Appendix N

Burrowing Owl Population Viability Analysis Santa Clara Valley Habitat Conservation Plan/ Natural Communities Conversation Plan (HCP/NCCP)—March 2010

SANTA CLARA COUNTY

BURROWING OWL POPULATION VIABILITY ANALYSIS

SANTA CLARA VALLEY HABITAT CONSERVATION PLAN/ NATURAL COMMUNITIES CONVERSATION PLAN (HCP/NCCP)

MARCH 2010

ALBION ENVIRONMENTAL, INC.

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BURROWING OWL POPULATION VIABILITY ANALYSIS

SANTA CLARA VALLEY HABITAT CONSERVATION PLAN/ NATURAL COMMUNITIES CONVERSATION PLAN (HCP/NCCP)

MARCH 2010

PREPARED FOR:

COUNTY OF SANTA CLARA
HCP/NCCP PROJECT TEAM

PREPARED BY:

JACK BARCLAY
ALBION ENVIRONMENTAL, INC.
1414 SOQUEL AVENUE, SUITE 205
SANTA CRUZ, CALIFORNIA 95062

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INTRODUCTION

The Santa Clara Valley HCP/NCCP (Plan) contains the biological goal and objective of increasing the size and distribution of the burrowing owl (*Athene cunicularia*) population in the Plan area. Implicit in this goal is the assumption that increasing the size and distribution of the burrowing owl population will increase the likelihood that a population of owls will persist into the future through the 50-year term of the Plan. This goal invites examination of the question of how large the burrowing owl population in the Plan area has to be so it has an acceptably high probability of persistence. This report contains a quantitatively-informed examination of this question by using count-based population viability analysis (PVA) techniques of three of the largest extant burrowing owl colonies in the Santa Clara Valley at Mineta San Jose International Airport (SJC), NASA Ames Research Center/Moffett Field (Moffett), and Shoreline at Mountain View (Shoreline).

Results of the statewide burrowing owl survey in 1991-1993 (DeSante et al. 1997, 2007), and surveys for nesting burrowing owls in the Plan area in 2000 (Albion Environmental, Inc. 2000) and 2008 (Albion Environmental, Inc. 2008) suggest the population of nesting burrowing owls in Santa Clara County has declined in recent decades (also see discussion in Townsend and Lenihan 2007). Conclusions about the magnitude of decline have been based on different sources of information including anecdotal evidence from previous years (DeSante et al. 1997, 2007, Townsend and Lenihan 2007) or changes in abundance at individual colonies (Barclay 2007 for SJC; Trulio 1997 and Trulio and Chromczak 2007 for Moffett and Shoreline). DeSante et al. (1997, 2007) estimated the San Francisco Bay area burrowing owl population from 153 -165 pairs in the early 1990s and suggested a 50% decline since the late 1980s. Information about owl abundance in the City of San Jose also suggested an approximately 50% decline: from 43-47 pairs in 1997, to 39-40 pairs in 2000 and 20-21 pairs in 2008. To date there has been no quantitative analysis of population growth rate and variance using the same analytical method for the three best-studied burrowing owl colonies in Santa Clara County.

The goals of this analysis are to:

1. Quantify population size, growth rate and variance in the burrowing owl colonies at SJC, Moffett, and Shoreline in recent years,

2. Evaluate the probability of persistence of these colonies (individually and combined) using population growth and variance over recent years, and

3. Make an informed recommendation about how the conservation measures for burrowing owls could be constructed to increase the chances of meeting the Plan's biological goals and objectives for burrowing owls.

METHODS

I used count-based PVA methods described by Dennis et al. (1991), Morris et al. (1999), and Morris and Doak (2002) using annual counts of adult (i.e., ≥ 1 year old) burrowing owls recorded during the early part of the nesting cycle at SJC, Moffett, and Shoreline for the years shown in Table 1. Assumptions of count-based PVA include (Morris et al. 1999, Morris and Doak 2002):

1. The data represent exhaustive counts of a subset of individuals (i.e., adults) comprising a fraction of the entire population that does not change over time.

2. Year-to-year variation in the counts reflects the true magnitude of environmentally-driven variation, censuses were performed in a sufficient number of years (at least 10) to accurately assess year-to-year variation in population growth rate, and variation in counts must not be due primarily to observation error in estimating population size each year.

3. Inter-annual environmentally-driven variation is not extreme and there are no large-magnitude fluctuations caused by extreme catastrophes or unusually good years.

4. The population growth rate is not affected by density and does not change as the population increases or decreases.

Other conditions that affect the precision of estimates of persistence include the absence of autocorrelation (e.g., an increase following an increase or decline following decline) and no significant change in the growth rate over time (Morris and Doak 2002).

Implicit in this analytical technique is the assumption that environmental effects on vital rates (i.e., birth rates and death rates) and immigration and emigration are summarized in annual numbers of adult owls (Morris and Doak 2002).

Annual (t) population growth rate λ (lambda) was calculated as:

$$\lambda_t = N_{t+1}/N_t$$

Where N_t = number of adult owls in year t.

The geometric mean of λ (λ_G) expresses population growth and is the value that gives the same average annual population growth rate as observed over a long sequence of stochastically varying growth rates (Morris and Doak 2002). The geometric mean is used because it better represents exponential growth of populations than the arithmetic mean. Stochastic population growth μ (mu) was calculated as:

$$\mu = \log \lambda_G \approx (\log \lambda_t + \log \lambda_{t-1} + \log \lambda_{t-2} + \ldots + \lambda_2 + \lambda_1 + \lambda_0)/\ t$$

The variance in the rate at which μ changes over time is expressed as σ^2 (sigma squared) and is approximated by the variance of the log λ_t values (Morris and Doak 2002).

These equations predict that if $\mu > 0$, then $\lambda_G > 1$, and most population trajectories will grow and if $\mu < 0$, then $\lambda_G < 1$, and most trajectories decline. The more the population growth rate λ varies from year to year as a result of environmental and demographic stochasticity the greater will be the value of σ^2 and the greater the range of possible population sizes in the future (Morris and Doak 2002). Greater variance leads to less precise predictions of persistence (Morris and Doak 2002).

The probability of a population with parameters μ and σ^2 reaching a user-defined extinction threshold (i.e., quasi-extinction threshold) is based on diffusion approximation theory and the cumulative distribution function (CDF) (Morris and Doak 2002). The quasi-extinction threshold is a selected number for the purpose of comparing relative extinction risk of two or more populations rather than predicting when the last individual dies and the population is functionally extinct, which becomes imprecise with time (Morris and Doak 2002). Dennis et al. (1991), Morris et al. (1999), and Morris and Doak (2002) discuss the theoretical underpinnings of extinction approximation and CDF.

Annual number of adult burrowing owls

Annual numbers of adult burrowing owls at SJC represent the number of adult owls recorded in March or April as reported in annual breeding burrowing owl reports for SJC (Albion Environmental, Inc. 1997-2009, Barclay 2007). I selected the number of adult burrowing owls at Moffett from data supplied by C. Alderete (PAI Corporation) and the number of adult owls in March or April from data supplied by S. Kleinhaus (Santa Clara Valley Audubon Society) for Shoreline (Table 1, Figure 1).

I performed count-based PVA for each colony for the respective time periods for which adult count data were available (Table 1, Figure 1). I also analyzed a combined data set consisting of annual numbers of adult owls at SJC, Moffett, and Shoreline for the 11 year period 1999-2009 when adult count data were available for all three colonies (Table 1). For comparison to show a different growth rate for a similar-sized burrowing owl colony approximately during the same time period, I conducted the same analysis of adult burrowing owls at Sharpe Depot in San Joaquin County during 1997-2009 (Albion Environmental, Inc. annual breeding burrowing owl census reports, 1997-2009).

I simulated population growth in the Santa Clara County owl population by increasing the total population of adult owls (as of 2009), instantaneously and incrementally over time. Increasing the population enabled evaluation of the influence of future Plan conservation measures to support a larger burrowing owl population and how simulated population growth affected population persistence. Analyses were done with a count-based PVA tool obtained from Sinauer Associates (www.sinauer.org obtained October 2009).

RESULTS

Trends

Each of the burrowing owl colonies at SJC, Moffett, and Shoreline showed declining trends (i.e., $\mu < 0$) over their respective time periods (Table 1, Figure 1). SJC and Moffett showed very similar magnitudes and variance of decline compared to Shoreline that showed a greater magnitude and variance of decline (Table 1). However, the 95% confidence limits (CL) of decline (μ) for each colony ranged from negative to positive (i.e., spanned equilibrium) (Table 1).

The combined numbers of adult owls in all three colonies for the 11-year period 1999-2009 also showed a declining trend and relatively high variance (i.e., $\sigma^2 \geq 2\mu$, Morris and Doak 2002) (Table 1).

Probability of persistence

The colonies at SJC and Moffett showed similar probabilities of persistence represented by the mean and 95% CL of the probability of reaching a quasi-extinction threshold of two adult owls (Figure 2). These two colonies showed similar probabilities of quasi-extinction at 50 years: 0.5293 (0-0.9936) at SJC and 0.5256 (0-0.9954) at Moffett (Table 1). Shoreline showed a higher probability of reaching the quasi-extinction threshold of two adults (Figure 2), due to the smaller size of this colony and greater decline and variance (Table 1).

The probability of quasi-extinction, set at six adults (representing two adults at each colony) for the combined counts (Figure 3) was slightly higher (0.06909, 0-0.996) than for the individual colonies at SJC and Moffett (Table 1).

DISCUSSION

As an example of the effect of a positive growth rate (μ) on population persistence Figure 4 shows annual counts of adult burrowing owls at Sharpe Depot in San Joaquin County for 1997-2009 (Albion Environmental, 1997-2009). The mean probability of persistence coincides with the x-axis (i.e., zero) although the 95% CL show that this colony still has a fairly high probability of quasi- extinction (2 owls) with time (95% CL ~ 90% at 50 years), due to the wide confidence limits of μ (-0.1070 – 0.2225) and variance (σ^2 = 0.0672) (Figure 4).

In order to evaluate the effect of population size on population persistence, I experimentally doubled the combined 2009 population of adults at the three colonies (51 adults, Table 1) to 102 and show the probability of persistence CDF in Figure 5 (top). The best estimate of reaching the quasi-extinction threshold in 50 years is 0.5363 (95% CL 0 – 0.991). Because doubling the population size did not substantially lower the probability of quasi-extinction (compare with Figure 3 bottom) I increased the population to 204 (i.e., 4 x the 2009 population) and show the probability of quasi-extinction CDF in Figure 5 (bottom). In this case the best estimate of quasi-extinction in 50 years declined to 0.3836 (95% CL 0-9982).

While increasing population size lowered the mean probability of extinction, the 95% confidence limits still approach 100% in about 30 years (Figure 5). These analyses show that population size alone does not increase the probability of persistence to an acceptably high level. One of the reasons is that instantaneously increasing population size does not reverse the declining trend from the previous 11 years in the three major colonies during 1999-2009 (Table 1). This suggests that in order for burrowing owls to have a higher probability of persistence during the 50-year term of the Plan the population growth rate will have to change from a decreasing trend ($\mu < 0$) to an increasing trend ($\mu > 0$).

To assess how long it might take to achieve a positive growth rate, I incrementally increased the population at the three colonies combined (51 adults) in 2009 by three percent per year (rounded to whole integers) until μ changed to positive. Figure 6 shows that it took 16 years of three percent increase per year to obtain a positive growth rate. The probability of quasi-extinction CDF of the resulting population (Figure 6 bottom) shows how a positive growth rate increases the chances of population persistence.

RECOMMENDATIONS

The PVA of burrowing owls in the Santa Clara Valley demonstrates that population persistence is not based solely on numbers, but rather it will be necessary to reverse the negative growth rate observed in the three largest local burrowing owl colonies during the last 11 years in order to reduce the probability of extinction to an acceptably low level (Figure 6). To accomplish this, the Plan's conservation goals and objectives should contain provisions to conserve and manage nesting habitat in optimum condition as soon as practicable after Plan approval to enable the local burrowing owl population to increase.

Second, the Plan should contain a detailed annual monitoring protocol (Morris et al. 1999, Morris and Doak 2002) designed to yield thorough annual counts of adult owls at a consistent subset of locations occupied by nesting burrowing owls. These could include colonies at SJC, Moffett, Shoreline, Alviso area, Mission College, Warm Springs District. Annual adult counts at a consistent subset of breeding sites should be included in annual on-going count-based PVA updates to enable monitoring of population trend and variance during the term of the Plan. Finally, success criteria for burrowing owl conservation in the Plan should be evaluated in terms of annual adults and annual monitoring of the growth rate (μ).

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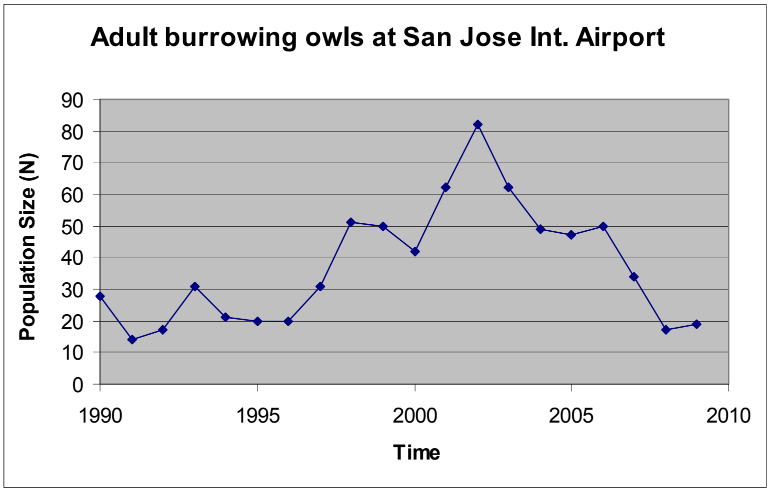
Table 1. Adult burrowing owl counts and count-based population viability analysis parameters for colonies at Mineta San Jose International Airport (SJC), NASA Ames Research Center/Moffett Field (Moffett), and Shoreline at Mountain View (Shoreline) and combined counts for all three colonies for 1999-2009.

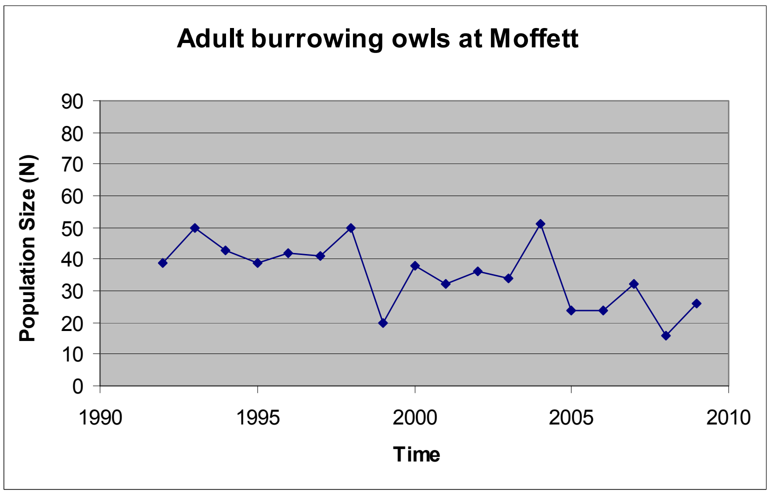
Year	SJC[1]	Moffett[2]	Shoreline[3]	SJC, Moffett, Shoreline combined
1990	28			
1991	14			
1992	17	39		
1993	31	50		
1994	21	43		
1995	20	39		
1996	20	42		
1997	31	41		
1998	51	50		
1999	50	20	11	81
2000	42	38	22	102
2001	62	32	18	112
2002	82	36	18	136
2003	62	34	20	116
2004	49	51	21	121
2005	47	24	11	82
2006	50	24	18	92
2007	34	32	21	87
2008	17	16	9	42
2009	19	26	6	51
No. of years	20	18	11	11
Mean λ	0.9798	0.9764	0.9412	0.9411
(95% CL)	(0.8185 - 1.1728)	(0.7827 - 1.2180)	(0.6681 – 1.3257)	(0.6681 – 1.3257)
μ	-0.0204	-0.0238	-0.0606	- 0.0462
(95% CL)	(-0.2003 - 0.1594)	(-0.2449 - 0.1972)	(-0.4032 - 0.2819)	(-0.2649-0.1724)
σ^2	0.1392	0.1850	0.2293	0.0934
Probability of quasi-extinction at 50 years (95% CL)	0.5192 (0 – 0.9936)	0.5256 (0 – 0.9954)	0.9156 (0.0018 – 0.9999)	0.6909 (0 – 0.9996)
Quasi-extinction threshold	2	2	2	6

[1] Source: J. Barclay, Albion Environmental, Inc., annual burrowing owl breeding summary reports 1990-2009

[2] Source: C. Alderete, PAI Corporation, NASA Ames wildlife biologist

[3] Source: S. Kleinhaus Santa Clara Valley Audubon Society from P. Delevoryas and P. Higgins





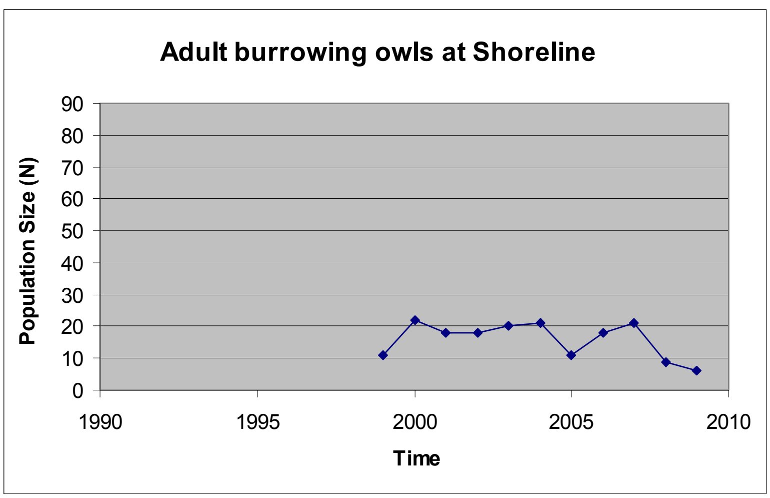


Figure 1. Adult burrowing owl counts at SJC (1990-2009), Moffett (1992-2009), and Shoreline (1999-2009) used in individual colony count-based population viability analysis.

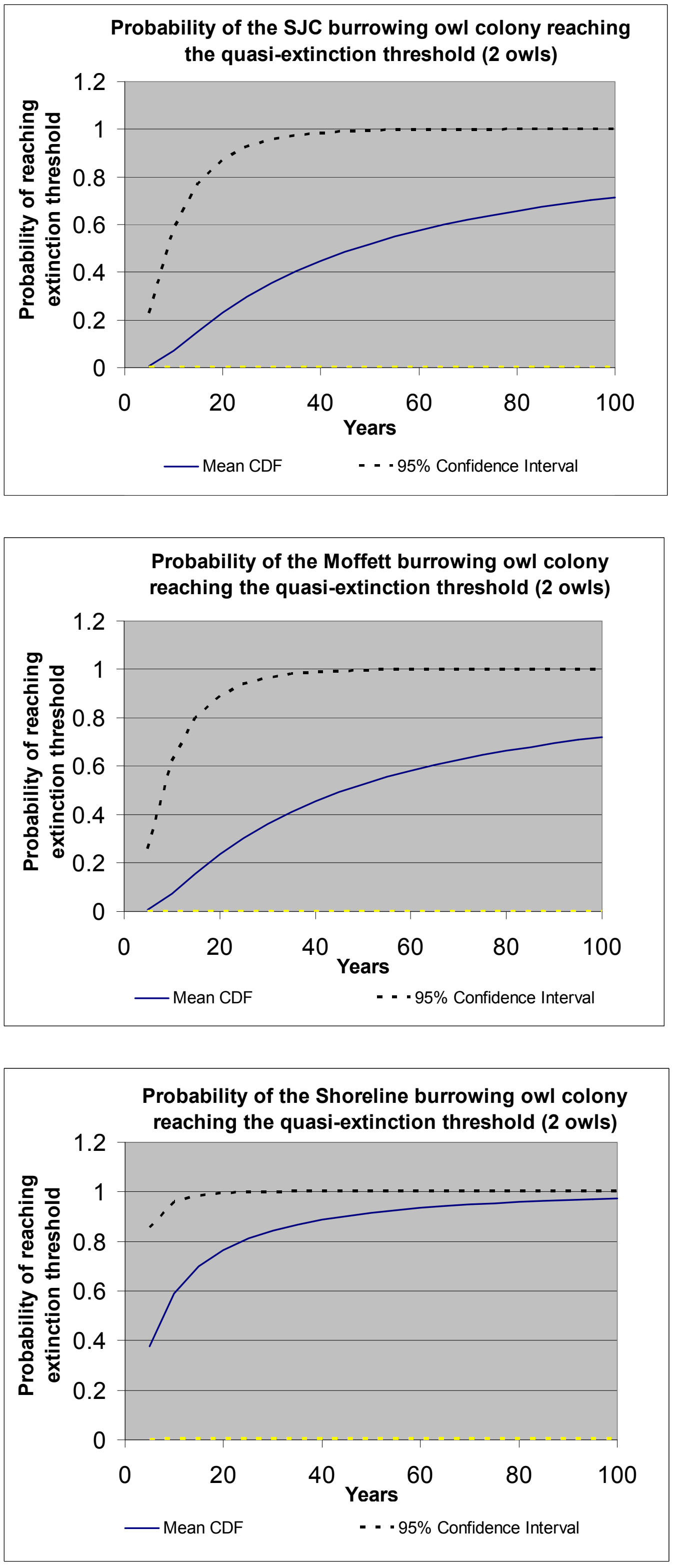
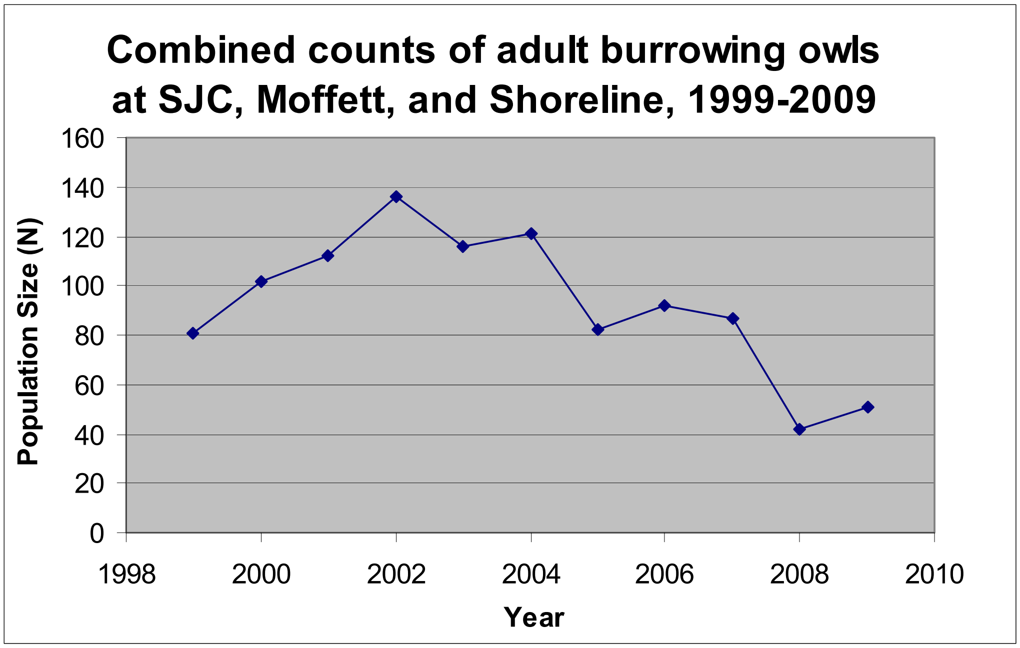


Figure 2. Probabilities of the burrowing owl colonies at SJC, Moffett, and Shoreline reaching a quasi-extinction threshold of two owls based on cumulative distribution function (CDF).



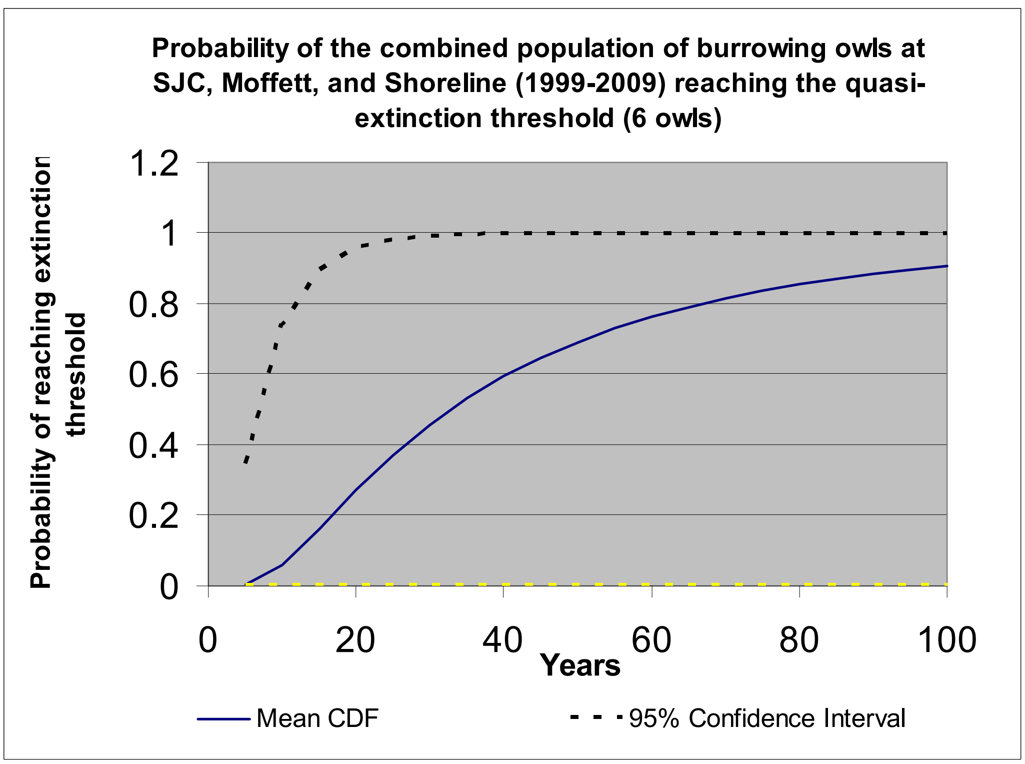
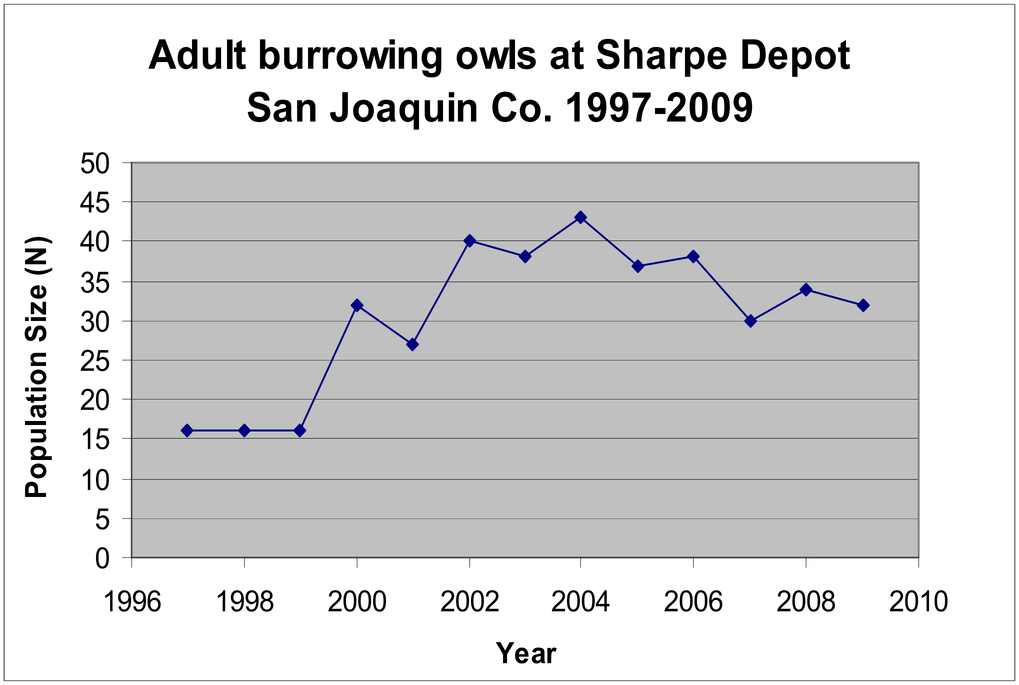


Figure 3. Combined counts of adult burrowing owls at SJC, Moffett, and Shoreline for the years 1999-2009 (top graph) and probability of the combined population reaching a quasi-extinction threshold of six owls (bottom graph): mean $\lambda = 0.9547$ (95% CL 0.7672 - 1.1881), $\mu = -0.0462$ (95% CL -0.2649 – 0.1724), $\sigma^2 = 0.0934$.



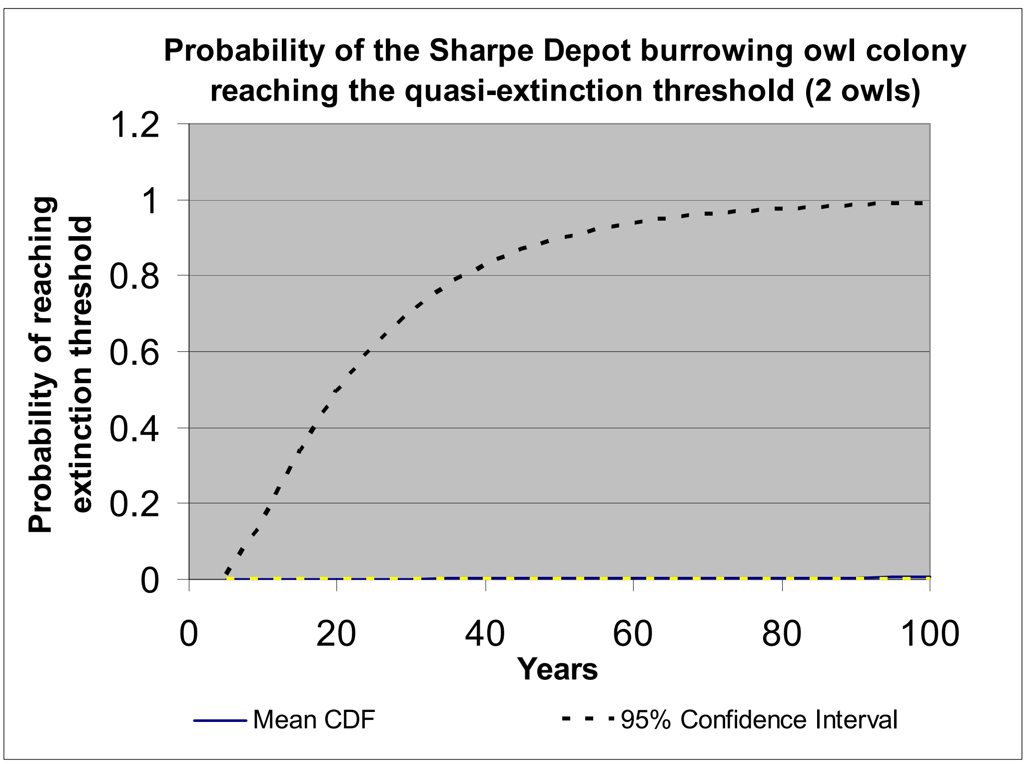
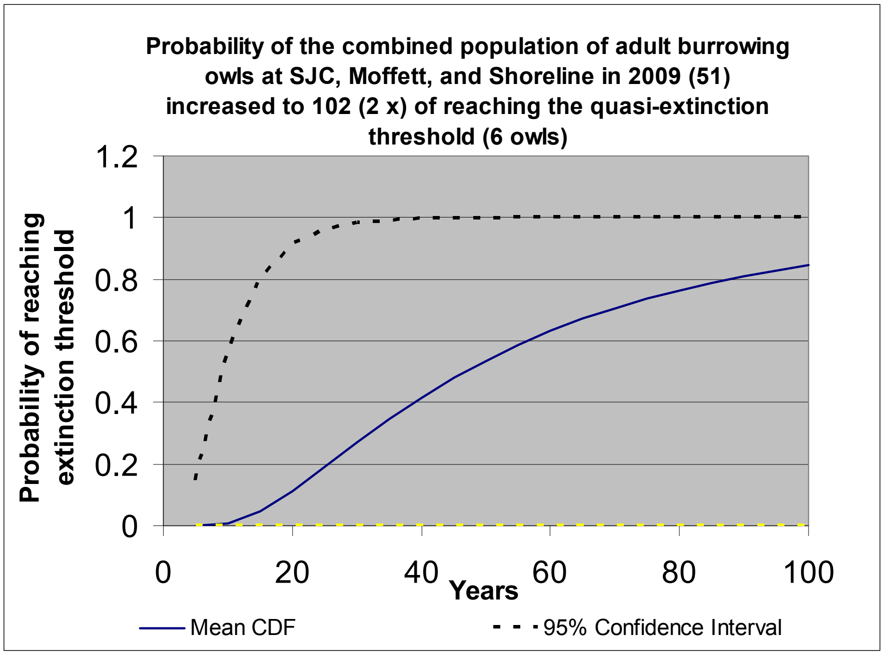


Figure 4. Adult burrowing owl counts at Sharpe Depot from 1997-2009 (top graph) and probability of the colony reaching a quasi-extinction threshold of two owls (bottom graph): mean $\lambda = 1.0595$ (95% CL 0.89840 – 1.2492), $\mu = 0.0577$ (95% CL -0.1070 – 0.2225), $\sigma^2 = 0.0672$).



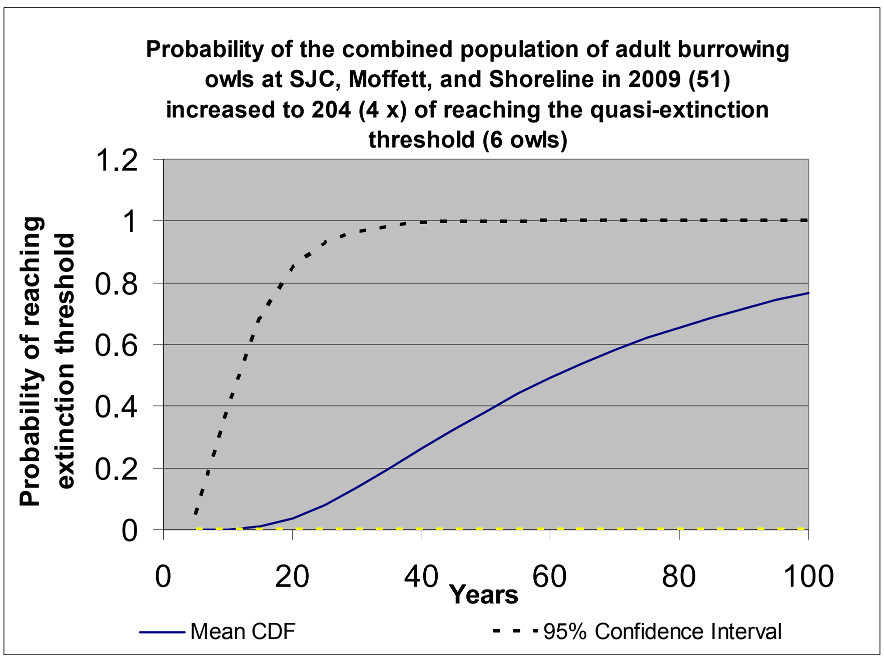
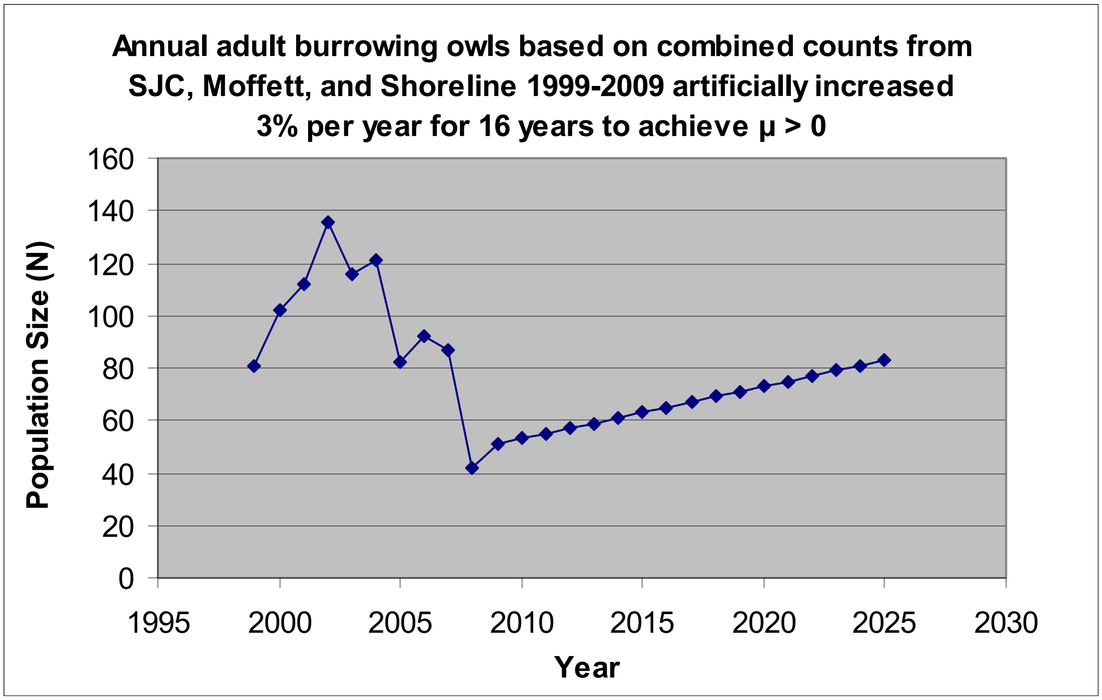


Figure 5. Probability of the adult burrowing owl population at SJC, Moffett, and Shoreline in 2009 (51 adults) increased 2 x (top graph) and 4 x (bottom graph) of reaching a quasi-extinction threshold of six owls.



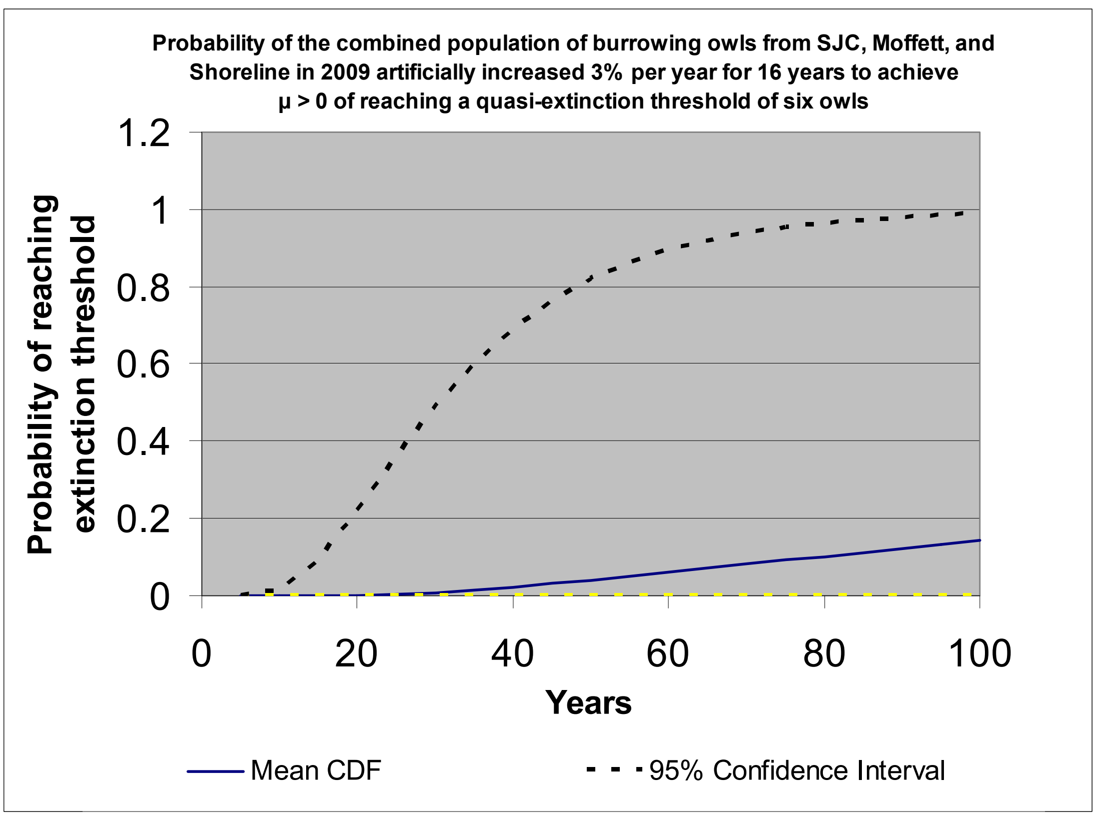


Figure 6. Adult burrowing owls at SJC, Moffett, and Shoreline 1999-2009 artificially increased 3% per year to achieve $\mu > 0$ (top graph) and probability of the resulting population: mean $\lambda = 1.0009$ (95% CL 0.9279 – 1.0796), μ = (0.0009 (95% CL -0.0747 – 0.0766), σ^2 – 0.0351, reaching a quasi-extinction threshold of six owls.