California Swainson's Hawk Inventory: 2005-2006

2005 Progress Report

A Joint Project

California Department of Fish and Game, Resource Assessment Program

University of California Davis, Wildlife Health Center

and in Collaboration with the

Swainson's Hawk Technical Advisory Committee
California Department of Water Resources
California Department of Parks and Recreation
United States Fish and Wildlife Service

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Report Authors

Dick Anderson, Roxie Anderson, Mike Bradbury, Calvin Chun, Julie Dinsdale, Jim Estep, Kristi Fien, Ron Schlorff

Introduction

The Swainson's hawk was listed as a threatened species in 1983 by the California Fish and Game Commission. This listing was approved in part due to the results of the statewide survey conducted in 1979 by Pete Bloom for the California Department of Fish and Game (DFG) (Bloom 1980). The Bloom (1980) survey provided valuable information on the nesting distribution of the species in the state. Bloom's work included conducting surveys throughout the state during one nesting season, and by using generalized habitat associations and nest site densities determined during the nesting survey, making a determination of the remaining nesting population and of the minimum percent decline of the nesting population. He estimated that there were 350 nesting pairs remaining in the state and determined this to be a 90 percent population reduction of historic Swainson's hawk numbers.

Since 1980, several research efforts have been conducted or are ongoing that have provided additional information on many aspects of the species' ecology, but also have provided more recent information on the local distribution of the Swainson's hawk in California (Woodbridge 1985, Estep 1989, Swolgaard 2004). Additionally, DFG duplicated Bloom's (1980) effort in 1998. As a result, the estimated population was revised to 550 nesting pairs.

To address management, research, and land use issues affecting the Swainson's hawk, the Swainson's Hawk Technical Advisory Committee (SWHTAC) was established in 1989. This ad hoc committee of researchers and agency biologists was initially formed primarily to advise the DFG on land use issues affecting the species. Since then the SWHTAC has been active in promoting, conducting, assisting and encouraging Swainson's hawk research. As a result of information from these research efforts, around the year 2000, the SWHTAC estimated the nesting population to include 700-1,000 breeding pairs in the state - 600 to 900 of these occurring in the Central Valley. Since this estimate, additional site-specific information has become available, including additional DFG studies in the Sacramento Valley, suggesting that this may still be an underestimate of the statewide population.

There continues to be rapid loss and modification of habitat for Swainson's hawks in the California Central Valley. Human population increases and projected urbanization in Swainson's hawk habitat in California, continues to place the Swainson's hawk at the heart of development controversies. In order to accommodate human population and development growth and maintain a sustaining Swainson's hawk population in the state, it is essential that more complete and accurate inventory information be available regarding available habitat, breeding pair numbers, and species distribution. To this end, DFG has initiated this study to inventory the state of California for Swainson's hawk breeding pairs and provide an up-to-date and accurate assessment of the Swainson's hawk population in California.

GOALS

1) To estimate Swainson's hawk breeding pair numbers in California.
2) To test and establish a survey protocol that will be appropriate for long-term trend analysis of Swainson's hawk breeding pair numbers and habitat changes.

To achieve this, the project objectives are:

1) develop a scientifically based sample design and protocol for estimating Swainson's hawk breeding pair numbers statewide,
2) develop a habitat type map to correspond with Swainson's hawk range,
3) develop a protocol for a long-term trend analysis of Swainson's hawk breeding pairs, distribution, and habitat changes,
4) conduct a pilot study and an inventory of Swainson's hawk breeding pairs,
5) describe the current Swainson's hawk abundance and distribution.

Questions to be addressed:

1) How many breeding pairs of Swainson's hawks are there in California?
2) What are the current abundance, distribution and condition of habitats?
3) How to determine the future trends in abundance, distribution and condition of habitats?

Methods

Study area and geographic scale

The inventory will take place throughout current Swainson's hawk range in California. Swainson's hawks inhabit the flat portions of California's Central Valley, lower elevation Great Basin lands in Northeastern California, the Owen's Valley in Eastern California, and portions of the Mojave Desert in the Antelope Valley area. Figure 1 illustrates the historic and current range for Swainson's hawks in California.

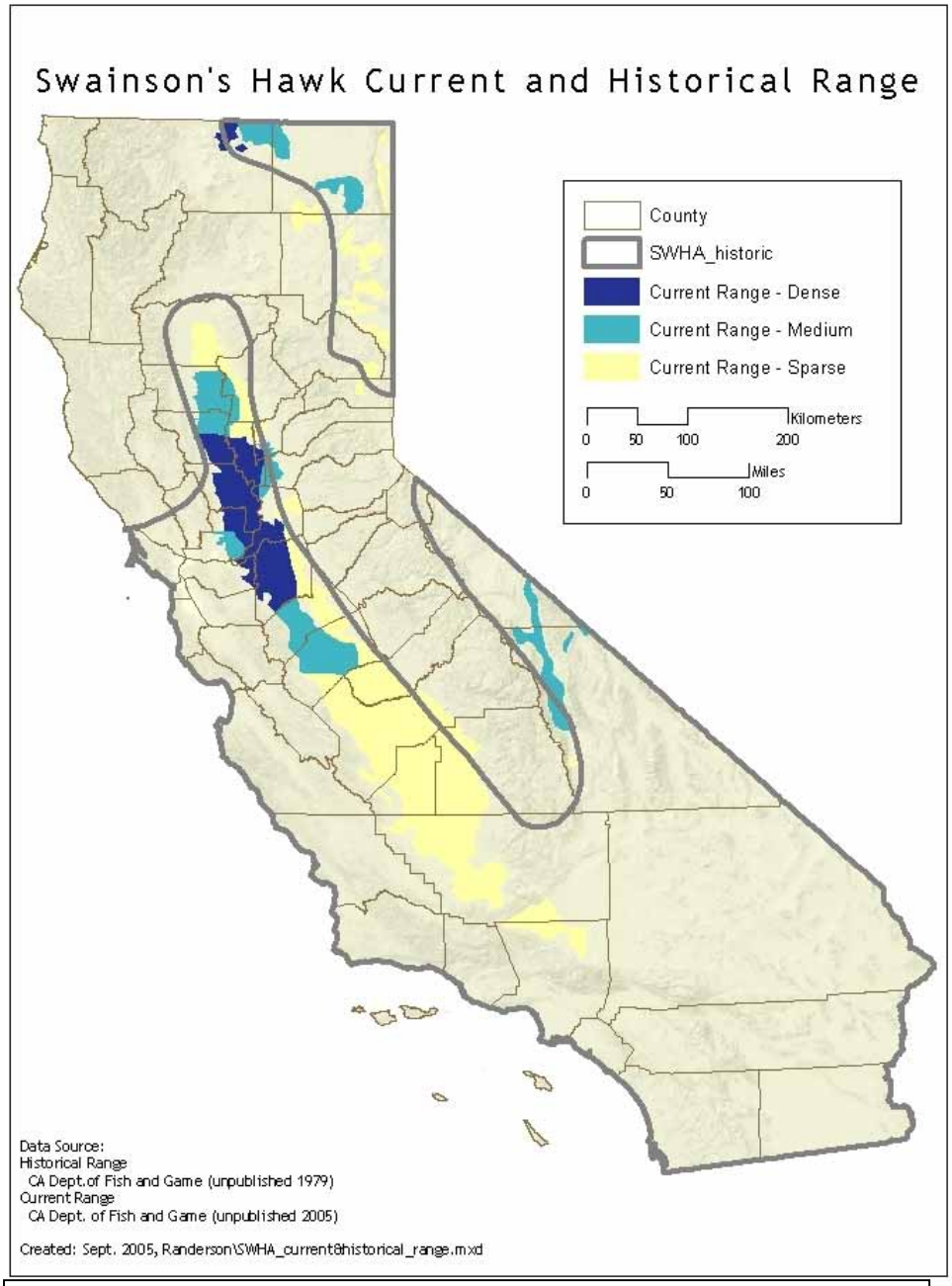


Figure 1. Historic and Current Swainson's Hawk Range

General description of study and sampling design

Swainson's hawk breeding pair densities vary throughout their range in California. These varying densities cannot easily be explained by land cover/habitat type. This study stratifies current range into one of three strata across the state by known breeding pair densities. Dense, moderately dense and sparse strata (e.g. Dense = average density is ≥ one breeding pair per 10 sq mi, Moderately Dense = average density is ≥ one breeding pair per 11 to 75 sq mi, and Sparse = average density is ≥one breeding pair per 76+ sq mi) will be delineated within current range. Random samples were selected within each of these strata. The sample strata were overlain with the Township, Range and section grid, that delineate cells approximately one mile on a side (one sq mi). The exact area of each section is known as is the estimated total area of Swainson's hawk range, so breeding pair detection is based on a per square mile metric. Individual sample units were selected at random within each stratum for a sample design with two hundred samples in dense strata, 100 samples in Moderately dense strata, and 60 samples in sparse strata. An observer conducted a census of each sample unit and visited each sample unit one or more times, until the observer was satisfied he or she knew how many, if any, breeding pairs of Swainson's hawks inhabited the sample unit. Sample units that were not completely inventoried were mapped to show the portion that was surveyed and that area was used in the "per square mile" analysis. For efficiency, observers were assigned sample units that coincided with the geographic location with which they had the most familiarity. Maps of the sample units, field forms, and instructions were provided to the observers. A data management system was established as well as a Quality Control process to ensure data was entered with few errors.

A unique feature of this effort is the collaborative participation of several established experts on Swainson's hawk from other agencies or non-government entities in California. Through an interagency agreement with the University of California, the Department of Fish and Game has been able to secure and support the expertise needed to conduct these surveys that are of relatively short duration but time-consuming during the survey period. Such constraints in the appropriate timing of surveys for a particular wildlife species, and existing staff duties independent of this project, make it difficult to put together an internal team to conduct a statewide survey. The Department and members of the SWHTAC worked to identify and recruit experts to participate in this project.

Work started in 2005 that will be completed in late 2006

Current and historic (where available) land cover information is being obtained and GIS layers created to overlay with current and historic Swainson's hawk range. Other data layers such as soil types may be obtained as time and resources allow. The purpose of this work is to look for correlations between land cover and Swainson's hawk breeding pair densities.

A sampling strategy protocol for a long-term monitoring and trend analysis is planned. A new random sample of Swainson's hawk range will be inventoried at a frequency to-be-determined. This information will be used to track changes in Swainson's hawk breeding pair numbers.

Statistical Analysis

The following formulas were used for calculating estimates of Swainson's hawk breeding pairs.

The formulas are taken from Cochran (1977), Sampling Techniques, third edition.

Let L= number of strata.

Let N_h = total number of units in sampling frame for stratum h,

and n_h = number of units in sample for stratum h.

Let $N = \sum_{h=1}^{L} N_h$ = total units in the sampling frame.

Let $W_h = \frac{N_h}{N}$.

Let $f_h = \frac{n_h}{N_h}$.

Let z = 1.96.

Let y_{hi} = response variable (count) for i-th sample unit from stratum h.

Stratified Mean and Confidence Interval.

The stratified mean is $\bar{y}_{st} = \sum_{h=1}^{L} W_h \bar{y}_h$.

$$v(\bar{y}_{st}) = \sum_{h=1}^{L} W_h^2 \frac{s_h^2}{n_h}(1 - f_h) \ ,$$

where s_h^2 is the sample variance for y in stratum h: $s_h^2 = \frac{1}{n_h - 1}\sum_{i=1}^{n_h}(y_{hi} - \bar{y}_h)^2$, and

$\bar{y}_h = \frac{\sum_{i=1}^{n_h} y_{hi}}{n_h}$.

The 95% confidence interval for the stratified mean is

$\bar{y}_{st} \pm z\sqrt{v(\bar{y}_{st})}$.

Simple Total and Confidence Interval within Stratum h.

The simple total within stratum h is $T_h = N_h \bar{y}_h$.

The 95% confidence interval for the simple total is

$T_h \pm z\frac{N_h s_h \sqrt{1 - f_h}}{\sqrt{n_h}}$,

where s_h is the sample standard deviation of y in stratum h.

Stratified Total and Confidence Interval.

The stratified total $T = N\bar{y}_{st}$,

where $\bar{y}_{st}$ is the stratified mean.

The 95% confidence interval is $T \pm tN\sqrt{v(\bar{y}_{st})}$,

where t= critical value using estimated degrees of freedom and t distribution if "df" is mentioned in Table 2; otherwise t=1.96 and normal distribution.

Simple Ratio and Confidence Interval within Stratum h.

Let y_{hi} and x_{hi} be response variables within stratum h.

The simple ratio within stratum h is $\hat{R} = \dfrac{\sum_{i=1}^{n_h} y_{hi}}{\sum_{i=1}^{n_h} x_{hi}}$.

$$s(\hat{R}) = \frac{\sqrt{1-f_h}}{\sqrt{n_h}\,\bar{x}_h}\sqrt{\frac{\sum_{i=1}^{n_h} y_{hi}^2 - 2\hat{R}\sum_{i=1}^{n_h} y_{hi}x_{hi} + \hat{R}^2\sum_{i=1}^{n_h} x_{hi}^2}{n_h - 1}} \quad ,$$

where $\bar{x}_h = \dfrac{\sum_{i=1}^{n_h} x_{hi}}{n_h}$.

The 95% confidence interval for the simple ratio is $\hat{R} \pm z\sqrt{s(\hat{R})}$.

Stratified Ratio and Confidence Interval.

Let $\hat{Y}_{st} = \sum_{h=1}^{L} N_h \bar{y}_h$ and let $\hat{X}_{st} = \sum_{h=1}^{L} N_h \bar{x}_h$.

Then the stratified ratio is $\hat{R}_{st} = \dfrac{\hat{Y}_{st}}{\hat{X}_{st}}$.

Let $u_{hi} = \dfrac{N_h}{n_h}\dfrac{(y_{hi} - \hat{R}_{st}x_{hi})}{\hat{X}_{st}}$. (cf: Cochran, p. 171)

Then $v(\hat{R}_{st}) \cong \sum_{h=1}^{L} \dfrac{(N_h - n_h)n_h}{N_h}\dfrac{\sum_{i=1}^{n_h}(u_{hi} - \bar{u}_h)^2}{(n_h - 1)}$.

The 95% confidence interval for the stratified ratio is

$\hat{R}_{st} \pm z\sqrt{v(\hat{R}_{st})}$.

Results

Approximately 95% of California SWHAs exist in the Central Valley. The 2005 survey estimate for California SWHA pairs was 1912 (range 1471-2353 (95%)). The estimate for California Central Valley (CV) pairs is 1830 (range 1399-2262 (95%)). The *Dense* areas had 0.51 nests per sq mi, *Moderate* areas had 0.07 nests per sq mi., and *Sparse* areas had 0.0 nests per sq. mi. because we didn't have any hits in the *Sparse* samples. Certainly there are pairs in the *Sparse* areas but they are in such low numbers they are difficult to sample.

Table 1 lists the number of units (sections) in each County by density (strata). It also lists the number of units sampled in each County and the total square miles of the inventory area. Table 2 lists the results of the inventory and shows the 95 percent confidence intervals for the estimates. It also lists the mean height of the nests and nest trees, and the more common tree species used for nesting. Valley oaks were used for 36 percent of the nest trees, Cottonwood and willows were tied with 17 percent each and seven additional tree species together made up the remaining 30 percent. Figure 2 displays the results of the 2005 inventory. It shows where the samples were located and which sample sites had one or more Swainson's hawk pairs.

Benefits of 2005 results

The preliminary results of the 2005 inventory are being used to assist in the drafting of a Departmental interim conservation strategy for the Swainson's hawk in California. As of this date, a number of habitat conservation plans (HCP's) are being completed and implemented within California Central Valley Swainson's hawk range where development of essential habitats for the species is continuing at an accelerated pace. This same area (Central Valley) will be the focus of surveys for the 2006 effort. Results of this statewide inventory, both in 2005 and 2006, will be used to assess the species status. Additionally, geographical information systems (GIS) and other tools needed to assist in the design and implementation of recovery and conservation planning strategies can be developed from this population inventory. Implementation of these conservation strategies, contained in the HCP's and other planning vehicles, will be needed in order to ensure the recovery of the Swainson's hawk and prevent its extirpation from California.

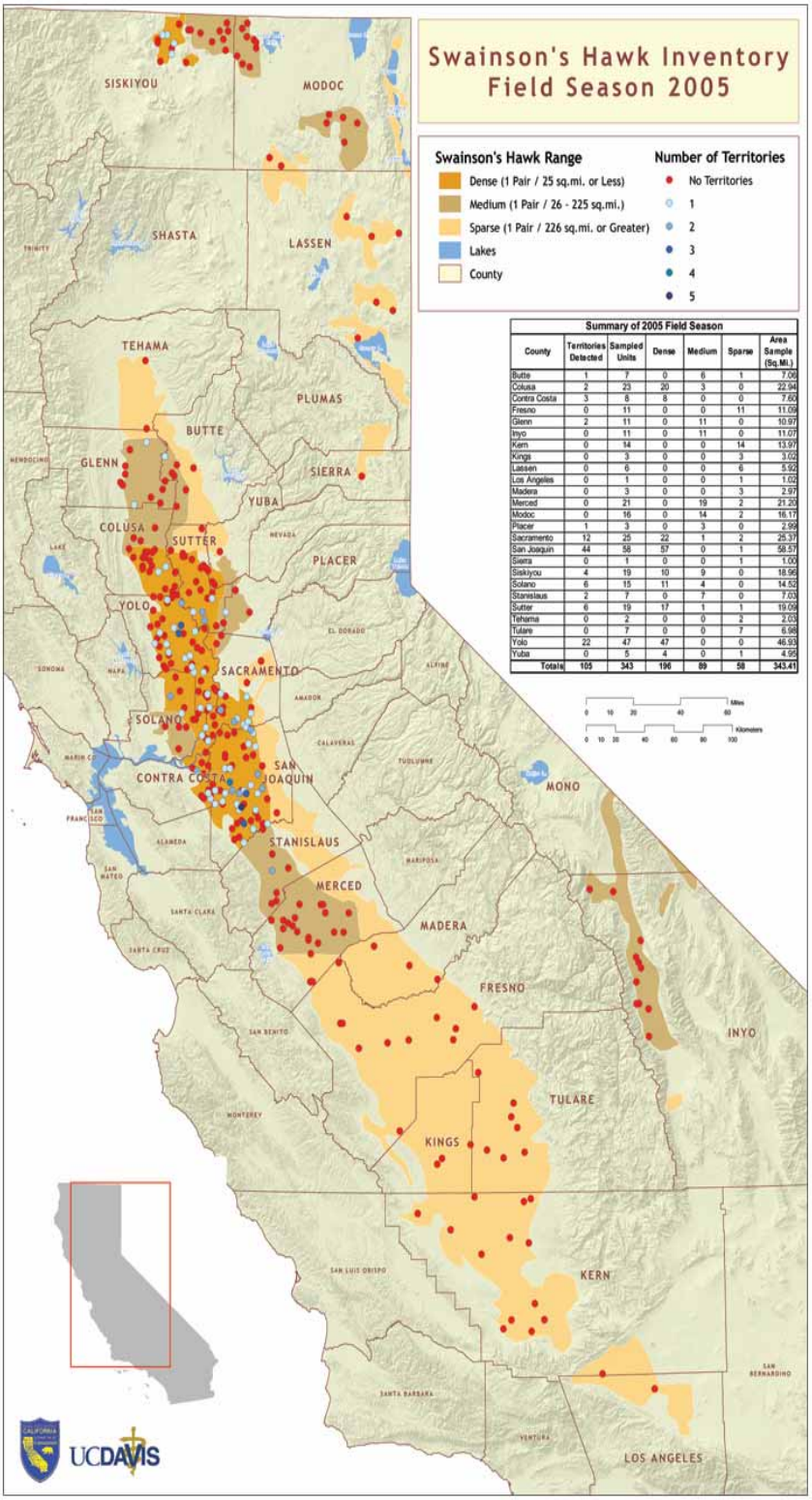
Table 1. Current Range and Inventory Units Summarized by County

COUNTY	UNITS	SAMPLED	DENSE	MEDIUM	SPARSE	SQUARE MI
ALAMEDA CO	4	0	4	0	0	4.0451
BUTTE CO	507	7	0	182	325	502.2003
COLUSA CO	570	23	300	270	0	570.7970
CONTRA COSTA CO	117	8	117	0	0	111.5794
FRESNO CO	2408	11	0	0	2408	2422.4297
GLENN CO	511	11	0	468	43	511.4631
INYO CO	724	11	0	691	33	734.4600
KERN CO	2231	14	0	0	2231	2230.5642
KINGS CO	1110	3	0	0	1110	1119.0676
LASSEN CO	824	6	0	0	824	814.8112
LOS ANGELES CO	413	1	0	0	413	418.3124
MADERA CO	751	3	0	0	751	754.2555
MERCED CO	1285	21	0	799	486	1290.4861
MODOC CO	801	16	0	548	253	797.8776
MONO CO	204	0	0	204	0	191.3309
PLACER CO	139	3	0	139	0	136.9997
PLUMAS CO	99	0	0	0	99	99.2456
SACRAMENTO CO	549	25	332	35	182	549.7768
SAN JOAQUIN CO	1141	58	853	3	285	1152.3972
SIERRA CO	59	1	0	0	59	58.5232
SISKIYOU CO	454	19	180	274	0	434.5127
SOLANO CO	474	15	283	191	0	469.1441
STANISLAUS CO	725	7	0	423	302	732.3189
SUTTER CO	594	19	377	82	135	593.6123
TEHAMA CO	431	2	0	0	431	423.6942
TULARE CO	1453	7	0	0	1453	1456.3139
YOLO CO	707	47	707	0	0	691.5696
YUBA CO	194	5	45	58	91	193.8580
TOTAL	**19479**	**343**	**3198**	**4367**	**11914**	**19465.6463**

Units Summarized by Density			
DENSITY	**UNITS**	**SAMPLED_UNITS**	**SQMI**
Dense	3198	192	3170
Medium	4367	90	4348
Sparse	11914	61	11947
TOTAL	**19479**	**343**	**19466**

Table 2. 2005 Inventory Results

DESCRIPTION	ESTIMATE	LOWER 95% LIMIT	UPPER 95% LIMIT
Pairs/sample (stratified mean)	0.1	0.08	0.12
Pairs/sq mi (stratified ratio)	0.1	0.08	0.12
Pairs/sq km (stratified ratio)	0.04	0.03	0.05
Pairs/CA (stratified total)	1912	1471	2353
Pairs/sq mi dense stratum (simple ratio)	0.51	0.39	0.62
Pairs/sq km dense stratum (simple ratio)	0.19	0.15	0.24
Pairs/dense stratum (simple total)	1617	1264	1970
Pairs/sq mi moderate stratum (simple ratio)	0.07	0.007	0.13
Pairs/sq km moderate stratum (simple ratio)	0.03	0.003	0.05
Pairs/moderate stratum (simple total)	294	31	558
Pairs/sq mi sparse stratum (zero pairs)	0		
Pairs/sq km sparse stratum (zero pairs)	0		
Pairs/sparse stratum (zero pairs)	0		
Pairs/Colusa County (stratified total, df)	30	0	72
Pairs/Sacramento County (stratified total, df)	182	86	278
Pairs/San Joaquin County (stratified total, df)	658	425	892
Pairs/Yolo County (stratified total, df)	331	181	481
Pairs/Central Valley (stratified total)	1830	1399	2262
Pairs/sq mi Central Valley (stratified ratio)	0.11	0.08	0.14
Pairs/sq km Central Valley (stratified ratio)	0.04	0.03	0.05
Pairs/Sacramento Valley (stratified total)	1009	713	1305
Pairs/sq mi Sacramento Valley (stratified ratio)	0.1	0.06	0.13
Pairs/sq km Sacramento Valley (stratified ratio)	0.04	0.02	0.05
Pairs/San Joaquin Valley (stratified total)	796	497	1095
Pairs/sq mi San Joaquin Valley (stratified ratio)	0.14	0.08	0.19
Pairs/sq km San Joaquin Valley (stratified ratio)	0.05	0.03	0.07
Pairs/Northern CA (stratified total)	72	16	128
Pairs/Owen's Valley (zero pairs)	0		
Mean tree height for nests (ft)	53.1	48.3	58
Mean nest height for nests (ft)	43.4	39.2	47.8
df=df and t dist, else used 1.96 and normal			
% tree type for nests	%	**(n=83 trees)**	
CW	17		
VO	36		
WI	17		
other (EU,JU,OC,OE,ON,PI,WA)	30		



Summary of 2005 Field Season

County	Territories Detected	Sampled Units	Dense	Medium	Sparse	Area Sample (Sq.Mi.)
Butte	1	7	0	6	1	7.06
Colusa	2	23	20	3	0	22.94
Contra Costa	3	8	8	0	0	7.60
Fresno	0	11	0	0	11	11.09
Glenn	2	11	0	11	0	10.97
Inyo	0	11	0	11	0	11.07
Kern	0	14	0	0	14	13.97
Kings	0	3	0	0	3	3.02
Lassen	0	6	0	0	6	5.92
Los Angeles	0	1	0	0	1	1.02
Madera	0	3	0	0	3	2.97
Merced	0	21	0	19	2	21.20
Modoc	0	16	0	14	2	16.17
Placer	1	3	0	3	0	2.99
Sacramento	12	26	22	1	2	25.37
San Joaquin	44	58	57	0	1	58.57
Sierra	0	1	0	0	1	1.00
Siskiyou	4	19	10	9	0	18.96
Solano	6	15	11	4	0	14.52
Stanislaus	2	7	0	7	0	7.03
Sutter	6	19	17	1	1	19.09
Tehama	0	2	0	0	2	2.03
Tulare	0	7	0	0	7	6.98
Yolo	22	47	47	0	0	46.93
Yuba	0	5	4	0	1	4.95
Totals	105	343	196	89	58	343.41

Figure 2. Results of 2005 Swainson's Hawk Inventory

2006 Inventory

In 2006, we will continue to inventory the known breeding range of the Swainson' hawk in California in order to estimate the current population. In addition, we will continue to refine, and delineate, the range of the species, and conduct habitat relationships and related investigations. This information will have numerous species conservation and land use planning applications for the future.

Goal

The objective for the Statewide Inventory in 2006 is to refine the estimates made in 2005 by concentrating efforts in California's Central Valley. We have estimated, based on results obtained in 2005, that about 95% of the population breeds in the Central Valley. A more intensive and concentrated inventory within these counties will allow us to reduce the confidence interval from the 2005 results, and obtain a better estimate of the number of Swainson's hawk breeding pairs within the "core" of the range in California.

Sample Design and Methodology

The sample design and methodology for the inventory in 2006 will remain largely the same as in 2005, namely a stratified random sample design. The number of random samples for 2006 has been increased to 450 from the total of 360 inventoried in 2005. All samples in 2006 will be located in the "dense" and "moderate" strata in the CV (95% of the breeding pairs). This will allow us to get an estimate with a narrower confidence interval at the 95% confidence level. We will also stratify to ensure that the six most SWHA populated counties (Sacramento, San Jaoquin, Yolo, Solano, Sutter, and Colusa) include at least 50 sample sites so that we can create an estimate of pairs for those counties. For our efforts this year we have adjusted the boundaries here and there to reflect findings from last year. We know there are some SWHA pairs in the Sparse areas but not many. We are not down-playing the value of those pairs in the least, it is simply not efficient to sample for them when they are in such small numbers. Detection of SWHA in areas where they are rare is difficult because of the large sample sizes needed when using random sampling. Consequently, field biologists often use targeted surveys based on historical information for rare species when needing to confirm presence in a specified area. Such targeted surveys are not amenable for statistical extrapolation to the statewide and Central Valley level, but they do provide important location information for local conservation purposes. Since our study used stratified random sampling rather than a targeted survey, we did not, by chance, encounter nests in historically sparse areas, even though they may exist there.

Essentially, the same observers employed in 2005 will return to complete the inventory in 2006. While some adjustment may be needed, most observers will be returning to the same general areas they became familiar with last year. The new random sample units assigned to each individual observer will also be adjusted to account for the approximate 25% increase in inventory intensity this year. The California Department of Fish and

Game's biostatistics section will again be assigned to analyze the raw inventory data and arrive at a new estimate of the breeding pairs of Swainson's hawks in California in 2006.

Collaborators

The CDFG project leads are Ronald Schlorff and Steve Torres; biostatistical design by Calvin Chun, Ph.D; RAP program lead is Eric Loft

The University of California Davis, Wildlife Health Center Project Administrators are Walter Boyce, Jonna Mazet, and Christine Kreuder; Dick Anderson (UCD-WHC agreement) is the Field Project Coordinator and primary author

Swainson's Hawk Technical Advisory Committee

Agency collaborators are California Department of Water Resources, California Department of Parks and Recreation, and the US Fish and Wildlife Service.

Acknowledgements

The 2005 inventory was a true collaborative effort. Everyone involved contributed greatly to the inventory. Thanks to Ron Schlorff, Steve Torres, Eric Loft, and Carolyn Rech of the RAP program at CDFG for their support an encouragement. Several additional members of the CDFG spent many hours in the field looking for Swainson's hawks, they are Dan Gifford, Chris Rocco, Paul Hofmann and Adrienne Disbrow. Still more CDFG staff assisted with GIS work and produced some beautiful maps, they are Roxie Anderson and Kristi Fien. CDFG staff Phil Deak and Alex Mandel provided advice regarding data management. Calvin Chun provided much consultation and advice regarding sample design and methodology and conducted the statistical analysis---many thanks to Calvin. Julie Dinsdale provided exceptional help with almost every part of the study including a huge number of samples. Kathy Collins and Sherrie Smith of the UC Davis Wildlife Health Center (WHC) provided administrative support and Walter Boyce, Christine Kreuder, Jonna Mazet, and Deanna Fritcher-Clifford provided valuable advice regarding sample design, objectives and methodology. Lastly, but most importantly, a gracious thanks to the tireless and ever optimistic field observers and associates, that actually conducted the inventory. They are Dick Anderson, Kieth Babcock, Pete Bloom, Mike Bradbury, Chris Briggs, Nikolle Brown, Julia Camp, Phil Detrich, Julie Dinsdale, Adrienne Disbrow, Melinda Dorin, Sid England, Jim Estep, Dan Gifford, Paul Hofmann, Waldo Holt, Terry Hunt, Anne Orlando, Julie Rechtin, Chris Rocco, Craig Swolsgaard, and Brian Woodbridge.

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