	Percent increase/decrease estimates.....	38
2.3.2	Stratified estimates of mean # CACW seen per plot:	38
2.3.3	Yearly Percent change. None are significantly different.....	38
2.4	Modeling of increase/decrease in CACW counts with time.....	39
2.5	Analysis of number of visits per site	40
2.5.4	New bootstrap: use 2 visit sites and 3 visit sites.....	41
2.6	Sample size Estimates.....	42
2.7	stratified estimate of mean, SE mean.....	43
2.8	Computations: Analysis of number of visits per site.....	44
2.8.5	Bootstrap estimate of variability.....	44
2.9	Computer output for stratified estimates of percent complete at visit 2.	45

1 CAGN ANALYSIS

1.1 SAMPLING DESIGN

The monitoring sites were randomly selected within a stratified design, sampling within subarea, land designation, and year. Each stratum was initially divided into 20 ha plots. The number of such plots with at least 50% cover of CSS is denoted "Population Total" below. A SRS of size "N Obs" 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 percent. In particular, the "fragment" stratum comprises 15% of the sample, but only 5% of the study area. Hence estimates of means, and mean differences should be appropriately weighted as shown below in the section "Computing Weighted Estimates".

The choice of model for these estimates is discussed in detail in the section "Normal or Poisson model" below. 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 percent changes in CAGN counts and the Poisson model works well for these standard errors, as verified by a bootstrap computation. An un-weighted model is misleading for estimating population totals. We adopt the policy in this analysis of consistently using weighted estimates with a normal model for major results, and occasionally using an un-weighted Poisson regression model for convenience. In the future, it is advised to program a weighted version of Poisson regression.

1.2 STRATUM INFORMATION

Stratum Index	subarea	land_des	Population Total	Sampling Rate	N Obs	N	Stratum fraction of population
1	central	core	87	11.5%	10	10	23.3%
2		edge	67	10.4%	7	7	18.0%
3		fragment	20	15.0%	3	3	5.4%
4	coastal	core	101	8.91%	9	9	27.1%
5		edge	73	11.0%	8	8	19.6%
6		fragment	25	12.0%	3	3	6.7%

17-1 0.50
0.385
0.185

1.3 NUMBER OF VISITS TO EACH SITE.

The number of repeated visits to each site during a field season changed over the three years of the study, in an empirical effort to balance more complete spatial coverage with minimal detection error at a given level of field resources. 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 seen fewer times. The first is addressed in detail in sections below, 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 the second visit where available, and to adjust counts upwards if only one visit occurred.

Because of large variability from year to year and only two years worth of data, it was decided to use a simple ratio adjustment based the number of birds seen at visit two relative to visit one. Robb Hamilton feels the first counts in 2001 were unusually low compared to the second because of rainy damp weather at the first visit. Because of this, only the 2000 data were used in the adjustment, as shown below.

COMPUTATION OF ADJUSTMENT FACTOR

2000 data	61/57 = 1.07	(with 95% confidence less than 1.28)
2001 data	134/108 = 1.24	(with 95% confidence less than 1.34)
Notes:	Confidence intervals from a Poisson model: count = year + siteno + visit x year indicator variables. There is obviously considerable year to year variation here.	

Conclusion:

The counts from 1999 and 2000 for sites which were only visited once were multiplied by 1.07 to give an adjusted count. These adjusted counts are used throughout. However, the adjustment is based on a highly variable estimate. The future analysis should explicitly incorporate the number of visits into the model, probably using a compound Poisson model. It is also suggested that monitoring be restricted to fair weather to avoid low detection rates.

TABLES OF RAW COUNTS.

Count of territories and mean number per site at visit 1, 2, or 3, broken out by the total number of visits to the site. Code: 'linear trend.sas'

		YEAR								
		1999			2000			2001		
		#	mean	N	#	mean	N	#	mean	N
total number of visits	visit number	CAGN	#		CAGN	#		CAGN	#	
1	1	163.7	4.093	40	23.54	1.471	16	.	.	.
2	1	.	.	.	.	.	.	31	1.938	16
	2	.	.	.	.	.	.	41	2.563	16
3	1	.	.	.	57	2.333	24	77	3.208	24
	2	.	.	.	61	2.542	24	93	3.875	24
	3	.	.	.	65	2.708	24	98	4.083	24

Counts for visit 2 compared to visit 1 for the sites visited more than once.

	year	
	2000	2001
	# terr	# terr
visitno		
1	57	108
2	61	134

1.4 EXAMPLE COMPUTATION OF WEIGHTED ESTIMATES

COUNT OF CAGN TERRITORIES, MEAN, STD DEV BY STRATUM

Analysis Variable : adjcount= totatvst adjusted by x 1.07 on 1st visit

year	subarea	land_des	Obs	Sum	Mean	Std	Dv
1999	central	core	10	7.490	0.749	1.241	
		edge	7	53.500	7.643	7.475	
		fragment	3	38.520	12.840	3.707	
	coastal	core	9	14.980	1.664	1.701	
		edge	8	28.890	3.611	4.042	
		fragment	3	20.330	6.777	6.270	
2000	central	core	10	4.000	0.400	0.966	
		edge	7	30.070	4.296	5.115	
		fragment	3	27.770	9.257	6.423	
	coastal	core	9	4.070	0.452	0.734	
		edge	8	10.630	1.329	2.198	
		fragment	3	8.000	2.667	3.786	
2001	central	core	10	4.000	0.400	0.843	
		edge	7	38.000	5.429	6.161	
		fragment	3	40.000	13.333	12.702	
	coastal	core	9	10.000	1.111	1.364	
		edge	8	25.000	3.125	4.486	
		fragment	3	17.000	5.667	6.429	

WEIGHTED ESTIMATES OF TOTAL CAGN PER RESERVE AND TOTAL IN STUDY AREA.

Weighted estimates are computed as in the table below. Note the weighted mean x 373 gives 1435.1 CAGN in the study area, while the raw mean x 373 yields 1562.5 CAGN, an overestimate by 6%.

year	reserve	land designation (stratum)	adjusted count	sites in sample	mean count / site	std. error count	# 20 ha sites in stratum	% of total reserve in stratum	mean count / site, weighted by % of reserve in stratum	estimated total # territories ¹	standard error estimated total ²
1999	central	core	7.49	10	0.75	1.24	87	50.0%	0.37		
		edge	53.5	7	7.64	7.48	67	38.5%	2.94		
		fragment	38.52	3	12.84	3.71	20	11.5%	1.48		
Total central							174	100.0%	4.79	834.0	197.1
	coastal	core	14.98	9	1.66	1.70	101	50.8%	0.84		
		edge	28.89	8	3.61	4.04	73	36.7%	1.32		
		fragment	20.33	3	6.78	6.27	25	12.6%	0.85		
Total coastal							199	100.0%	3.02	601.1	149.5
Total NROC			163.7	40	4.09		373		3.85	1435.1	247.4

¹ # 20 ha sites in reserve x [Sum over strata in reserve: (mean count/site for stratum) x (% reserve in stratum)]

² # 20 ha sites in stratum x square root of:

[Sum over strata in reserve: {(std err for stratum)² x (% reserve in stratum)²} / (# sites in sample for stratum)]

0.75 x 87 = 65.25
7.64 x 67 = 511.88
12.84 x 20 = 256.8

1.4.1 COMPARISON OF WEIGHTED AND UNWEIGHTED ESTIMATES

Unweighted estimates of % change do just fine here. However, standard errors should be improved if they are obtained from a weighted Poisson regression in the future. For convenience, we will sometimes take p-values and confidence intervals for percent changes from an unweighted Poisson model.

Base year	Weighted Mean territories /site (SE mean)	Weighted count** of total territories at the 40 sites	Raw count of total territories at the 40 sites	Change to or from year	% change weighted estimate	% change raw count
1999	3.85 (.62)	154 (24.8)	163.7	decrease to 2000	50%	48%
2000	1.92 (.435)	76.8 (17.4)	84.5	increase to 2001	60%	59%
2001	3.07 (.668)	122.8 (26.7)	134	decrease from 1999	20%	18%

Table 1 ** Computed as (weighted mean terr /site) $\times$ 40 sites

1.5 BOXPLOTS OF ADJUSTED COUNTS BY STRATUM AND YEAR

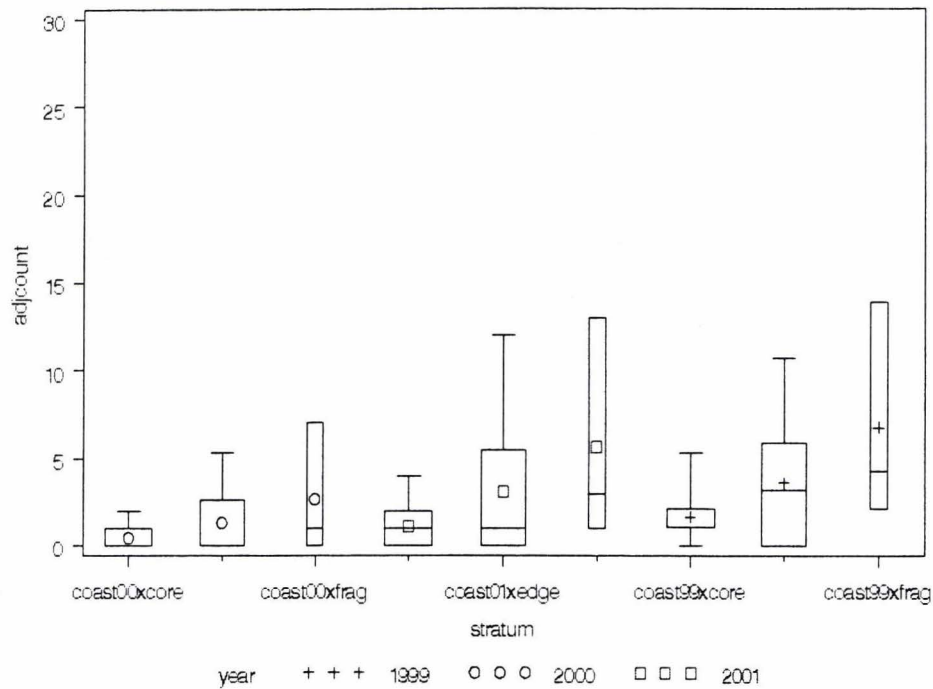
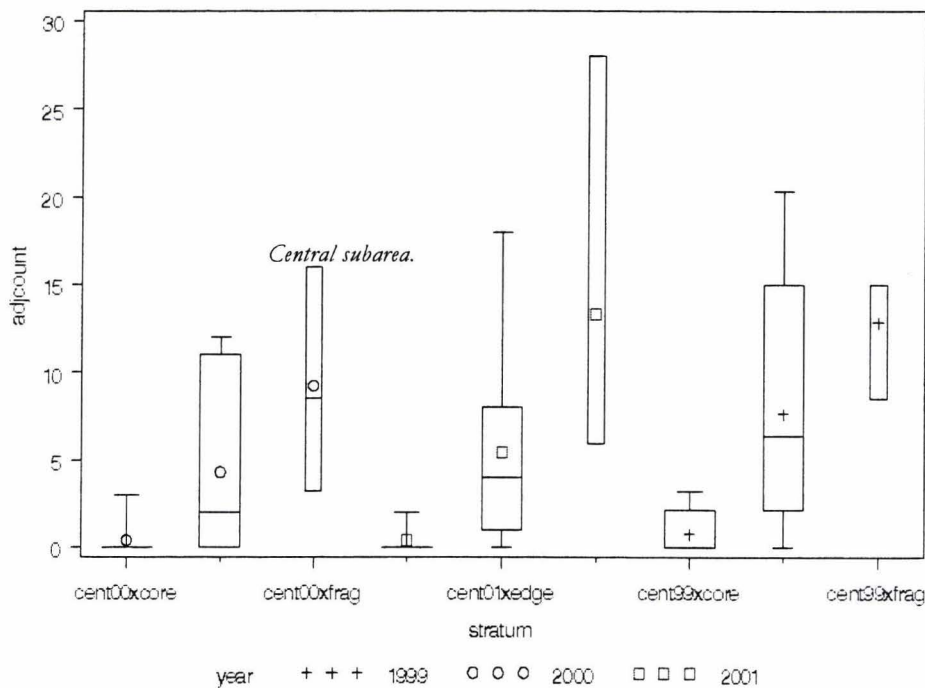


Figure Adjusted CAGN territory counts by stratum and year. Above, Coastal subarea. Below, Central Subarea. Width of box: proportional to number of sites in stratum. 1



1.6 WEIGHTED ESTIMATES OF TOTALS, MEANS, BY YEAR

Weighted estimates were computed using proc surveymeans in SAS. code: strat trendCagn2.sas.

1.6.1 TOTAL TERRITORIES BY YEAR

Overall									
Variable	DF	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
adjcount99	34	3.85	0.63	2.57	5.12	1435.2	233.59	960.47	1909.9
adjcount00	34	1.92	0.44	1.04	2.81	717.09	162.40	387.04	1047.1
adjcount01	34	3.08	0.67	1.72	4.43	1147.2	248.98	641.20	1653.2

1.6.2 TOTAL TERRITORIES BY RESERVE

subarea=coastl									
Variable	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum	
adjcount99	4.79	1.07	2.54	7.05	834.03	186.23	441.13	1226.9	
adjcount00	2.92	0.82	1.19	4.65	507.75	142.57	206.95	808.54	
adjcount01	3.82	1.16	1.38	6.26	665.18	201.39	240.29	1090.1	
subarea=central									
Variable	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum	
adjcount99	3.02	0.71	1.53	4.52	601.15	141.01	303.65	898.65	
adjcount00	1.05	0.39	0.23	1.88	209.34	77.77	45.25	373.43	
adjcount01	2.42	0.74	0.87	3.97	482.01	146.41	173.12	790.91	

1.6.3 TOTAL TERRITORIES BY LAND USE DESIGNATION

core								
Variable	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
adjcount99	1.24	0.34	0.53	1.95	233.27	63.40	99.52	367.03
adjcount00	0.43	0.18	0.04	0.81	80.47	34.36	7.98	152.97
adjcount01	0.78	0.26	0.23	1.33	147.02	48.97	43.71	250.34
edge								
Variable	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
adjcount99	5.54	1.46	2.39	8.69	775.69	204.40	334.10	1217.3
adjcount00	2.75	0.96	0.68	4.81	384.81	133.75	95.86	673.77
adjcount01	4.23	1.31	1.39	7.06	591.84	183.66	195.06	988.62
fragment								
Variable	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
adjcount99	9.47	2.08	3.70	15.25	426.22	93.61	166.30	686.13
adjcount00	5.60	1.90	0.32	10.87	251.80	85.46	14.52	489.08
adjcount01	9.07	3.57	-0.85	19.00	408.33	160.82	-38.17	854.83

1.7 WEIGHTED ESTIMATES OF CHANGE, BY YEAR

1.7.1 OVERALL CHANGE, BY YEAR

Statistics									
Variable	DF	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
diff00_99	34	-1.93	0.31	-2.56	-1.29	-718.1	116.29	-954.4	-481.8
diff00_01	34	-1.15	0.37	-1.89	-0.41	-430.1	136.16	-706.8	-153.4
diff01_99	34	-0.77	0.43	-1.65	0.11	-288.0	161.72	-616.6	40.67

1.7.2 CHANGE BY RESERVE AND YEAR

central									
Variable	DF	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
diff00_99	17	-1.88	0.49	-2.90	-0.85	-326.3	84.74	-505.1	-147.5
diff00_01	17	-0.90	0.61	-2.20	0.39	-157.4	106.63	-382.4	67.54
diff01_99	17	-0.97	0.82	-2.71	0.77	-168.9	143.19	-471.0	133.24
Coastal									
Variable	DF	Mean	Std Error Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
diff00_99	17	-1.97	0.40	-2.81	-1.12	-391.8	79.64	-559.8	-223.8
diff00_01	17	-1.37	0.43	-2.27	-0.47	-272.7	84.66	-451.3	-94.05
diff01_99	17	-0.60	0.38	-1.40	0.20	-119.1	75.18	-277.7	39.48

1.7.3 CHANGE BY LAND USE DESIGNATION. AND YEAR

core									
Variable	Mean	Std Error	Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
diff00_99	-0.81	0.24		-1.32	-0.31	-152.8	44.87	-247.5	-58.13
diff00_01	-0.35	0.22		-0.82	0.11	-66.55	41.57	-154.3	21.16
diff01_99	-0.46	0.26		-1.01	0.09	-86.25	48.84	-189.3	16.80
Edge									
Variable	Mean	Std Error	Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
diff00_99	-2.79	0.64		-4.18	-1.40	-390.9	90.26	-585.9	-195.9
diff00_01	-1.48	0.69		-2.97	0.02	-207.0	96.85	-416.3	2.21
diff01_99	-1.31	0.66		-2.73	0.11	-183.9	92.04	-382.7	14.99
Fragment									
Variable	Mean	Std Error	Mean	Lower 95% CL for Mean	Upper 95% CL for Mean	Sum	Std Dev	Lower 95% CL for Sum	Upper 95% CL for Sum
diff00_99	-3.88	1.29		-7.45	-0.30	-174.4	58.00	-335.4	-13.39
diff00_01	-3.48	1.92		-8.80	1.84	-156.5	86.20	-395.9	82.80
diff01_99	-0.40	2.75		-8.03	7.23	-17.88	123.68	-361.3	325.51

1.8 ESTIMATE OF % CHANGES FROM STRATIFIED ESTIMATOR, 95% CI

The percent change is computed as the ratio of (change)/(starting value). The standard error of the ratio is computed using a second order Taylor expansion, which includes the correlation between the numerator and the denominator.

OVERALL PERCENT CHANGE

Year	percent change	Correlation Baseline x increase (decrease)	std err %	LCL	UCL
1999 2000	-0.50	0.76	0.045	-7.5%	-2.6%
2000- 2001	-0.60	0.51	0.075	47.6%	72.4%
1999- 2001	0.20	0.17	0.103	-36.9%	-3.2%

Figure 2 Change 99-01 by site and subarea. Reference line indicates no change.

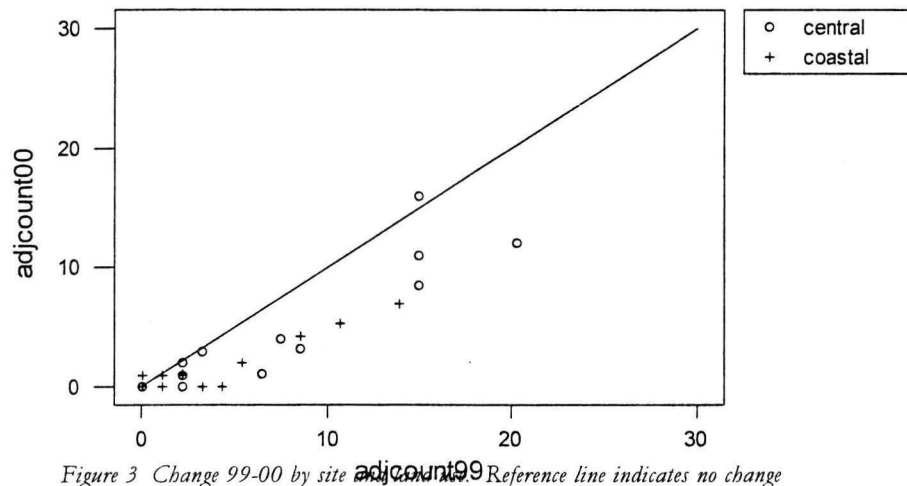
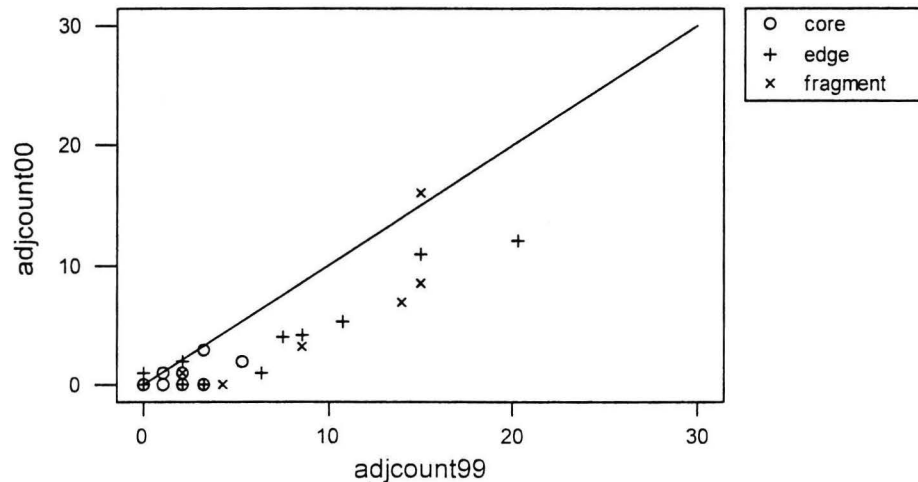


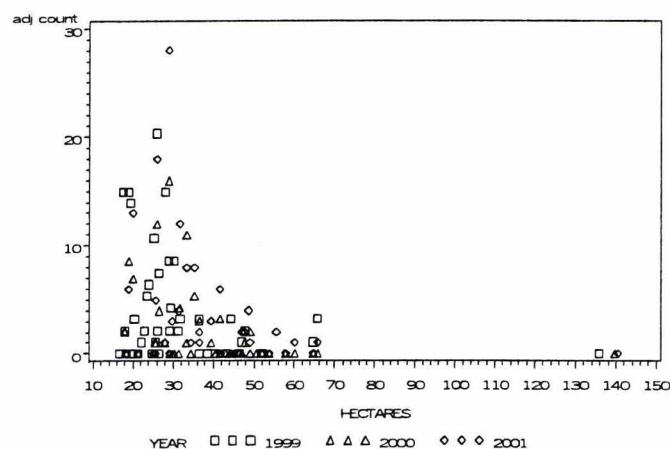
Figure 3 Change 99-00 by site and subarea. Reference line indicates no change



1.9 CHANGES IN SITE BOUNDARIES

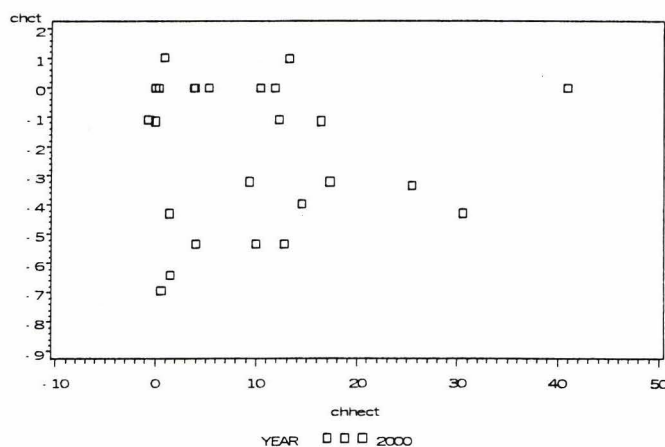
The original sites were chosen in a stratified random sample from among a listing of 20ha plots containing at least 50% CSS using a GIS representation of the NROC. In the first field season, it was necessary to adjust site boundaries in many cases, either because the originally selected site was inaccessible without considerable damage to the resource, or for safety reasons. Also, the total size of some sites was increased from 20 ha, generally those with fewer territories, as a survey in the absence of CAGN is faster than establishing the location of an active territory or verifying a previous territory record. Thus acreage of a site is negatively correlated with the count of territories at the site in all years (stratified regression of count on site area, $t=4.01$, $p<0.001$).

Figure 4. Territory count by site area. Negative correlation is significant, $p < 0.01$, stratified regression estimate.



The total area surveyed increased by 246 ha or 18.5% in 2000, and again by 25 ha in 2001, raising concern that in 2000 the increase in acreage would mitigate the drop in the number of CAGN. However, change in hectares was not a significant predictor of change in count of territories (stratified regression of change in count on change in site area 1999-2000: using only sites which increased in area, coefficient of hectares -0.08 territories/ha, 95% c.i. -0.21 to 0.05, $t=1.51$, $p=0.17$). Hence no adjustment for the boundary change was included.

Figure 5 Change in territory count by change in site area, 1999-2000, excluding sites with no boundary change. Negative correlation is ns, $p=0.17$, stratified regression estimate.



Note that the design will be slightly biased towards overestimation of the total number of CAGN in the study area, which is computed as the per site mean x 373 sites in the sampling frame. Density estimates within regions are similarly computed as estimated total for the region / estimated area for the region, and are also slightly biased. Note that density per site should not be used in the analysis. However the estimate of change over time is computed within sites, and remains unbiased. By increasing the detection rate at sparsely populated sites, the power to detect change over time is increased by this design. If sparsely occupied sites are a more sensitive indicator of population increase or decline, the power may be strongly increased.

1.10 POISSON MODELS OF CHANGE IN CAGN COUNTS OVER TIME.

File 'linear trend.sas'. 'strat trend CAGN2.sas'

A Poisson model and a normal stratified model are considered. A description of each is given below. In addition, in the future it may be useful to consider a quasi-likelihood using the empirical relation of the mean equal to the standard deviation on the data aggregated by stratum.

Conclusions:

The normal model adjusts for the stratified design and is unbiased. However, the residuals exhibit the classic "fan" shape. The estimated standard errors will be larger than they should be.

The Poisson model fits well. It will have somewhat smaller confidence intervals than the normal model. However, if percent change within strata varies widely, it will be biased, as the basic Poisson model does not adjust for the stratified design. It works well for these CAGN data, as the change is fairly uniform across strata.

Either model works fine in practice for these data and both agree closely w/ bootstrap estimates of confidence intervals (not given here). Example:

Estimated percent drop 1999-2000

Poisson model 48%

Normal model 50%

95% Confidence interval

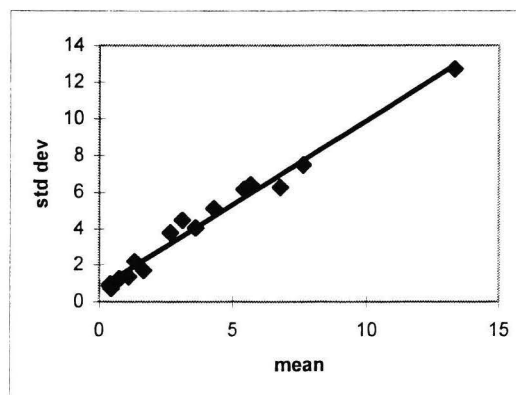
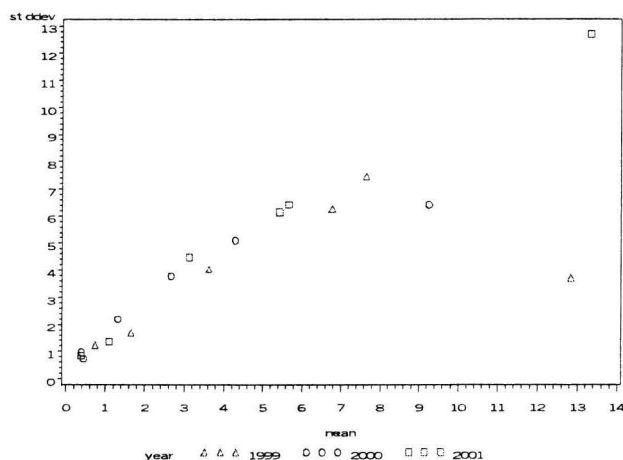
Poisson model: 61% to 31% decrease

Normal model 67% to 31% decrease.

Suggestion for future: program a stratified Poisson model or quasi-likelihood as described above.

Relation between mean and standard deviation of (Adjusted) counts

Each point in the scatterplot below is one stratum at one year. For each stratum, the mean and standard deviation of the count per plot is computed for each year. Perfectly linear. The two outliers are "fragment" sites w/ $n=3$ each. Hence in the future we may at times want to use the mean as the estimated standard deviation.



1.11 POISSON ESTIMATES OF DECREASE/INCREASE EACH YEAR OVER BASELINE (1999).

A Poisson model fits well, with sites random or sites fixed and overdispersion estimated by the deviance. The offset is lnhectares so the output of the model is mean CAGN territories per hectare. Response is count at visit 2, or adjusted count at visit 1 for sites with only one visit. (Adjusted counts are count multiplied by 1.07.

In this preliminary analysis, these Poisson models do not compute means or variances using the stratified design. In these data changes from year to year are roughly proportional within strata. In the future, a proper stratified Poisson estimate should be programmed. This will reduce standard errors and shrink confidence intervals.

The model is *additive*: count(adjusted) = site + year offset = lnhectares. This leaves 78 d.f. The model is neither over- nor under- dispersed. The residuals look good.

Table of estimated effect sizes Change in CAGN from base year 1999 to Year 2000 or 2001. An overall test of the year effect is significant at $p < 0.0001$.

Year	Observed % change in number of CAGN :	Estimated % change in mean # of CAGN per plot	Parameter estimate (std dev)	p	95% C.I.	
2001	18% decrease	18% decrease	-0.200 (.1255)	0.11	36% decrease	5% increase
2000	48% decrease	48% decrease	-.669 (0.144)	<0.001	61% decrease	31% decrease

1.11.1 FIT A LINEAR TIME TREND:

These data do not support fitting a linear time trend, as opposed to modeling each year separately (likelihood ratio test; $-2 \log \Lambda = 183$, d.f. = 1; $p < 0.0001$). If we do so anyhow, the coefficient on time is ns ($p = .13$).

Table of parameter estimates: from poisson model:

ANALYSIS OF PARAMETER ESTIMATES								
PARAMETER		DF	ESTIMATE	STANDARD ERROR	WALD	95% CONFIDENCE LIMITS	CHI-SQUARE	PR > CHISQ
INTERCEPT		1	-1.5800	0.3260	-2.2190	-0.9410	23.49	<.0001
YEAR	2001	1	-0.2003	0.1255	-0.4462	0.0457	2.55	0.1105
YEAR	2000	1	-0.6609	0.1443	-0.9436	-0.3781	20.98	<.0001
YEAR	1999	0	0.0000	0.0000	0.0000	0.0000	.	.
SITENO	5	1	-0.6144	0.5396	-1.6721	0.4433	1.30	0.254
SITENO	12	1	1.4894	0.3540	0.7956	2.1831	17.71	<.000
siteno	14	1	0.3735	0.4154	-0.4407	1.1878	0.81	0.368
:								
siteno	39	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	1.0772	0.0000	1.0772	1.0772		

Parameter interpretation for poisson model

In a Poisson model, the coefficient on an indicator variable is the log of a multiplicative effect. For example, the mean number of CAGN in 2001 is estimated to be $\text{Exp}(-0.2003) = 0.82$ times the mean number in 1999, an 18% decrease. A 95% confidence interval for the decrease is given by $\text{exp}(0.0457) = 1.05$ to $\text{exp}(-.4462) = 0.64$, from a 5% increase to an 36% decrease.

1.12 NORMAL ESTIMATES OF DECREASE/INCREASE EACH YEAR OVER BASELINE (1999)

Using a normal model appropriately weighted for the stratified design, sampling within subarea, land designation and year (18 strata).

File: strat trend cagn2.sas

These models show a classic “fan” shape in the residuals, and so are not correct. However, they do correctly take into account the stratified design, and are unbiased for population means. They have larger standard errors than the Poisson model, but the Poisson model may be biased.

These normal models are easier to interpret, as the coefficients are just difference from baseline (1999) in units of number of territories.

Coefficient of variation 99-2000 is 15.1%

Estimated drop is 77 (48 to 104) territories, a 50% decrease from the 154 estimated for 2000 (over the 40 sample sites.). This agrees w/ the naïve and Poisson estimates of 48%. A similar estimate on the year to year difference within sites yields the same estimates, but a larger std. error because of the loss of degrees of freedom. (e.g. cv 99- 2000 is 16.2%)

95% Confidence interval Poisson model: 61% to 31% decrease
Strat. Estimate 67% to 31% decrease.

ANOVA for Dependent Variable adjcount					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	41	22632.23	552.0056	17.40	<.0001
Error	78	2474.89	31.7293		
Corrected Total	119	25107.11			
Effect	Num DF	F Value	Pr > F		
Model	41	18.21	<.0001		
Intercept	1	185.10	<.0001		
year2000	1	30.79	<.0001		
year2001	1	3.58	0.0613		
siteno(subarea*land_des)	34	17.18	<.0001		
subarea*land_des	5	52.82	<.0001		
The denominator degrees of freedom for the F tests is 102.					
Parameter	95% CONFIDENCE Interval			DESIGN Effect	
Intercept	9.127995	15.2768512		2.03	
year2000	-2.613330	-1.2370465		0.79	
year2001	-1.581507	0.0373436		1.10	

Table of parameter estimates: from Normal model:

Parameter interpretation for Normal model

These normal models are easier to interpret, as the coefficients are just difference from baseline (1999) in units of mean number of territories per plot

For example, the estimated drop from 1999 to 2000 is 1.925 CAGN / plot x 40 plots in sample = 77 territories in the sample. A 95% confidence interval for the drop is similarly given as -2.6 x 40 to -1.2 x 40.

1.13 ANALYSIS OF NUMBER OF VISITS PER SITE

% of visit 3 total achieved by visit 2: 95% lower confidence intervals

As a two visit protocol is suggested in the future, it is of interest to estimate what percent of the total number of territories seen in 3 visits will be seen in two visits.

In 2000, three sites out of the 18 3 visit sites which saw CAGN missed 1, 1, and 2 CAGN each at visit 2. In 2001, two of these sites missed 1 and 4 CAGN each.

Two bootstrap methods were used, which are described below. *In the future, a capture/recapture model will be used, assuming the number of territories at a site to be Poisson with parameter λ determined by conditions at the site, and the detection probability at a visit to be independent with probability p determined by conditions at the visit.*

Overall Conclusions:

Across the range of variation in these data, a 95% lower confidence limit of 90% complete by visit 2 seems supportable. That is, *the 2 visit protocol will see 90% or more of the 3 visit total CAGN territories 95% of the time.*

A two visit protocol seems more reliable on a percentage basis when there are more CAGN. A sensitivity analysis should be run to ensure that the 90% figure is still appropriate when there are fewer CAGN.

Robb has suggested that both visits be required to be in fair weather. This will be modeled in the capture/recapture approach. See the discussion on visit 1 adjustments.

1.14 BOOTSTRAP ESTIMATES OF NUMBER OF VISITS PER SITE

There were 18 sites with 3 visits where gnatcatchers were seen during the study. These were resampled to make $N=10,000$ bootstrap samples. A measure of the percent of total CAGN seen by visit 2 was constructed for each bootstrap sample. The 95th percentile of the bootstrap distribution was taken as the estimate of the upper confidence limit. These estimates may be biased, as the three visit sites on average had more CAGN at visit 2, and a higher percent complete on average.

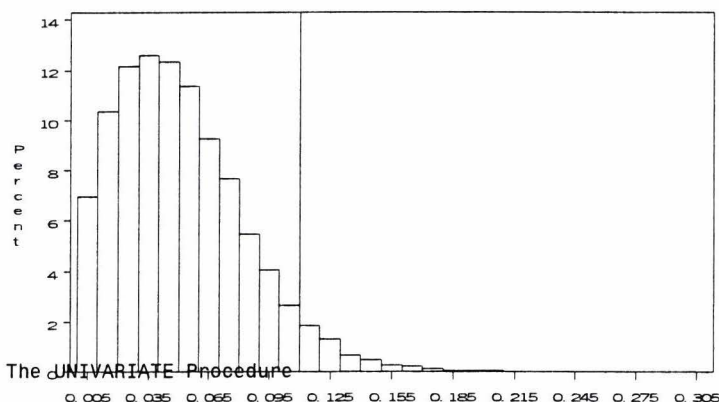
Two bootstrap sample of size $N = 10000$ will be computed

Sites will be resampled within the original strata, using the 24 sites with 3 visits, and combining years. The number missed at visit 2 relative to visit 3 will be resampled. The total number at visit 3 will also be resampled independently. This will increase the variability of the estimate, giving conservative confidence limits.

Stratified estimates of the total # of CAGN missed at visit 2 and of total # seen at visit 3 will be computed, using the sampling weights from these 24 sites. The percent complete will be computed as the ratio of these estimates.

Code: 'bootstrap2of3faircagn.sas'

Percent missed on visit 2 out of 3. Bootstrap distribution, 10,000 samples.

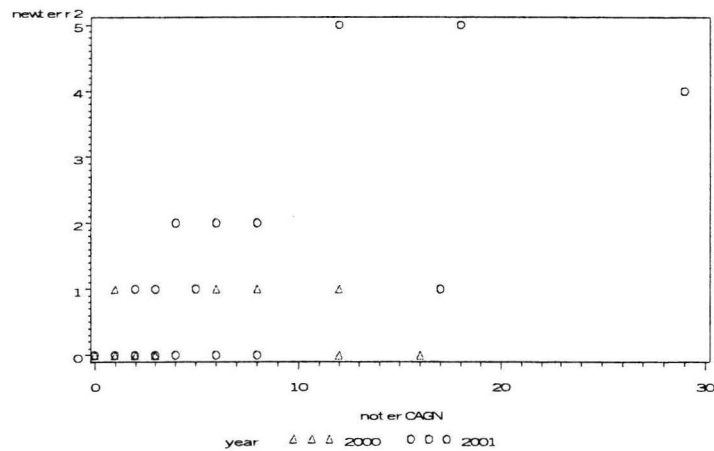


Quantile	Estimate	Variable: perc2of3		
100% Max	0.30767656	Mean	0.050771	Std Deviation
99%	0.14553855	Median	0.046303	Variance
95%	0.11011460	Mode	0.00105	
90%	0.09430977		0.000000	Range
75% Q3	0.06990914		0.30768	Interquartile Range
50% Median	0.04630292		0.04349	
25% Q1	0.02641642	<i>Conclusion:</i>		
10%	0.01279089	This "fair" bootstrap supports a 95% LCL of greater than 90%. This may be adequate. A mark-recapture model shows no dependence of site discovery with visit number. It gives an estimated detection probability of .8, which would yield an estimated detection rate of 96% after two visits. (Paul Dougherty, USFWS, personal communication.)		
5%	0.00855578			
1%	0.00000000			
0% Min	0.00000000			

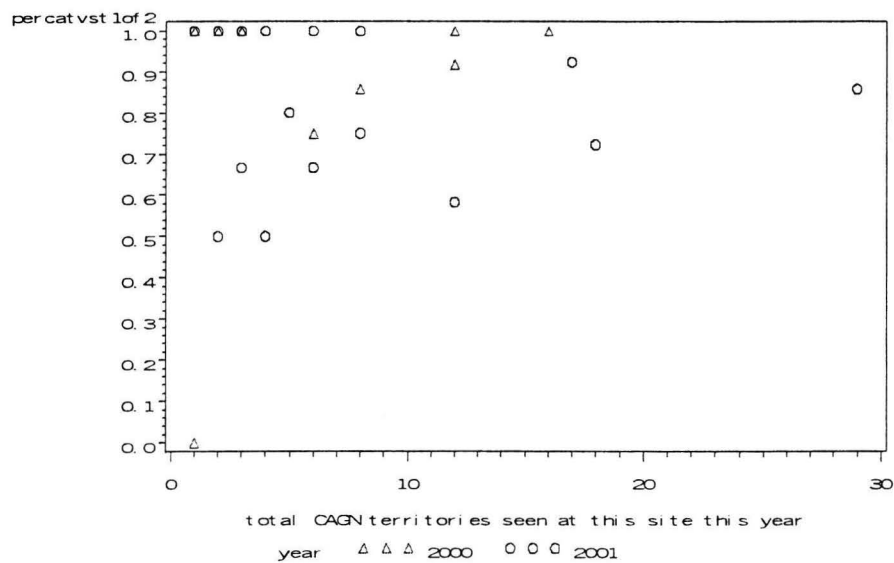
Bootstrap: Miss rates vary by # OF CAGN AT THE SITE

Note there is a positive relation between # of territories missed at visit one and total # of CAGN territories detected at the site.

of new territories at visit2



The percent complete at visit 1 as proportion of total seen at visit 2 also rises as the # of territories at visit 2 rises.



1.15 STRATIFYING BY AREA OR LAND DESIGNATION.

Here sites are included as a source of random variation within area or land designation.

The model is e.g. $\text{count} = \text{year} + \text{land designation} + \text{site}$ where *site* is random.
Offset = lnhectares.

Coefficient estimates on next page.

Search for appropriate stratifying variables:

Sub area is almost significant ($p=.11$, Score test, sites random). Central did better than coastal.

Land_des is sign ($p=.004$) However edge was not s different from fragment ($p=.21$). Edge and fragment did better than core ($p<.001$). Subarea x Land_des interaction ns ($p = .70$)

Create new variable "core" or "frag/edge" Sing at $p = .0012$

Land_subdes is sign ($p=0.004$). Gives a better fit, in the form of reduced residual variation. Now subarea is really ns ($p=.20$)

- o Road edge not s different from mixed edge $p = .13$
- o Core is not s different from residential edge $p = .17$
- o Road and mixed edge did better than residential and core $p<.001$.

High density sites, defined as $\text{CAGN} > 0.2$ territories /hectare in 1999, are also significantly higher in 2000 and 2001 ($p<.0001$ in a model with only years 2000 and 2001), bearing out the hypothesis that these sites are better quality habitat.

Although Low density sites are observed to be more volatile than High density sites on the basis of their percent decrease or increase from year to year, the excess volatility in the data for 2000 to 2001 is ns ($p=.18$). More years of data are needed to adequately test this hypothesis.

If DENSITY is included, Land_subdes is no longer sign. ($p=.18$)

MODELS: ALL INCLUDE YEAR.

Subarea + land designation

.subarea	central	0.5161	0.3094	-0.0903	1.1225	1.67	0.0953
subarea	coastal	0.0000	0.0000	0.0000	0.0000	.	.
land_des	edge	1.5086	0.3289	0.8640	2.1532	4.59	<.0001
land_des	fragment	1.9772	0.3478	1.2955	2.6589	5.68	<.0001
land_des	core	0.0000	0.0000	0.0000	0.0000	.	.

Subarea + edge/frag. vs. core

subarea	central	0.5259	0.3077	-0.0773	1.1290	1.71	0.0875
subarea	coastal	0.0000	0.0000	0.0000	0.0000	.	.
core	frag/edge	1.6495	0.2946	1.0722	2.2268	5.60	<.0001
core	core	0.0000	0.0000	0.0000	0.0000	.	.

Density models. Estimate only based on 2000, 20001 data

Model 1 (2000 2001 data only)

den	H	2.4961	0.3077	1.8931	3.0991	8.11	<.0001
den	L	0.0000	0.0000	0.0000	0.0000	.	.

Model 2

Land Subdesignation models:

Model 1

land_subdes	road edge	1.4055	0.3989	0.6237	2.1872	3.52	0.0004
land_subdes	residential edge	0.3902	0.2827	-0.1639	0.9443	1.38	0.1675
land_subdes	mixed edge	1.9487	0.2383	1.4816	2.4159	8.18	<.0001
land_subdes	core	0.0000	0.0000	0.0000	0.0000	.	.

Model 2

roadmix	1.7546	0.2861	1.1939	2.3153	6.13	<.0001
---------	--------	--------	--------	--------	------	--------

ARE LAND SUB-DESIGNATION AND DENSITY RELATED?

Yes, very clearly so ($p < .0001$, Fisher's exact test).

Residential edge and Road edge are not related to H, L ($p = .25$), but Core and Mixed edge are out of proportion under the null hypothesis ($p < .001$, Fisher's exact test).

CAGN counts by density class

density land_subdes

Frequency

Percent

Col Pct	'core	'mixed ed	'residential	'road edg'	Total
	'core	'ge	'ial edg	'e	
L	10	0	5	3	18
	34.48	0.00	17.24	10.34	62.07
	90.91	0.00	83.33	50.00	
H	1	6	1	3	11
	3.45	20.69	3.45	10.34	37.93
	9.09	100.00	16.67	50.00	
Total	11	6	6	6	29
	37.93	20.69	20.69	20.69	100.00

Fisher's Exact Test

Table Probability (P) 3.815E-05
Pr <= P 6.874E-04

1.16 SAMPLE SIZE ESTIMATES

1.16.1 FOR A CONFIDENCE INTERVAL ON **CHANGE** IN # CAGN

, ASSUMING A LINEAR MODEL AND FIVE YEARS OF DATA.

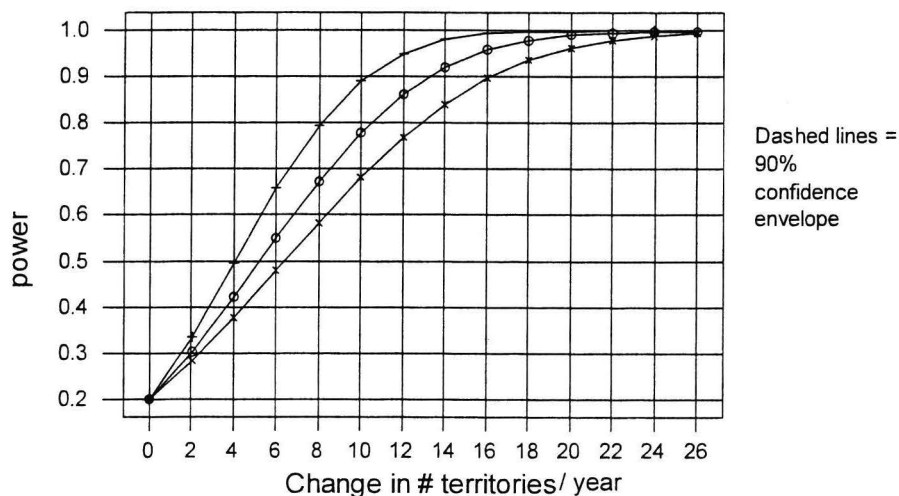
A pooled estimate (over years and strata) of the standard error of the mean annual change in territories per site using a normal stratified estimator on within site differences is 0.34. A bootstrap estimate of the standard error of the mean from the stratified estimator is 0.33, from 10,000 replicates resampling within strata over the two combined differences 99-00 and 00-01.

Note the bootstrap and reported estimates of the standard error of the mean are close. Hence we will use the quantiles of the bootstrap distribution of the reported standard errors to give an approximate 90% confidence interval for the standard error of the stratified estimator of the mean. This yields an approximate 90% confidence interval of from 0.24 to 0.38. The median value is 0.31.

Hence the estimated standard error in the estimate of the change in total territories over the 40 sites is 12.6, giving a margin of error in a 90% confidence interval for the change in total territories of ± 20.7 (at 90% confidence, the margin of error is from ± 16 to ± 25). Assuming a linear model, combining 5 years of data yields four independent such estimates, giving an approximate estimated 90% confidence interval for the slope of ± 10 territories / year (from ± 8 to ± 12.5 territories).

The approximate power curves below are computed using a model of linear change as above, assuming the slope is tested with a z test against a one-sided hypothesis at with a 20% type I error rate. The standard error of the mean is taken from the bootstrap estimates, as are the 90% confidence limits on the standard error.

Power to detect a change in # of territories, alpha = .20



Power to detect a decrease in the number of CAGN, assuming a linear change over five years. Standard error of the change is estimated by the bootstrap, as are the 90% confidence limits for that standard error.

1.16.2 FOR A CONFIDENCE INTERVAL ON **TOTAL** # CAGN.

We are required to estimate the sample size need to estimate CAGN total within $\pm 20\%$ at 90% confidence. For economy, instead we use one sided interval: We require the 90% upper confidence limit (UCL) of the estimated total to be no less than 80% of the true population total. Then 90% of the time, our estimate will be above 80% of the true population total.

Should this be computed as an upper confidence limit instead? So that 90% of the time, our estimate will be no more than 20% over the true population level?

Either condition is the same as requiring the coefficient of variation (CV) of the estimated mean to be less than 15.5%, under a normal approximation.

The normal approximation is adequate, as verified by a bootstrap estimator.

The existing sample size is not large enough for CAGN, although it is for CACW.

Adequacy of the sample size depends on :

- The total number of territories. Larger numbers of birds are estimated with greater percentage accuracy.
- The distribution of territories among the strata. Specifically, the mean and standard deviation of the mean # territories / plot for each stratum.
- The allocation of number of plots sampled per stratum.
 - A common allocation strategy is to make the sample size in a stratum proportional to the population size in the stratum (Proportional sampling). This is approximately what has been done.
 - The Optimal allocation strategy depends on the mean and standard deviation mentioned above. Much smaller samples can be used under optimal sampling, but they depend on the mean and standard deviation being stable over the years.
- After discussion with Dr. Paul Doherty, William Miller (both USFWS), and Robb Hamilton, it was decided to continue the current sampling design for the 2002 season. Karen Messer and Paul Doherty will discuss adaptive designs or rotating panel designs for the following season, and present these for consideration.

Below are preliminary sample size computations. Using the existing design, and adding sites to approximate an optimal sampling allocation, an adequate sample size for numbers of birds seen over these three years is achieved at $n = 50$. However, this may not be adequate if the number of CAGN drops substantially.

We need to investigate model-based estimators (post-stratification, ratio estimators) more carefully. An initial look at a ratio estimator using hectares of habitat was disappointing.

1.17 SAMPLE SIZE COMPUTATIONS FOR ESTIMATING TOTAL # CAGN

1.17.1 FOR A **CHANGE** IN CAGN, SAMPLE SIZES MAY BE ADEQUATE

Given the assumptions of section 15, a we can be 95% confident to have power of 90% or more to detect a loss of 16 territories per year over 5 years.

1.17.2 FOR ESTIMATING **TOTAL** CAGN, EXISTING SAMPLE SIZES ARE NOT ADEQUATE.

Existing Sample: 90% one sided confidence limits for mean (# terr / plot). n = 40 need LCL > .80 x estimated mean					
year	Bootstrap approx for <u>proportional</u> sampling total count seen = 163, 84.4 and 133.6 20% decrease = 130, 67.5, 106		Current stratified estimates Mean # terr per plot projected # terr in 40 plots		
	LCL bootstrap	LCL, bootstrap normal quantiles	Est. Mean (std error of mean)	CV	LCL (20% decrease in mean)
1999	129.5	128.3	3.85 (.62) 154 (24.8)	16.3%	2.78 (3.05) 111.2 (122.0)
2000	58.5	59.9	1.92 (.435) 76.8 (17.4)	22.6%	1.35 (1.53) 54.35 (61.44)
2001	96	91.6	3.07 (.668) 122.8 (26.7)	21.7%	2.21 (2.45) 88.4 (98)

From the bootstrap comparisons, we may have confidence in using estimated standard errors with a normal approximation. The current stratification scheme does not achieve the efficiency of proportional sampling. Even under proportional sampling in none of the years is n=40 an adequate sample size..

1.17.3 TOTAL CAGN: COMPARISON OF SRS ,PROPORTIONAL , AND OPTIMAL SAMPLING

	Estimated variance	Std dev at n=40	CV
SRS	(1/n) 22.4	0.75	25.4%
Proportional	(1/n) 14.93	0.61	20.6%
Optimal	(1/n) 8.24	0.45	15.25%

These computations use the observed average mean and std. dev for each stratum, at the overall average mean of 2.95 (= 118 observed territories under SRS.) File 'bootstrap pwr.sas'.

We see that under optimal sampling, the sample of size n=40 is adequate, but not under any other sampling scheme. This discussion ignores the finite population correction, which is at about 90% for these data.

Hybrid: Here are the proportional, the optimal, and a suggested hybrid sample sizes for the observed data at $n = 50$. The hybrid leaves the existing design intact, and adds 10 sites.

The suggested allocation does not quite meet the goal: the coefficients of variation of the estimator for the three years are 13% 18% and 17% respectively. The optimal allocation has CV of 12% ,16%, and 15.5% at $n=50$.

.year	sub	land	n pop	suggstd	propor	optimal	sample	seen	mean	Sdev	% of pop
1999	central	core	87	10.0	11.7	4.1	10	3	0.7	1.2	0.23
1999	central	edge	67	11.0	9.0	19.2	7	6	7.6	7.5	0.18
1999	central	fragment	20	5.0	2.7	2.8	3	3	12.8	3.7	0.05
1999	coastal	core	101	9.0	13.5	6.6	9	8	1.7	1.7	0.27
1999	coastal	edge	73	10.0	9.8	11.3	8	6	3.6	4.0	0.20
1999	coastal	fragment	25	5.0	3.4	6.0	3	3	6.8	6.3	0.07
2000	central	core	87	10.0	11.7	4.8	10	3	0.4	1.0	0.23
2000	central	edge	67	11.0	9.0	19.4	7	6	4.3	5.1	0.18
2000	central	fragment	20	5.0	2.7	7.3	3	3	9.3	6.4	0.05
2000	coastal	core	101	9.0	13.5	4.2	9	8	0.5	0.7	0.27
2000	coastal	edge	73	10.0	9.8	9.1	8	6	1.3	2.2	0.20
2000	coastal	fragment	25	5.0	3.4	5.4	3	3	2.7	3.8	0.07
2001	central	core	87	10.0	11.7	2.7	10	3	0.4	0.8	0.23
2001	central	edge	67	11.0	9.0	15.1	7	6	5.4	6.2	0.18
2001	central	fragment	20	5.0	2.7	9.3	3	3	13.3	12.7	0.05
2001	coastal	core	101	9.0	13.5	5.0	9	8	1.1	1.4	0.27
2001	coastal	edge	73	10.0	9.8	12.0	8	6	3.1	4.5	0.20
2001	coastal	fragment	25	5.0	3.4	5.9	3	3	5.7	6.4	0.07

This allocation does work for the CACW. The cv's are 10%, 12% 12%.

These are the profiles of the std deviations of the mean counts within years, averaged over years. I.E the central fragment std dev is 29% of the sum of total std dev's

	std dev
central core	0.04
central edge	0.25
central fragment	0.29
coastal core	0.05
coastal edge	0.14
coastal fragment	0.22

1.18 SUPPORTING COMPUTATIONS AND SAS OUTPUT

Sample size for stratified est..

Mean x std dev for strata across years.

Average mean and std dev by stratum across years.

N	subarea	land_des	Obs	Variable	Mean
	central	core	3	mean	0.5163333
				stddev	1.0166667
		edge	3	mean	5.7893333
				stddev	6.2503333
		fragment	3	mean	11.8100000
				stddev	7.6106667
	coastal	core	3	mean	1.0756667
				stddev	1.2663333
		edge	3	mean	2.6883333
				stddev	3.5753333
		fragment	3	mean	5.0370000
				stddev	5.4950000

Use averages to
left, average
overall mean of
2.95 (= 118 total
observed)

*Estimated Variance of mean given SRS, Proportional sample,
optimal sample:*

$$Var(\bar{X} | \text{SRS}) = 1/n \sum_{\text{strata}} W_s (\mu_s - \mu)^2 + \sum_{\text{strata}} W_s \sigma_s^2$$

$$Var(\bar{X} | \text{proportional sample}) = 1/n \sum_{\text{strata}} W_s \sigma_s^2$$

$$Var(\bar{X} | \text{optimal sample}) = 1/n \left(\sum_{\text{strata}} W_s \sigma_s \right)^2$$

	Estimated variance	Std dev at n=40
SRS	(1/n) 22.4	0.75
Proportional	(1/n) 14.93	0.61
Optimal	(1/n) 8.24	0.45

Computations for formulas

land_des	npop	mnmmct	mnstddevct	wgt	muvar	proporvar	optvar
core	87	0.5163	1.01667	0.23324	5.9227	1.381	0.237
edge	67	5.7893	6.25033	0.17962	8.0618	1.448	1.123
fragment	20	11.8100	7.61067	0.05362	78.4996	4.209	0.408
core	10	1.0757	1.26633	0.02681	3.5131	0.094	0.034
edge	73	2.6883	3.57533	0.19571	0.0685	0.013	0.7
fragment	25	5.0370	5.49500	0.06702	4.3556	0.292	0.368

Counts of plots which never saw CAGN by stratum

Table of subarea by land_des

subarea	land_des		Total
Frequency	core	edge	
central	7	1	8
coastal	1	2	3
Total	8	3	11

SAS OUTPUT: BOOTSTRAP OF STRATIFIED ESTIMATES OF ANNUAL CHANGE IN MEAN #
TERRITORIES / SITE.

Bootstrap of stratified estimate of mean # of territories / site

The UNIVARIATE Procedure

Variable: diff_Mean

Moments

	N	10000	Sum Weights	10000
	Mean	-1.5393163	Sum Observations	-15393.163
	Std Deviation	0.33373934	Variance	0.11138195
Quantile	Estimate			
100% Max	-0.329597			
99%	-0.791409			
95%	-0.998656			
90%	-1.111982			
75% Q3	-1.305093			
50% Median	-1.540750			
25% Q1	-1.765734			
10%	-1.967974			
5%	-2.096220			
1%	-2.325641			
0% Min	-2.787849			

Bootstrap estimates of variability of reported std errors of stratified estimator

N	10000	Sum Weights	10000
Mean	0.31090621	Sum Observations	3109.06209
Std Deviation	0.04464856	Variance	0.00199349
Skewness	0.02027616	Kurtosis	-0.1888687
Uncorrected SS	986.559651	Corrected SS	19.9329434
Coeff Variation	14.3607803	Std Error Mean	0.00044649
Quantile	Estimate		
100% Max	0.470219		
99%	0.413483		
95%	0.384275		
90%	0.368755		
75% Q3	0.341754		
50% Median	0.310995		
25% Q1	0.279604		
10%	0.253441		
5%	0.237578		
1%	0.212627		
0% Min	0.149207		

Sas output: bootstrap of Stratified estimates of annual change in mean # territories / site. .

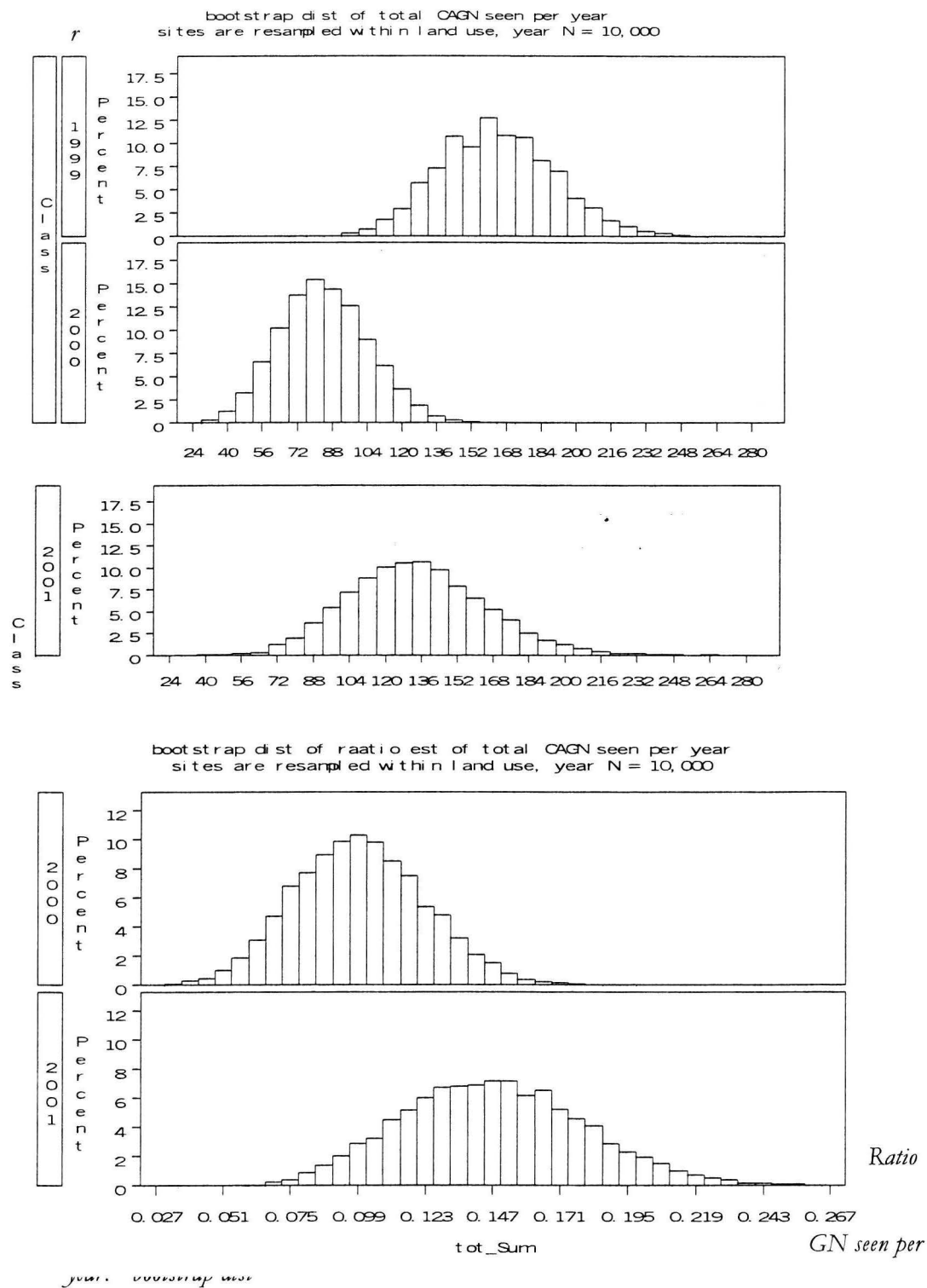
Computed on within site differences, by year. Proc surveymeans.

The SURVEYMEANS Procedure							
Statistics							
Variable	DF	Mean	Std Error of Mean	Var of Mean	t Value	Pr > t	Lower 95% CL for Mean
diff00_01	34	-1.153107	0.365033	0.133249	-3.16	0.0033	-1.894942
diff01_99	34	-0.772081	0.433570	0.187983	-1.78	0.0839	-1.653202

Statistics						
Variable	Upper 95% CL for Mean	Coeff of Variation	Sum	Std Dev	Var of Sum	Lower 95% CL for Sum
diff00_99	-1.291590	-0.161944	-718.095183	116.291261	13524	-954.427460
diff00_01	-0.411271	-0.316565	-430.108790	136.157199	18539	-706.813510
diff01_99	0.109039	-0.561560	-287.986393	161.721696	26154	-616.644421

Statistics	
Variable	Upper 95% CL for Sum
diff00_99	-481.762905
diff00_01	-153.404069
diff01_99	40.671636

*SAS output for estimates of sampling variability of CAGN total
bootstrap sites within stratified design (land use) within yea*



The UNIVARIATE Procedure

Variable: tot_Sum

year = 2001

Moments

N	10000	Sum Weights	10000
Mean	0.14735433	Sum Observations	1473.54328
Std Deviation	0.0323029	Variance	0.00104348
Skewness	0.22769964	Kurtosis	-0.1611532

year = 2000

Moments

N	10000	Sum Weights	10000
Mean	0.09944834	Sum Observations	994.483424
Std Deviation	0.02319971	Variance	0.00053823

Lcl's from bootstrap quantiles: .07 0.10 .6

Estimates from normal additive Model Year + site

year	land_des	subarea	Estimate	Error	DF
2000	edge	central	1.4576	0.3515	
2000	edge	coastal	0.2842	0.5912	90% LCL
2000	core	central	-0.9163	0.9638	2.729627
2000	core	coastal	-0.7936	0.9554	619744
2000	fragment	central	2.2253	0.3658	
2000	fragment	coastal	0.9808	0.6815	
2001	edge	central	1.6917	0.3127	
2001	edge	coastal	1.1394	0.3855	
2001	core	central	-0.9163	0.9638	
2001	core	coastal	0.1054	0.6095	
2001	fragment	central	2.5903	0.3048	
2001	fragment	coastal	1.7346	0.4675	

Simple summary statistics from data

Unstratified summary of data.

The MEANS Procedure

Analysis Variable : adjcount

N	year	Obs	Mean	Std Dev	Std dev of total
	1999	40	4.0927500	5.3080645	33.5
	2000	40	2.1135000	3.7931555	23.9
	2001	40	3.3500000	5.7134569	36.13

Strat is 80-90% of unstrat agrees w/ theory.

2 CACW ANALYSIS

2.1 CACW COUNTS

TOTAL # TERRITORIES, MEAN, STD DEV BY STRATUM

year	subarea	land_des	Obs	Sum	Mean	Std Dev
1999	central	core	10	35.650	3.565	2.131
		edge	7	34.500	4.929	2.714
		fragment	3	4.600	1.533	0.664
	coastal	core	9	4.600	0.511	0.835
		edge	8	11.500	1.438	2.107
		fragment	3	2.300	0.767	0.664
2000	central	core	10	40.050	4.005	3.837
		edge	7	25.450	3.636	2.163
		fragment	3	4.300	1.433	0.491
	coastal	core	9	1.150	0.128	0.383
		edge	8	7.600	0.950	1.254
		fragment	3	4.300	1.433	1.250
2001	central	core	10	42.000	4.200	3.360
		edge	7	23.000	3.286	2.215
		fragment	3	1.000	0.333	0.577
	coastal	core	9	2.000	0.222	0.667
		edge	8	11.000	1.375	1.408
		fragment	3	3.000	1.000	1.732

Most CACW are seen in the Central subarea, core and edge. This is quite different than CAGN. Of the 10 sites where no CACW was seen during the 3 years, all are in the coastal subregion.

TOTAL CACW SEEN BY YEAR

all sites, adjusted counts, visit 1 or 2

	year								
	1999			2000			2001		
	# terr		n	# terr		n	# terr		n
	N	Mean		N	Mean		N	Mean	
novisits									
1	93.15	2.329	40	21.85	1.366	16	.	.	.
2	.	.	.	.	.	.	21	1.313	16
3	.	.	.	61	2.542	24	61	2.542	24
All	93.15	2.329	40	82.85	2.071	40	82	2.05	40

Visit2vs3cacw.sas

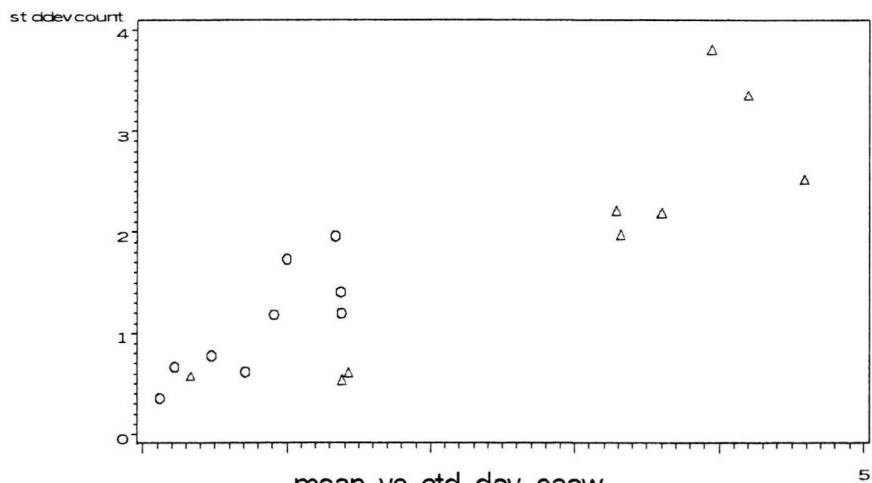
2.1.1 CACW COUNTS, NO. VISITS, BY SITE AND YEAR.

4	
31-	
3	
	2
	3
	3
	2
	2
	3
	2
	2
	3
	3
	3
	2
	3
	3
	3
	3
	2

FOR AGGREGATED DATA, THE STANDARD DEVIATION VARIES AS A LINEAR FUNCTION OF THE MEAN

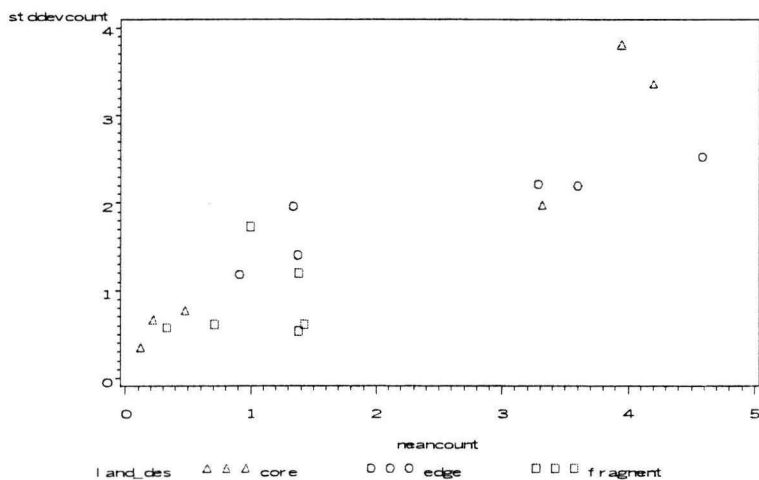
mean vs std dev cacw

data points are coastal xl and_des



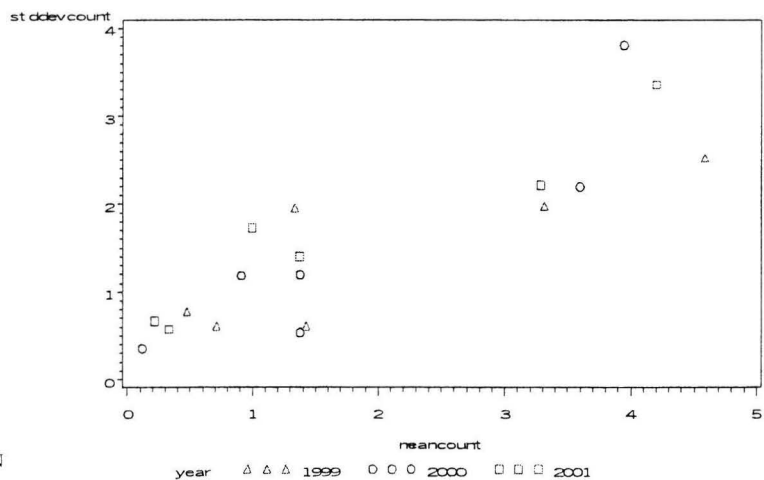
mean vs std dev cacw

data points are coastal xl and_des



mean vs std dev cacw

data points are coastal xl and_des



2.2 ADJUSTMENT OF VISIT1 DATA.

File: 'adjrate.sas'

Here we are trying to estimate the percent of visit 2 total complete by visit 1, and use this percent to adjust the counts in 1999 and 2000 which only had 1 visit.

total CACW seen at site by visit 2

sites w/ 2 or 3 visits which saw CACW at some visit

		year					
		2000			2001		
		#	# new	n	#	# new	n
		'terr	'terr		'terr	'terr	
visitno							
1		53'	53'	16'	60'	60'	30'
2		61	8	16	82	22	30

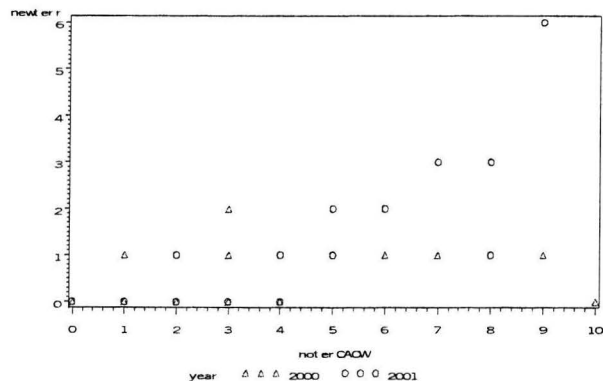
Adjustment using 2000 data: $61/53 = 1.15$

Adjustment using 2001 data $82/60 = 1.37$

Adjustment using both years: $143/113 = 1.26$

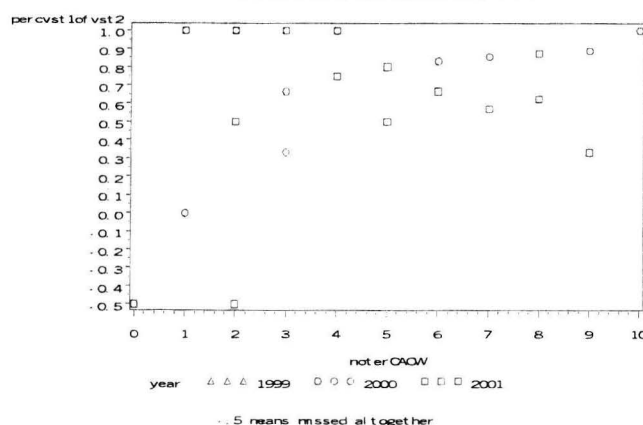
new CACW territories at 2nd visit

territories w/ at least 2 visits



% total territories x total seen at 2nd visit

sites w/ 2 or 3 visits which saw CACW at some visit



Conclusion:

As before, we will use the simple year 2000 adjustment of 1.15. However, this estimate seems even more variable than the CAGN estimate. See CAGN discussion. Also as before, the percent of visit 2 sites seen by visit 1 rises as total # of territories rises.

2.3 PERCENT INCREASE/DECREASE ESTIMATES

Adjusting for the stratified design, on adjusted counts

2.3.2 STRATIFIED ESTIMATES OF MEAN # CACW SEEN PER PLOT:

year	Est. Mean (std error of mean)	CV	Count adjusted for stratified design, visit 1 (Mean x 40)	Observed counts (visit 1 adjusted)	Observed counts, unadjusted (% of adjusted counts)
1999	2.11 (.26)	12.2%	84.4 (10.4)	93.1	81 (96%)
2000	1.94 (.31)	16.1%	77.6 (12.4)	82.9	72 (93%)
2001	1.98 (.30)	15.2%	79.2 (12.0)	82	82 (104%)

2.3.3 YEARLY PERCENT CHANGE. NONE ARE SIGNIFICANTLY DIFFERENT

(F=1.50, df = 2, 114; p = 0.23 stratified ANOVA on adjusted counts)

year	Strat estimates % decrease or increase	naïve estimate adjusted counts	naïve estimate unadjusted counts
1999-2000	8% decrease	11% decrease	26% decrease
2000-2001	2% increase	1% decrease	1% increase
1999-2001	6% decrease	12% decrease	26% decrease

Conclusion: naïve estimates of % change are not representative.

2.4 MODELING OF INCREASE/DECREASE IN CACW COUNTS WITH TIME.

Estimating change year to year as a linear normal contrast, stratified estimate

Years 99-00 and 99-01 not significantly different. $P = .23$

Data Summary

Number of Observations	120
Sum of Weights	1119.0
Weighted Mean of adjcount	2.07826
Weighted Sum of adjcount	2325.6

Stratum Index	subarea	land_des	N Obs	Population Total	Sampling Rate
1	central	core	30	87	34.5%
2		edge	21	67	31.3%
3		fragment	9	20	45.0%
4	coastal	core	27	101	26.7%
5		edge	24	73	32.9%
6		fragment	9	25	36.0%

Effect	Num DF	F Value	Pr > F
Model	41	45.51	<.0001
Intercept	1	616.40	<.0001
year	2	1.50	0.2266
siteno(subarea*land_des)	34	27.56	<.0001
subarea*land_des	5	92.97	<.0001

Tests of Model Effects

Differences from 1999

Effect	Num DF	F Value	Pr > F
Model	41	45.51	<.0001
Intercept	1	218.58	<.0001
year2000	1	2.39	0.1245
year2001	1	2.32	0.1303
siteno(subarea*land_des)	34	27.56	<.0001
subarea*land_des	5	92.97	<.0001

Standard Parameter	Estimate	Error	cv	66%	65%
year2000	-0.2894877	0.18707074			
year2001	-0.2861485	0.18776298			
Parameter	95% C Interval				
year2000	-0.6600734	0.08109795			
year2001	-0.6581055	0.08580856			

Differences from 2001

Parm estimate, std error.		
year2000	-0.0033393	0.17410030
year1999	0.2861485	0.18776298
95% confidence interval		
year2000	-0.3482306	0.34155205
year1999	-0.0858086	0.65810546

2.5 ANALYSIS OF NUMBER OF VISITS PER SITE

Percent of visit 3 total achieved by visit 2. 95% lower confidence intervals

Stratified estimator from 2000 2001 data, 3 visits sites only

File: 'visit2 vs 3CACW .sas'.

Use years 2000, 2001, sites w/ 3 visits only.

There were 24 sites w/ 3 visits in 2000 and 2001.

2000: one site out of the 16 which saw CACW missed 1 CACW (site 17)

2001: two sites out of the 16 which saw CACW missed 1 and 2 CACW each. (sites 17 and 28)

Site 17 is central edge. Site 28 is coastal fragment.

Estimated percent complete by visit 2.

	Year 2000 tot CACW = 62	Year 2001 tot CACW = 64	Combined years tot CACW = 63
Naïve estimate:	98.3% (61 / 62)	95.3% (61 / 64)	96.8% (122 / 126)
Estimate from simple mean #missed / site** (LCL)			94.7% (64%)
Stratified est: mean # missed /site (std dev) 95% UCL (biased up)	.036 (.035) .109	.103 (.073) 0.256	.069 (.038) 0.132
# seen at these 24 sites, visit 2 + # missed adjusted for stratified est, . (biased up)	77.6 + 1.4 = 79	79.2 + 2.9 = 82.1	78.4 + 1.52 = 80
% complete: stratified mean (95% LCL)** [biased up or down]	98.1 % (94.5%)	93.6% (87.5%)	96. 5% (93.4%)
Bootstrap mean. (std dev) 95% LCL [biased up]			97.1% (1.9%) 94.6%

** (mean # missed / site) x # sites = total CACW missed visit 2.

Percent missed = Total CACW missed visit2 / total seen visit 3

The bootstrap is biased towards high total CACW counts.
Mean total # territories at visit two for bootstrap is 98. Total in data is 82 in 2000 and 2001.

Conclusions

total CACW seen at site by visit
sites w/ 3 visits which saw CACW at some visit

	year					
	2000			2001		
	# terr	# new terr	n	# terr	# new terr	n
visitno						
1	53	53	16	42	42	16
2	61	8	16	61	19	16
3	62	1	16	64	3	16

All estimates are based on visit 2 from 3 visit sites. As 3 visits sites had more CACW, these are biased up:

See the plots of visit 1 completion rates on the next page- percent complete rises w/ # territories.

Hence a 95% lower confidence limit of 90% complete by visit 2 may not be supportable from these computations.

2.5.4 NEW BOOTSTRAP: USE 2 VISIT SITES AND 3 VISIT SITES

Two bootstraps of $N = 10000$ will be computed

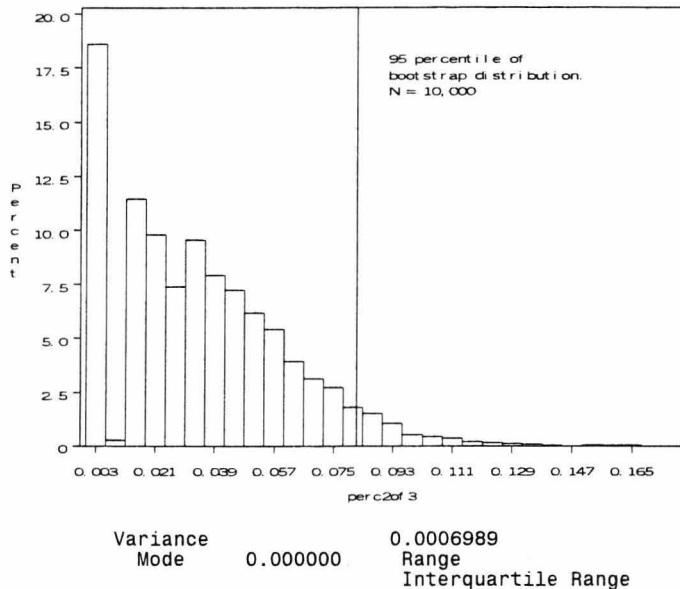
Number missed at visit 2 will be sampled from 3 visit sites only following the original stratified design. As these sites tend to have more CACW, this will bias the # missed upwards. The average # missed / site will be computed for each bootstrap sample using the stratified estimator.

Number seen will be sampled from all sites in 2000 and 2001 (visit 2 for 3 visit sites, visit 1 adjusted otherwise) again following the original stratified design. Mean number seen at visit 3 will be computed as mean seen from this bootstrap + (mean number missed / site) [for the first bootstrap]. All means computed using the stratified estimator.

The percent complete will be computed as # missed (first bootstrap) / number seen by visit 3. This will give an estimate which is biased up.

Code: 'bootstrap2of3newcacw.sas'

Percent complete on visit 2 out of 3. Bootstrap distribution, 10,000 samples.



Conclusion:

This conservative bootstrap which is biased downwards supports a 95% LCL of greater than 90%.

2.6 SAMPLE SIZE ESTIMATES

Estimate CACW total within $\pm 20\%$ at 90% confidence

Stratified estimates of mean and se mean, # CACW territories			
year	Adjcount mean	Mean x 40	Cv
1999	2.11 (0.259)	84.4 (10.4)	12.25%
2000	1.95 (0.314)	78 (12.6)	16.1%
2001	1.98 (0.301)	79.2 (12.0)	15.2%

As before, we need CV < 15.5% to achieve our goal. We are much closer with CACW. They are less variable. The sample sizes suggested in the CAGN report work for CACW.

Total # territories, mean, std dev by stratum

year	subarea	land_des	Obs	Sum	Mean	Std Dev
1999	central	core	10	33.170	3.317	1.983
		edge	7	32.100	4.586	2.526
		fragment	3	4.280	1.427	0.618
	coastal	core	9	4.280	0.476	0.777
		edge	8	10.700	1.338	1.961
		fragment	3	2.140	0.713	0.618
2000	central	core	10	39.490	3.949	3.807
		edge	7	25.210	3.601	2.196
		fragment	3	4.140	1.380	0.537
	coastal	core	9	1.070	0.119	0.357
		edge	8	7.280	0.910	1.185
		fragment	3	4.140	1.380	1.197
2001	central	core	10	42.000	4.200	3.360
		edge	7	23.000	3.286	2.215
		fragment	3	1.000	0.333	0.577
	coastal	core	9	2.000	0.222	0.667
		edge	8	11.000	1.375	1.408
		fragment	3	3.000	1.000	1.732

2.7 STRATIFIED ESTIMATE OF MEAN, SE MEAN

The SURVEYMEANS Procedure

Statistics							
Variable	Sum of Weights		DF	Mean	Std Error of Mean	Lower 90% CL for Mean	Upper 90% CL for Mean
hectares	373	34	34.794932	3.305676	29.205284	40.384581	
adjcount	373	34	2.112218	0.258727	1.674729	2.549706	
Coeff of Variable	Variation						
			hectares	0.095005			
			adjcount	0.122491			
----- year=2000 -----							
hectares	373	34	34.794932	3.305676	29.205284	40.384581	
adjcount	373	34	1.944763	0.314207	1.413462	2.476064	
Coeff of Variable	Variation						
			hectares	0.095005			
			adjcount	0.161566			
----- year=2001 -----							
hectares	373	34	34.794932	3.305676	29.205284	40.384581	
adjcount	373	34	1.983992	0.300955	1.475100	2.492884	
Coeff of Variable	Variation						
			hectares	0.095005			
			adjcount	0.151692			

2.8 COMPUTATIONS: ANALYSIS OF NUMBER OF VISITS PER SITE

2.8.5 BOOTSTRAP ESTIMATE OF VARIABILITY

Percent complete at visit 2, bootstrapped from visit 3 sites only.

Biased estimates of % complete

Distribution is highly skewed.

Bootstrap from all visit 2 sites where there is a visit 3.

Bootstrap in stratified way, according to original sampling frequencies.

3 visits sites:

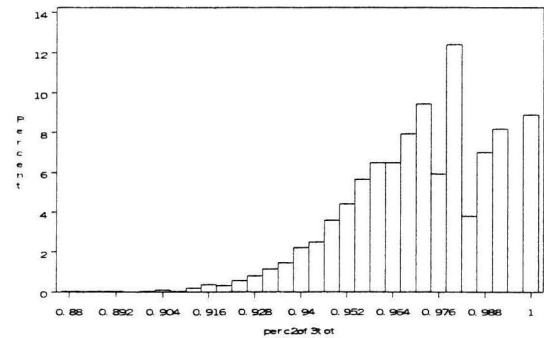
subarea land_des

Frequency'

	'core'	'edge'	'fragment'	Total	
central	6	5	1	12	
coastal	6	4	2	12	
Total	12	9	3	2424	

Skewed towards high CACW counts. Understates variability of percent complete. Biased up.

bootstrap dist of mean percent complete at visit 2
sites resampled with n strata: tot missed/tot found



2nd visit at 2 visit sites compared to 3 visit sites

novisits	N Obs	Variable	Mean of 2 nd visit	Std Dev
2	16	newterr	0.1875000	0.4031129
		totatvst	1.3125000	1.4008926
		noterCACW	1.3125000	1.4008926
3	48	newterr	0.5625000	1.1280986
		totatvst	2.5416667	3.0244277
		noterCACW	2.6250000	3.0150333

These distributions are biased towards too many CACW. Based on bootstrapping only visit 3 sites.

Bootstrap distribution of percent complete at visit 2 of visit 3.

The UNIVARIATE Procedure

Variable: perc2of3tot percent complete at visit two

Moments

N	10000	Sum Weights	10000
Mean	0.97098711	Sum Observations	9709.87112
Std Deviation	0.01858281	Variance	0.00034532

Here we see the bootstrapped total seen is too high:

Variable: totatvst_Sum = estimated total using visit 2

Moments

N	10000	Sum Weights	10000
Mean	98.371	Sum Observations	983710
Std Deviation	11.4250782	Variance	130.532412

Quantile	Estimate
100% Max	1.000000
99%	1.000000
95%	1.000000
90%	0.991453
75% Q3	0.983471
50% Median	0.972222
25% Q1	0.959184
10%	0.946237
5%	0.937500
1%	0.921200
0% Min	0.880000

Quantile	Estimate
100% Max	139
99%	125
95%	117
90%	113
75% Q3	106
50% Median	98
25% Q1	91
10%	84
5%	80
1%	72
0% Min	49

2.9 COMPUTER OUTPUT FOR STRATIFIED ESTIMATES OF PERCENT COMPLETE AT VISIT 2.

Stratified estimate of mean # missed at visit 2 for the 24 3 visits sites in 2000.

Number of Strata		6		
Number of Observations		24		
Sum of Weights		373		
Stratum Information				
subarea	land_des	Total	Rate	N Obs
central	core	87	6.90%	6
	edge	67	7.46%	5
	fragment	20	5.00%	1
coastal	core	101	5.94%	6
	edge	73	5.48%	4
	fragment	25	8.00%	2

Statistics

Variable	Mean	Std Error of Mean	Lower 95% CL for Mean	Upper 95% CL for Mean
newterr	0.035925	0.034558	-0.036680	0.108530
adjcount2	2.355362	0.402393	1.509966	3.200758

Note the count is biased up compared to the estimate using all data of 1.944. Hence these sites had more CACW than the average, and so missed more than average. Total estimated missed = 1.4 Total CACW seen by visit 3: 95.65
2001

Variable	Mean	Std Error of Mean	Lower 95% CL for Mean	Upper 95% CL for Mean
newterr	0.102949	0.072987	-0.050392	0.256290
adjcount2	2.349598	0.324150	1.668583	3.030612

The same is true for 2001. More were missed. Total estimated missed = 4.1

Combined estimate, 2000 and 2001.

Variable	Mean	of Mean	CL for Mean	CL for Mean
newterr	0.069437	0.037833	-0.006914	0.145788
adjcount2	2.352480	0.242815	1.862459	2.842501

total estimate missed: 2.76

Simple mean missed per site at visit 3.

The MEANS Procedure		
Analysis Variable : newterr		
Mean	Std Dev	N
0.0833333	0.3472281	48

Comments on data.

10 sites had no CACW at any time during study. These were often dropped from the analysis

Why are these sites all in the 30's?

Sites which saw any CACW, year 200, visit 3

subarea	land_des	N	Mean
central	core	6	5.33333331
	edge	5	4.4000000
	fragment	1	2.0000000
coastal	core	1	0
	edge	2	1.5000000
	fragment	1	2.0000000

Sites w/ no CACW	Sites w/ no CAGN
siteno	siteno
29	2
31	4
32	7
33	8
34	9
36	10
37	13
38	17
39	34
40	36
	40

Number of visits split out by stratum

N	subarea	land_des	novisits	Obs	N
central	core		1	4	4
			3	6	6
	edge		1	2	2
			3	5	5
	fragment		1	2	2
coastal	core		3	1	1
			1	3	3
	edge		3	6	6
			1	4	4
	fragment		3	4	4
			1	1	1
			3	2	2

Very unbalanced.

Sites where no CACW was seen during the 3 years

subarea	land_des	novisits	Obs	N
coastal	core	1	1	1
		3	5	5
	edge	1	1	1
		3	2	2
	fragment	3	1	1