DEVELOPMENT OF RELIABLE POPULATION INDICES FOR BAND-TAILED PIGEONS

FINAL REPORT

Webless Migratory Game Bird Research Program
April, 2000

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Executive Summary

The band-tailed pigeon (*Columba fasciata*), once an important game species, is distributed in two distinct regions of western North America. The Pacific band-tailed pigeon (*Columba fasciata monilis*) is found in the mountain and foothill region primarily west of the crest of the Cascade-Sierra Nevada mountain ranges from British Columbia south to Baja California. The Interior race (*Columba fasciata fasciata*) is found primarily in the Rocky Mountains south of Wyoming and is commonly referred to as the "Four Corners" population. Wildlife professionals and sportsmen have observed serious declines in pigeon populations over the past 15-30 years. However, there is no formal population survey that is uniformly applied across the species range that can substantiate these observations. The objectives of this study are 1) to examine the potential effects of augmenting the Breeding Bird Survey (BBS) in providing a reliable and precise population index for both the Pacific and Interior population of band-tailed pigeons, and 2) to evaluate the effectiveness of call-count routes and mineral site counts as alternative methods in indexing the population.

We obtained historical data of band-tailed pigeon abundance. This data consists of the Breeding Bird Survey counts (1974-1996), Washington Call Counts (1975-1997), Washington Mineral Site counts (1993-1997), and Oregon Mineral Site counts (1950-1997). We used population regression models, measuring the standard error about the estimated annual rate of change, to conduct trend analyses on the data over short-term intervals (3 & 5 years). These standard errors were used to calculate power, the probability of detecting a significant change given a change exists. Standard errors and powers were compared across the data sets as a means for determining the effectiveness of detecting short-term changes. Simulation studies were conducted to determine how route length, replication, and number of survey sites might affect calculations of power. The trend estimate for each site contributed to the overall trend estimate calculated as a weighted average where weights were determined by the pigeon abundance at each site.

The trend analyses were performed separately over 3 and 5-year moving intervals for each site in each of the data sets. For example, we compared the estimated statistical power of standard BBS routes, call count routes, and mineral site surveys in detecting a 10% change in population index each year for a three-year period at the 0.05 significance level. Results

indicated that with a sample size of 50, we would expect the statistical power of the Pacific BBS to be about 10%, Interior BBS to be 29%, Washington call-count routes 17%, and Washington/Oregon mineral site counts to be 62%. We also examined the predicted effects of changing route length on the BBS and Washington call-count routes, and found that the power varied widely with no consistent pattern with respect to route length.

In addition to the statistical testing and modeling of historical data, we also conducted counts of pigeon abundance at Northern California mineral sites from early May until late August of 1998 (7 sites) and 1999 (8 sites). We calculated the daily totals, mean, standard deviations, and coefficient of variation over different date and time intervals for the entire study period. By minimizing the coefficient of variations we identified ranges of dates during which the pigeon counts appeared most consistent relative to the mean. The period from July 1 to July 31 had the lowest CV (36.43) and SD (9.73) overall for both years. We examined two-year trends at these sites as well as incorporated replication into the trend analysis. We found replication had minimal effect on sample size requirements and power.

Our findings indicate that large sample size requirements and high SD for BBS routes and other call count routes make these methods inadequate to identify short term (3-5 year) population trends for band-tailed pigeons in either the Pacific or Interior region. Augmentation of the survey by increasing route length or replication would have minimal effect on the power to detect short-term changes. Furthermore, the number of new routes that would have to be added to significantly improve power is unrealistic. However, we found that mineral site counts are more effective in detecting short-term trends in breeding population index, at least in the Pacific Coast population, due to lower variation and smaller sample size requirements. Further investigation of an appropriate survey methodology for the Interior population is warranted. Incorporation of a standardized Pacific population mineral site survey could help reduce variation and improve the power for detecting trends and provide a reliable breeding population index for the Pacific Coast population.

Acknowledgements

We thank field technicians Andrew Forde, Matt Law, Chris Miles, Heide Oberg, Jeff Schneiderman, and David Van Baren for their diligent and exhaustive efforts. Volunteer help from Gordon McDermid and Brett Heale was also greatly appreciated. The staff at the Whiskeytown National Recreation Area, and in particular, Russ Weatherbee, assisted with both logistics and field work for this study. Todd Sanders, from Oregon State University, assisted in field work and offered his insights into band-tailed pigeon biology. We thank Don Kraege and Brad Bales for providing critical data obtained on Washington and Oregon mineral site counts and call-count routes. Sam Blankenship from the California Department of Fish and Game, as well as William Perry, Pam Barnes and Glenn Wiley from the Dixon Field Station all offered technical and administrative assistance. The staff at Patuxent Wildlife Research Center provided BBS count data for power analysis, and in particular we thank John Sauer, Bruce Peterjohn, William Link, and Jim Nichols for their assistance. We also thank Grey Pendleton for providing SAS code. This project was made possible by a grant from the Webless Migratory Game Bird Research Program administered by David Dolton of the US Fish & Wildlife Service, and we thank him for his assistance and interest in this work. This project was also supported by the California Department of Fish and Game, the Biological Resources Division of USGS (Western Ecological Research Center), the Washington Department of Fish and Wildlife, and Oregon State University.

Table of contents

Executive Summary…………………………………………………..……………… ii

Acknowledgements ……………………………………..…………………….… iv

List of Tables ……………………………………………………………….….. vii

List of Figures …………………………………………………………………….. viii

I. Introduction ……………………………………………………………….... 1

II. Methods ………………………………………………………………………….. 3

Data ………………………………………………………………………………. 3

Trend estimation ……………………………………………………………….. 4

Power estimation ……………………………..…………………………………. 5

Long-term changes…………………………………...…………………….. 5

Short-term changes…………………………………………………………. ……. 5

Determining effects on power by duration or route length…….…………………... 6

Determining effects on power by replication…………………………………….6

California mineral sites…………………………………………………..…….7

Use of arrival and departure counts...………………………………………………7

Timing…………………………………………………….………………...……7

Age………………………………………………………………………………….8

Survey replication…………………………………………………………………...8

III. Results ………………………………………………………………………… 9

Size of sample used……...…………………………………………………………….9

Comparison between the BBS, WACC, and WAORMS surveys..……………..……..11

Effects of term length on trend estimation …………………………....…………12

Effects of route length on trend estimation………………..……………......…...12

Survey Timing…………………………………………………...……………….13

Arrivals, departures, and clock timing………………………………….………...18

Age……………………………………………………………………………………..18

Effects of replication on trend estimation in CAMS survey…………………...……19

Effects of timing on trend estimation in CAMS survey……………………………..19

IV. Management Implications….……………………………………………………21
V. Literature Cited….………………………………………………….………23

List of Tables

Table 1: Number of visits per location (route or site), number of locations surveyed, and number of locations with a trend estimate. Mean (range) numbers for a typical 3 or 5-year term. Trends were not estimable when data was sparse and/or too many zero counts occurred.

Table 2: Estimated power of detecting a 10% per annum change in population over a 3-year term at the 0.1 significance level for Pacific BBS, Washington Call Count, and Washington/Oregon Mineral Site Surveys.

Table 3: Means of band-tailed pigeon counts conducted at 8 mineral sites in Northern California, May-August 1998-1999.

Table 4: Standard deviation (SD) of band-tailed pigeon counts conducted at 8 mineral sites in Northern California, May-August 1998-1999.

Tables 5: Coefficient of variation (CV) of band-tailed pigeon counts conducted at 8 mineral sites in Northern California, May-August 1998-1999.

Table 6: Juvenile proportion of band-tailed pigeons counted at California mineral sites.

List of Figures

Figure 1:	Average band-tailed pigeon population indices by survey type and year.
Figure 2:	Estimation of long-term trends in abundance of band-tailed pigeons for Interior BBS, Pacific BBS, Washington Call Counts, and Oregon Mineral Site surveys.
Figure 3:	Estimation of long-term (1975-96) trends in abundance of band-tailed pigeons on Interior BBS, Pacific BBS, Washington Call Counts, and Oregon Mineral Site surveys.
Figure 4a-11a:	Estimation of 5 and 3 year trends in abundance for band-tailed pigeons for the Pacific BBS, Interior BBS, Washington Call Counts, Oregon and Washington Mineral Site Counts.
Figure 4b-11b:	Power for estimating 5 and 3 year trends in abundance for band-tailed pigeons for the Pacific BBS, Interior BBS, Washington Call Counts, Oregon and Washington Mineral Site Counts.
Figure 12:	Estimated 5-year breeding population trends in percent annual change of band-tailed pigeon numbers at mineral sites, along BBS routes, and on Washington Call Count routes in Washington, Oregon, and California. Surveys include Pacific states when available: Pacific BBS data includes surveys in all 3 Pacific states, mineral site surveys include Washington and Oregon, and WA Call Count surveys include Washington state only.
Figure 13:	Estimated 3-year breeding population trends in percent annual change of band-tailed pigeon numbers at mineral sites, along BBS routes, and on Washington Call Count routes in Washington, Oregon, and California. Surveys include Pacific states when available: Pacific BBS data includes surveys in all 3 Pacific states, mineral site surveys include Washington and Oregon, and WA Call Count surveys include Washington state only.
Figure 14:	The relationship between power and term duration for Pacific and Interior BBS routes.
Figure 15:	The relationship between power and term duration for Washington Call Counts and Washington and Oregon Mineral Site counts.
Figure 16:	The relationship between power and route length for BBS surveys.
Figure 17:	The relationship between power and route length for Washington Call Count surveys.

Figure 18: Maximum number of band-tailed pigeons counted arriving or departing from eight different mineral sites in Northern California in 1998 and 1999.

Figure 19: Counts of band-tailed pigeons at eight California mineral sites in 1998 and 1999, by survey date.

Figure 20: Number of band-tailed pigeons arriving and departing at eight California mineral sites.

Figure 21: Average number of band-tailed pigeon arrivals during 1-hour intervals from June15-August 31, 1998 and 1999.

Figure 22: Average number of band-tailed pigeon departures during 1-hour intervals from June 15 -August 31, 1998 and 1999.

Figure 23: Maximum total number of band-tailed pigeons at California mineral sites compared to estimated maximum number of adults.

Figure 24a: Effects of replication on estimation of 2-year trends in abundance for band-tailed pigeons at California mineral sites during May-August, 1998-99.

Figure 24b: Effects of replication on power for estimating 2-year trends in abundance of band-tailed pigeons at California mineral sites during June-August, 1998-99 (CH=level of change detected).

Figure 25: Estimation of 2-year trends in abundance for band-tailed pigeons at California mineral sites during May-August, 1998-99.

I. Introduction

The band-tailed pigeon (*Columba fasciata*) is distributed in two distinct regions of western North America. The Pacific band-tailed pigeon (*Columba fasciata monilis*) is found in the mountain and foothill region primarily west of the crest of the Cascade-Sierra Nevada mountain ranges from British Columbia south to Baja California (Am. Ornithol. Union 1957). The Interior race (*Columba fasciata fasciata*) breeds primarily in the Rocky Mountains south of Wyoming and is commonly referred to as the "Four Corners" population (Braun 1994). Despite their geographic separation there is some evidence of limited interchange between the two populations (Schroeder and Braun 1993). Breeding Bird Survey (BBS) data indicates that the coastal population of band-tailed pigeons has declined substantially during the past 15-30 years while there is insufficient data to describe long-term trends for the interior population (Braun 1994). Declining or altered forest habitat along the Pacific coast may be partly responsible for the population decline (Braun 1994). Hunting regulations have been severely restricted since the late 1980's with reduced bag limits and shorter season lengths (Sanders 1999), however these restrictions have not had an apparent effect on population size. Disease, in particular trichomoniasis, may have substantial effects on population size and may be exacerbated by exposure to other columbids at suburban feeding and watering sites (Braun 1994).

Development of a reliable population index is critical for band-tailed pigeons because they may be particularly susceptible to hunting pressure and they have a relatively low reproductive potential (1 egg clutch, 2 clutch/yr) (Gutierrez et al. 1975, Jarvis and Passmore 1992). All recent comprehensive literature dealing with research needs for band-tailed pigeons identify the need of a reliable population index for both the Pacific and Interior races as a top research priority (Braun 1994; Western Migratory Upland Game Bird Tech. Comm. 1994; Jeffrey 1977; Keppie et al. 1970). There is no formal population survey applied uniformly across the species range to index band-tailed pigeon breeding populations. Only two states estimate band-tailed pigeon numbers using species-specific surveys. In Washington call-count routes (WACC) (Jeffrey 1989) and mineral site counts are conducted (WAMSS) (Kraege unpublished rept. 1997). In Oregon, mineral site counts (ORMS) are conducted at several consistently surveyed sites (Western Migratory Upland Game Bird Tech. Comm. 1994). Both of these methods have limitations. Access throughout the breeding range is constrained, making call-count routes difficult to distribute through some important breeding areas. Mineral sites are not used consistently throughout the range of the band-tailed pigeon, and timing and intensity of use may vary widely depending on food availability (Braun 1994).

Biologists in California have attempted both mineral site counts and call count routes on a limited basis and they have also conducted post-hunting season counts of pigeons throughout California (CDFG unpubl. data). None of these counts were believed to yield consistent enough data to establish either long-term or annual indices, and were discontinued.

Methods such as bait station counts and mark/recapture have been investigated as techniques for developing population indices for band-tailed pigeons. Curtis and Braun (1983) recommend criteria for selection of bait station sites, timing of counts, and type of grain. Braun (1994) suggests that bait stations may provide a method of census in areas where food is limiting, and he suggests further investigation of this census technique. Braun (1976) suggests mark/recapture as a method for population monitoring of individual flocks, but this method would be costly and not feasible over a large area (Braun 1994). Sanders (1999) suggested a point count methodology to survey for band-tailed pigeons, using random survey points within their breeding range. This point count method may offer an alternative to current surveys, and warrants further investigation.

The Breeding Bird Survey (BBS), overseen by the US Geological Survey (Biological Resources Division) and the Canadian Wildlife Service, currently provides annual population data on all bird species. However, the BBS has limitations for band-tailed pigeons including a paucity of routes in pigeon habitat and low pigeon densities along these routes. These factors contribute to a high variance in predicted population indices and relative trends, especially in the Interior states where densities are very low and variances high (Braun 1994). The BBS has detected significant long-term trends for Pacific band-tailed pigeons, but estimates for the Interior population have failed to detect any significant trends (Braun 1994). Nonetheless, the BBS may offer a framework for improvement to conduct a systematic population survey throughout the range of the band-tailed pigeon.

We evaluated augmentation of the BBS as a means to provide a reliable and precise population index for both the Pacific and Interior population of band-tailed pigeons. Investigation of how to improve the trend estimates and population indices for pigeons provided by the BBS might provide a suitable population-wide index for band-tailed pigeons. We also evaluated the effectiveness of mineral site counts, to allow comparison of results between survey methods to help assess survey validity. The opportunity exists to combine mineral site estimates from Washington and Oregon with potentially new mineral site counts in California (CAMS) to produce an index for the Pacific Coast population of band-tailed pigeons based on mineral site counts. These counts may offer an alternative to the roadside survey methodology of the BBS and WACC. Comparison of results from different techniques may offer insight into the most reliable technique as well as increasing confidence in results (Sauer et al. 1994).

II. METHODS

Creating a reliable index for band-tailed pigeons is dependant upon the development of a feasible methodology. The methodology must provide a robust estimate of long and short-term population changes. The results of this study are based on the statistical analysis of historical data, and mineral site data collected in California during 1998 and 1999. We examined the potential of existing band-tailed pigeon population surveys for detecting both long and short-term population changes. We considered short-term trends as 3 & 5 year intervals and long-term trends as 20-year intervals.

Data. We used trend analysis to determine both long and short-term population changes. In order to assess the performance of various survey types in detecting short-term trends, we performed separate trend analysis over 3 and 5-year moving intervals for each site in each of the following annual surveys.

I. HISTORICAL
   - A. Breeding Bird Survey 1974-1996
     1. Pacific population (Pacific BBS - California, Oregon, Washington)
     2. Interior population (Interior BBS – Arizona, Colorado, New Mexico, Utah)
   - B. Washington Call Count Survey 1975-1997 (WACC)
   - C. Washington and Oregon Mineral Site Survey 1961-1998 (WAORMS)
   - D. Oregon Mineral Sites – Eight Consistent Sites 1961-1998(OR)

II. PILOT
   - California Mineral Site Survey 1998-1999 (CAMS)

We combined mineral site data for Washington and Oregon into a single dataset because the Washington dataset was small (9 springs counted once each year for 5 years). There was little concern over dissimilarity in mineral site data between the two states because both datasets appeared to produce similar trend estimates and standard errors. Eight mineral sites in Oregon have been counted consistently between 1961 and 1998 and we use this subset (OR) of the Oregon data to examine trends as well.

Trend and power estimation

Trend estimation. We estimated trends based on a combination of approaches previously introduced for use with BBS data (Sauer et al. 1997, Link and Sauer 1994, Geissler and Sauer 1990). Geissler and Sauer (1990) proposed the use of independent linear regressions on log-transformed count data collected at each of a sample of sites. Link and Sauer (1994) updated the method of regression to a Poisson regression. Site-specific trend estimates were derived from regression slopes. The region-wide trend estimate was a weighted average of the site-specific trends, with weights determined by relative pigeon abundance, frequency of survey, and size of habitat area represented by site. Consequent to the randomness of the weights, the standard error was estimated by bootstrapping (Efron and Tibshirani 1993). By using the relationship between statistical power and standard error, the statistical power of detecting a trend was projected over a range of hypothetical sample sizes.

In a more recent development, Link and Sauer (1997) introduced an approach for modeling observer effects and for a larger class of population trajectory patterns (previous approaches assume a constant rate of change). We considered this approach inappropriate for our purposes because there is no obvious extension for estimating power for hypothetical sample sizes. Furthermore, the advantages offered by the method would not strongly apply to short-term estimation in which periods would be too short to contain information on observer effects or varying rates of change. In this report, we use the approach of Link and Sauer (1994).

Occasionally, the trend estimate for a site would be inestimable due to an insufficient number of surveys or a preponderance of zero counts. In these instances, we excluded these sites from the sample. We compare the average sample size of sites (routes or mineral sites) for which data was collected and the average sample size of sites yielding a trend estimate. When large sample sizes were used, we calculated normal confidence intervals, which assume normal errors and accurate standard errors. When small sample sizes were used, we calculated hybrid confidence intervals (Shao and Tu 1995). These nonparametric confidence intervals do not rely as much on obtaining accurate estimates of standard error, a difficult task with small sample sizes. Hybrid confidence intervals are less prone to "spectacularly wrong" results compared to other nonparametric methods (SAS software **http://www.sas.com/service/techsup/faq/stat/macro/jackboot.html**). However, the method is not a remedy for small sample size, and we cautiously interpreted estimates and confidence intervals associated with smaller sample sizes. We calculated trend estimations with SAS/STAT (SAS Institute 1997) and means with Microsoft Excel for tabular and graphical display.

Power estimation. Sample size, magnitude of the rate of change in population abundance, significance of statistical tests used to detect a trend, and inherent variability of perceived trends associated with the sampling of sites, all affect power estimates. The last factor is subject to additional influences circumstantial to the surveying conditions such as changes in observer skills, weather, survey timing, and location. Bootstrap standard deviation estimates represent estimates of variability without attempting to identify contributing causes. Sample size, trend size, and significance of test at hypothetical levels affect the corresponding power estimates. Power estimates increase with either sample size, trend size, or significance level, whereas power estimates decrease with standard deviation. We calculated all power estimates with Microsoft Excel for tabular and graphical displays.

Analysis of historical data

Long-term changes. Long-term changes in survey indices were illustrated by plotting average numbers of band-tailed pigeons counted at a roadside or mineral site surveys over time. These plots roughly depict changes in population sizes over time. However, they do not reflect factors in the survey that may have influenced average count size such as missed surveys or changes in observer. For comparison, the trends were also estimated for the largest common interval (1975-1996) for which data among all surveys are available.

Short-term changes. We assessed short-term changes by examining data for 3 and 5-year terms from each of the four surveys. We calculated moving trend estimates, standard deviations associated with trend estimated at one site, standard errors associated with the region-wide weighted average of site-specific trends, and confidence intervals around the region-wide trend estimates. Sample size is the number of all survey sites for which a trend estimate for that period was available. The average standard deviation across all terms was used to construct tables and figures for the power of detecting trends.

Determining effects on power by term duration or route length. We assessed effects on standard deviation and power of trend detection by varying the duration of time over which a trend was estimated and by varying the route lengths in the historical call count and BBS data. This applies only to the BBS and the WACC surveys in which each route consisted of 50 and 20 roadside stops 0.5 mile apart, respectively. We calculated the trend and power estimates for different route lengths after restricting the data to the first 10, 20, 30, or 40 stops for the BBS surveys or to the first 5, 6, 7,…, or 19 stops for the WACC surveys. Trend and power estimates for 50 stops in the BBS surveys or 20 stops in the WACC surveys are equivalent to estimates for the complete survey.

Determining effects on power by replication. We attempted a simulation analysis of the effect of replication in historical surveys. The CAMS provided information as to how counts might vary when a location was surveyed more than once in the same year. The CV observed in the CAMS was assumed to apply to the BBS surveys. We simulated replicates by randomly generating and rounding normal variates with means equal to the one observed value for the year and standard deviation determined from the CV. When the observed value was less than 5, random Poisson variates were used to avoid negative counts. When the observed value was 0, we assigned 0.5 as the Poisson mean. Large simulations of these replicates would offer no reduction in between-location variability of trend estimates since we generated the replicates around the one original data replicate. Any between-location variation in the original data would be preserved in the simulated data, regardless of how large a sample was generated. Therefore, we did not run the trend analysis technique on the simulated dataset. Instead, we attempted to estimate the within-location variance of the trend estimate. A reduction in this variance would lead to a reduction in the region-wide variance of the trend estimate. We applied Poisson regression to the replicates to mimic the conditions of trend estimation on replicated data, and this procedure was repeated several hundred times to determine variance.

California mineral site survey (CAMS)

California mineral sites. We located mineral sites in Northern California using historical records from the CDFG and local information provided by pigeon hunters and forest workers. Once we identified a mineral site and verified that pigeons were using the site, we began weekly counts of pigeon abundance. Counts began ½ hour before sunrise following similar protocol established in the operational ORMS (Jarvis and Passmore 1992). We counted pigeons from fixed, concealed positions at each site to maintain consistency and minimize disturbance. We recorded the number of pigeons arriving and departing in ½ hour blocks. We aged birds upon arrival using the presence or absence of the light-colored neck crescent to separate adults (neck crescent present) from hatch-year birds (no neck crescent) (Braun 1994). We conducted the surveys from early May through early September, depending on when we located sites.

Use of arrival and departure counts. On each survey date, we tallied the number of band-tailed pigeons arriving at and departing from mineral sites between sunrise and noon. We defined the count for each survey to be the highest value of either the total arrivals or total departures, since we assumed this to be closest to the actual number of band-tailed pigeons visiting the site that morning. We present data as arrivals and departures by date and survey hour for each site.

Timing. We examined various 1-month periods for optimal survey timing. We identified months with low variances or standard deviations as being the most optimal for survey consistency. Since low means are correlated with low standard deviations, the coefficient of variation was considered to be a better measure of survey consistency across periods. While the standard deviation measures absolute variation, the coefficient of variation measures variation relative to the mean. Timing was also examined from the perspective of trend estimation.

Age. We estimated number of adults and juveniles by visually aging arriving pigeons during each survey. We estimated adult and juvenile counts by multiplying the corresponding proportion with the total birds counted at the site; juvenile counts are the difference between total and adult counts. Because of small differences between the total and adult counts, all analyses in this report are based on total counts.

Survey replication. We assessed effects of survey replication on standard deviation and power of trend detection by varying the numbers of replicated survey counts within a 10-day period around the month of July (June 21-August 10). We selected this time period by identifying the month with lowest variation, and we assume visits within a ten-day buffer would yield consistent counts. Replicates were selected chronologically beginning June 21.

III. RESULTS & DISCUSSION

Historical data

Size of sample used. Since the number of locations (routes) surveyed varied with year, the sample size for trend estimation varied with the term (Table 1). Locations in which no birds were counted throughout a term were not used in the trend analysis for that term. This occurred more often when calculating trends for shorter term estimates, such as the 3-year trend. This also occurred more often when calculating trends in regions with sparse band-tailed pigeon populations, such as the Interior states. As a result, the number of locations used in trend estimation could be much smaller than the number of locations that were surveyed. In particular, we could use an average of only 5.8% of Interior BBS routes surveyed in a typical 5-year term for estimating the trend for that term. For the Pacific BBS, WACC, and WAORMS, these percentages are 28.6%, 65.9%, and 92.7% respectively.

Long term changes. We plotted average number of band-tailed pigeons counted on the BBS, call-count, and mineral site surveys over time (Figure 1). Interior BBS surveys offered minimal data with an average of around .25 birds/route. The Pacific BBS survey and WACC were similar, ranging between 1 and 4 pigeons/route. The WAORMS counts ranged from 150 to 600 birds/site. We estimated long-term trends in abundance of band-tailed pigeons using these four surveys as well (Figure 2). All three surveys conducted on the Pacific population yielded similar trend estimates, with a mean decline of 2% per year, however, only the Pacific BBS was statistically significant (α=0.05). The Interior BBS survey offered no evidence of a long-term population trend and had a wide confidence interval from –11% to 7% annual change. We examined trends from 1975-1996, the start of the WACC survey, and found that the Pacific BBS and WACC were again consistent, however the ORMS survey was indicating a slight increase, however not statistically significant (Figure 3).

Short-term changes. We examined short-term changes in population index using 3 and 5-year terms for each of the surveys (Figures 4a-11a). We also estimated power to detect trends for each of the surveys (Figures 4b-11b).

Table 1. Number of visits per location (route or site), number of locations surveyed, and number of locations with a trend estimate. Mean (range) numbers for a typical 3 or 5-year term. Trends were not estimable when data was sparse and/or too many zero counts occurred.

	Mean visits per location		Number of locations surveyed		Number of locations with estimate	
Survey	5-year	3-year	5-year	3-year	5-year	3-year
Pacific BBS	3.7 (2.5-4.0)	2.4 (2.0-2.6)	271.6 (198-391)	244.8 (98-372)	77.8 (44-108)	54.7 (14-85)
CA BBS	3.7 (2.3-4.1)	2.4 (1.8-2.6)	165.2 (135-181)	147.3 (61-173)	51.5 (36-66)	37.4 (25-50)
OR BBS	3.6 (2.9-4.3)	2.4 (2.0-2.8)	59.7 (41-116)	54.5 (21-111)	12.9 (8-23)	9.3 (5-20)
WA BBS	3.6 (3.0-4.3)	2.4 (1.9-2.8)	46.8 (22-94)	43.0 (16-90)	15.9 (11-28)	12.0 (6-22)
Interior BBS	3.4 (2.7-4.0)	2.3 (2.0-2.6)	138.5 (59-325)	125.2 (56-318)	8.1 (3-26)	4.5 (1-17)
AZ BBS	3.5 (2.4-4.3)	2.4 (1.8-2.8)	30.7 (16-69)	27.7 (14-66)	3.8 (2-10)	2.5 (1-8)
CO BBS	3.7 (2.7-4.6)	2.5 (1.8-2.9)	44.1 (17-113)	40.8 (15-110)	2.6 (1-6)	1.8 (1-4)
NM BBS	3.3 (2.0-4.4)	2.6 (1.5-3.0)	34.8 (14-66)	30.9 (8-66)	2.6 (1-9)	2.1 (1-8)
UT BBS	3.1 (1.7-3.9)	2.2 (1.3-2.8)	28.8 (9-77)	25.8 (6-76)	1.5 (1-3)	1.2 (1-2)
WACC	3.6 (2.6-4.0)	2.4 (1.7-2.6)	54.5 (46-62)	49.2 (35-57)	35.9 (26-46)	24.8 (12-39)
WAORMS	4.2 (3.3-4.7)	2.7 (2.3-2.9)	26.2 (11-46)	24.7 (8-46)	24.3 (9-46)	22.4 (8-46)

Comparison between the BBS, WACC, and WAORMS surveys in the Pacific region. We compared short-term trend analyses (Figures 12-13) using different surveys covering the Pacific population of band-tailed pigeons. Confidence intervals around these trend estimates demonstrate the three surveys changing in consistent directions for 5-year trends over time (Figures 4a, 8a, and 10a). Both the WAORMS and the BBS give evidence of population decreases occurring during the early-1970s to mid-1970s before the WACC had begun. The WAORMS gives further evidence of decrease as early as the mid-1960s before either the BBS or the WACC had begun. The three surveys were consistent in following population trends from the mid-1970s to late-1980s. All three survey results suggest population increases from the mid-1970s to late-1970s followed by population decreases from the early-1980s to the late-1980s.

However, during the late-1980s to early-1990s, 5-year trends for the BBS and the WACC both showed population decreases while the WAORMS showed increases. Similar discrepancies for that time period are observed in estimates of 3-year trends. From the late 1960s to the late 1980s, the WAORMS and the BBS are remarkably consistent despite fluctuating patterns of increase and decrease. Both surveys identify the same 3-year periods of peak changes until the late 1980s when their estimates become either asynchronous or divergent. After the early 1990s, the WAORMS and the BBS are in agreement. The BBS shows trend patterns that are more consistent with the WACC, however more often asynchronous than with the WAORMS.

Comparison of standard deviations indicates between-location variations are lowest for the WAORMS (Figures 12 and 13). This suggests the WAORMS has the best precision and greatest power of detecting trends. As an example, Table 2 illustrates the difference in powers for the Pacific BBS, WACC, and the WAORMS surveys. These values are taken from Figures 5b, 9b, and 11b.

Table 2. Estimated power of detecting a 10% per annum change in population over a 3-year term at the 0.1 significance level for Pacific BBS, Washington Call Count, and Washington/Oregon Mineral Site surveys.

# of Sites	Pacific BBS	WACC	WAORMS
30	0.13	0.19	0.79
50	0.16	0.26	0.94
70	0.19	0.32	0.98
100	0.21	0.41	1.00

Effects of term length on trend estimation in BBS, WACC, and WAORMS surveys. Figures 14-15 show power and standard deviation estimates for all historical surveys, the Pacific BBS, Interior BBS, WACC, and WAORMS surveys. Estimates are calculated for 2, 3, 4, and 5-year terms in addition to the 22-year term, 1975-1996, and the entire span of time for which the survey was run. Since the power and standard deviation are inversely related with each other, it suffices to interpret only the pattern in power. Power estimates for all surveys consistently increase with term length, suggesting population changes are easier to detect when estimating changes sustained over a longer period of years. Power rises sharply over increases within term lengths of 5 years and tapers toward 100% for longer term lengths. Based on detection of 10% annual changes using 100 sites and testing at the 0.1 significance level, the surveys listed in order of having the best short-term power are the WAORMS (reaching above 80% power at 3-year terms), the Interior BBS (reaching above 80% power at 4-year terms), the WACC (reaching 80% power at 5-year terms), and the Pacific BBS (reaching 80% power at between 5-year and 10-year terms).

Effects of route length on trend estimation in BBS and WACC surveys. Figures 16-17 show power and standard deviation estimates for the three route-based surveys, the Pacific BBS, the Interior BBS, and the WACC. Estimates for the BBS surveys were calculated for the first 10, 20, 30, 40, and 50 stops on the 50-stop routes. Estimates for the WACC surveys were calculated for the first 5, 6, 7,…,19, and 20 stops on the 20-stop routes. All power calculations were based on detection of 10% annual changes over a 5-year period using 100 routes and testing at the 0.1 significance level. Since the power and standard deviation are inversely related with each other, it suffices to interpret only the pattern in power. The Interior and Pacific BBS surveys do not show any consistent relationship between power and route length. Power estimates for the Interior and Pacific BBS bob within respective ranges of 0.07 and 0.04 of respective midpoints, 0.83 and 0.46, without any discernible relation to the length of route. Conversely, power estimates for the WACC increases steadily from a power of 0.67 using 5 stops (2-mile route) to 0.79 using 20 stops (9.5 mile route). The fluctuations in the BBS estimates can partly be attributed to lack of precision in the standard deviation estimates related to either low sample sizes or wide variation in sample variances. Lower sample sizes would cause standard deviation estimates to fluctuate more widely as it does for the Interior BBS survey, which has estimates based on 3-26 routes for any given 5-year trend compared to 44-108 for the Pacific BBS and 26-46 for the Washington Call Count survey (Table 1). This would lead to wide variation in the variance, standard deviation, and power estimates. The degree of this variation can be measured by the standard deviation of the standard deviation estimates, which was 22% for the Pacific BBS, 18% for the Interior BBS, and 13% for the WACC. It is not clear what factors may be contributing to the larger variation in survey standard deviation for the Pacific BBS. Generally, the evidence in the WACC suggests some benefit in power by increasing route length, though this benefit appears to be slight and is not apparent in the BBS surveys.

California mineral site survey

Survey timing. We plotted the number of band-tailed pigeons counted by year and date, with locations overlaid (Figure 18). We graphed the same information by site and date, with years overlaid (Figure 19). Numbers of band-tailed pigeons counted are defined as the maximum of the total arrivals and total departures occurring between sunrise and noon. The data is summarized using means and standard deviations within specific 1-month intervals in Tables 3-4. Means and standard deviations decreased dramatically going from late spring into mid-summer, reached a minimum during the month of July, and then slightly increased from mid-summer to late summer. One notable exception is the Jarbo Gap site where bird counts were unusually low during the first half of summer 1999 and increased dramatically in the middle of July. The coefficient of variation (Table 5) identifies the mid-month from July 15 to August 15 as having the lowest average standard deviation relative to the mean. Exclusion of data from the Jarbo Gap 1999 survey would have identified the month of July as having the lowest CV.

The timing of migration plays an important rule in the timing of the mineral site counts. In late spring and early summer, many pigeons are still migrating north to their respective breeding grounds. Jarvis and Passmore (1992) report that the nesting season in Oregon begins in mid-June and continues on to a peak in late August. Late migrants from California are still moving north during this time, as indicated by some large counts at several mineral sites during May and early June (Figure 19). Neff (1947) observed that pigeons tended to group in large flocks following the breeding season, and moved together tracking the succession of food crops. The breeding season in California is an extended one, beginning in February and continuing on into October (MacGregor and Smith, 1955). By mid to late August many of the earlier nesting birds may have completed their nesting season, and begun to congregate in larger flocks as described by Neff (1947). This may account for some of the large increases seen at some of the sites in late August and early September (Figure 19). For these reasons, and the relatively low CV and SE during the month of July, we recommend that mineral site surveys conducted in California, take place during this time period.

Table 3. Means of band-tailed pigeon counts conducted at 8 mineral sites in Northern California, during varying time periods 98-99.

		May 1- May 31		Jun 1- Jun 30		Jun 15- Jul 14		Jul 1- Jul 31		Jul 15- Aug 14		Aug 1- Aug 31		Jun 21- Aug 10		Jun 15- Aug 31	
Site	Year	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Big Bend	1998	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	1999	*	*	3	176.0	3	228.3	3	198.3	4	200.0	4	229.5	6	201.3	9	220.4
Indian Creek	1998	*	*	*	*	2	75.5	4	69.8	4	67.0	3	70.3	5	67.0	7	70.0
	1999	5	81.0	5	63.2	4	52.5	4	39.0	5	43.6	5	54.8	7	43.3	12	48.9
Jarbo Gap	1998	7	66.4	8	53.8	7	60.9	7	60.6	8	55.8	9	65.4	14	56.6	20	62.4
	1999	5	37.4	3	7.7	4	5.3	4	20.5	4	51.5	4	62.0	6	23.3	10	34.0
Need Camp	1998	1	0.0	2	36.5	2	40.0	4	40.0	5	31.8	4	31.8	5	36.2	9	35.7
	1999	4	70.0	5	24.0	5	16.2	5	11.6	5	25.6	4	48.5	8	18.9	12	26.8
Pigeon Point	1998	8	54.4	6	17.7	7	13.0	5	7.6	4	7.8	4	13.0	10	11.4	13	11.9
	1999	4	6.5	2	0.0	3	1.3	4	6.0	4	8.8	3	6.3	6	5.2	8	5.4
Spanish Creek	1998	*	*	4	107.8	4	72.0	4	52.3	4	54.0	4	65.3	6	54.7	10	65.4
	1999	5	179.2	5	58.8	5	51.8	5	50.0	5	60.6	4	62.3	8	48.3	12	55.3
Sky Ranch	1998	3	206.3	2	17.0	1	12.0	1	10.0	2	16.0	3	24.3	2	11.0	5	19.0
	1999	4	10.8	2	2.5	4	6.5	5	7.8	4	5.0	3	5.0	7	6.1	9	6.0
Willow Creek	1998	1	0.0	1	29.0	1	35.0	4	28.3	5	26.8	4	36.8	5	26.4	8	32.5
	1999	4	392.5	4	82.3	4	57.5	5	40.4	5	42.2	4	48.3	7	39.3	11	49.8
Average Mean:			92.0		48.3		48.5		42.8		46.4		54.8		43.3		49.6

* denotes no data collected.

Table 4. Standard Deviation (SD) of band-tailed pigeon counts conducted at 8 mineral sites in Northern California, during varying time periods in 1998-99.

		May 1- May 31		Jun 1- Jun 30		Jun 15- Jul 14		Jul 1- Jul 31		Jul 15- Aug 14		Aug 1- Aug 31		Jun 21- Aug 10		Jun 15- Aug 31	
Site	Year	N	SD	N	SD	N	SD	N	SD	N	SD	N	SD	N	SD	N	SD
Big Bend	1998	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	1999	*	*	3	111.1	3	43.3	3	22.1	4	35.5	4	53.4	6	28.3	9	43.6
Indian Creek	1998	*	*	*	*	2	0.7	4	9.3	4	13.6	3	14.0	5	10.2	7	10.4
	1999	5	11.8	5	41.9	4	16.6	4	9.7	5	13.5	5	17.2	7	13.9	12	16.2
Jarbo Gap	1998	7	49.8	8	30.2	7	10.9	7	6.4	8	6.6	9	12.8	14	6.9	20	11.1
	1999	5	33.3	3	4.6	4	3.7	4	22.8	4	26.2	4	22.1	6	23.7	10	30.9
Need Camp	1998	1	*	2	3.5	2	8.5	4	11.5	5	12.7	4	19.6	5	13.1	9	14.5
	1999	4	25.4	5	10.2	5	11.1	5	7.0	5	13.9	4	19.1	8	12.5	12	20.1
Pigeon Point	1998	8	56.7	6	9.5	7	8.4	5	2.4	4	2.2	4	6.1	10	7.5	13	7.2
	1999	4	12.3	2	*	3	2.3	4	4.9	4	1.5	3	2.1	6	4.6	8	4.0
Spanish Creek	1998	*	*	4	33.1	4	29.9	4	10.7	4	9.4	4	14.8	6	11.7	10	21.1
	1999	5	83.5	5	23.5	5	22.8	5	8.0	5	15.1	4	16.4	8	9.4	12	17.3
Sky Ranch	1998	3	301.8	2	7.1	1	*	1		2	8.5	3	11.7	2	1.4	5	11.1
	1999	4	8.3	2	3.5	4	5.7	5	3.6	4	2.2	3	2.7	7	4.3	9	3.9
Willow Creek	1998	1	*	1	*	1	*	4	9.0	5	9.3	4	12.5	5	8.8	8	11.1
	1999	4	115.6	4	44.4	4	24.6	5	8.7	5	24.8	4	28.0	7	17.0	11	22.1
Average SD:			69.9		24.8		14.5		9.7		13.0		16.8		11.5		16.3

* denotes no data collected.

Table 5. Coefficient of variation (CV) of band-tailed pigeon counts conducted at 8 mineral sites in Northern California, during varying time periods in 1998-99.

		May 1- May 31		Jun 1- Jun 30		Jun 15- Jul 14		Jul 1- Jul 31		Jul 15- Aug 14		Aug 1- Aug 31		Jun 21- Aug 10		Jun 15- Aug 31	
Site	Year	N	CV	N	CV	N	CV	N	CV	N	CV	N	CV	N	CV	N	CV
Big Bend	1998	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	1999	*	*	3	63.1	3	19.0	3	11.2	4	17.8	4	23.3	6	14.1	9	19.8
Indian Creek	1998	*	*	*	*	2	0.9	4	13.4	4	20.3	3	19.9	5	15.2	7	14.9
	1999	5	14.6	5	66.3	4	31.6	4	24.9	5	30.9	5	31.3	7	32.0	12	33.1
Jarbo Gap	1998	7	75.0	8	56.1	7	18.0	7	10.5	8	11.9	9	19.5	14	12.1	20	17.9
	1999	5	89.0	3	60.3	4	70.2	4	111.0	4	50.9	4	35.7	6	101.4	10	90.7
Need Camp	1998	1	*	2	9.7	2	21.2	4	28.8	5	39.9	4	61.6	5	36.2	9	40.7
	1999	4	36.4	5	42.5	5	68.8	5	60.5	5	54.3	4	39.4	8	66.0	12	74.9
Pigeon Point	1998	8	104.2	6	53.8	7	64.8	5	31.7	4	28.6	4	46.6	10	65.4	13	60.3
	1999	4	189.9	2	*	3	173.2	4	81.7	4	17.1	3	32.9	6	88.6	8	75.0
Spanish Creek	1998	*	*	4	30.7	4	41.5	4	20.5	4	17.4	4	22.6	6	21.3	10	32.2
	1999	5	46.6	5	39.9	5	44.1	5	16.1	5	24.9	4	26.8	8	19.6	12	31.3
Sky Ranch	1998	3	146.3	2	41.6	1	*	1	*	2	53.0	3	48.0	2	12.9	5	58.1
	1999	4	76.9	2	141.4	4	88.4	5	46.6	4	43.2	3	52.9	7	69.3	9	65.1
Willow Creek	1998	1	*	1	*	1	*	4	31.8	5	34.8	4	34.0	5	33.4	8	34.0
	1999	4	29.5	4	53.9	4	42.7	5	21.5	5	58.9	4	58.0	7	43.2	11	44.4
Average CV:			80.8		54.9		52.6		36.4		33.6		36.8		42.0		46.2

* denotes no data collected.

Arrivals, departures, and clock timing. Figure 20 shows the total arrivals and total departures overlaid for each site, year, and survey date. Generally the total arrivals and total departures are in agreement, especially when assessing changes from 1998 to 1999. Figure 21 and Figure 22 show the band-tailed pigeon counts of arrivals and departures, respectively, by site and time with the 1998 and 1999 years overlaid. Pigeons were counted upon arrival and departure from the mineral site area, and maximum counts of arriving or departing birds were used for the daily totals with an average discrepancy of 7.26 birds between arriving and departing counts for all sites counted in both 1998 and 1999 (Figure 20). There were usually 2-3 peaks in band-tailed pigeon arrivals and departures during the morning followed by a decrease to almost no birds at noon. These results are similar to what Jarvis and Passmore (1992) reported at Oregon mineral sites. They found that there were two peaks of arriving and departing pigeons, with most males arriving in the early morning (before 8:00 am) and females tended to arrive in the mid-morning period (between 9:30 & 10:30 am). This pattern of use was reinforced by pigeons using California mineral sites as well (Figures 21 & 22).

In order to evaluate the possible use of mineral sites during other parts of the day, we conducted several counts between noon and sunset. Only a few birds were observed using the sites during these hours and thus we continued to conduct our surveys during the morning hours.

Age. Figure 23 shows the number of total birds counted per visit overlaid with the estimate of adult numbers calculated by multiplying the total with the estimated proportion of adults. There are relatively small differences between the total and the adult counts and visual inspection suggests that year-to-year comparisons would not differ between use of either the total counts or the adult counts. Juvenile birds were first observed at California mineral sites in early June, and reached a peak in late August, similar to what was observed at mineral sites in Oregon (Jarvis & Passmore, 1992). There were some distinct differences in proportion of juveniles at a given site in both studies. Jarvis and Passmore (1992) found that the percentage of juveniles observed at their three sites, ranged from 5-30%. Juvenile proportions ranged from 0-25% depending on site and time of year. The principal advantage for using total counts for monitoring breeding population, although it would include both adults and juveniles, is that age ratios were often uncertain and sometimes not even available.

Table 6. Juvenile proportion of band-tailed pigeons counted at California mineral sites.

Site	June	July	August
BB [1]	4%	26%	26%
IC	9%[1]	9%	20%
JG	0%	9%	14%
NC	8%	15%	29%
PP	2%[1]	11%	25%
SC	10%	11%	23%
SR	0%[2]	11%	18%
WC	0%[1]	13%	19%

[1] based on 1999 data only
[2] based on 1998 data only

Effects of replication on trend estimation in CAMS survey. Figure 24a shows the results of trend estimation using different numbers of replicates between June 21 and August 10. The standard deviation decreases slightly with increasing numbers of replicates. The estimated change is an approximate 30% to 40% decrease from 1998 to 1999. By inspection of the confidence intervals, this decrease changes from borderline insignificant when based on 1 replicate to barely significant when based on 2 or more replicates. It is advantageous to use any replicated data whenever it is available, however this advantage might not justify expending the extra effort to collect replicates. The improvement in standard deviation when using 2 versus 1 replicate is barely noticeable. Figure 24b compares the power estimates based on 1 replicate versus estimates based on 3 replicates, which yield a substantial improvement in standard deviation. The amount of power in an analysis using 3 replicates is much lower than the same analysis using 1 replicate with 3 times the sample size. There is no evidence that replication would improve the efficiency of a mineral site survey, based on these two years of the CAMS.

Effects of timing on trend estimation in CAMS survey. Trend estimation at different time intervals yielded interesting results (Figure 25). The trend estimate is highly dependent on what part of the breeding season the survey is conducted. Part of this variability is related to the small sample size, especially in May when only 3 sites had data in both years. It is uncertain what other factors might be affecting the difference in trend and standard deviation estimates. Extreme changes such as the 80% decrease in May can be an artifact of year differences in the onset of the breeding season. For example, if band-tailed pigeons had not yet begun migrating from Northern California in May 1998 but had already migrated in May 1999, then the trend analysis would show dramatic decreases. Trend estimates, which may be influenced by this type of mass exodus or influx, can also cause sites to appear very similar in their extent of change, thus leading to low site-to-site variability and narrow confidence intervals. This part of the analysis offers little insight, other than there is a need to be cautious in selecting the timing of survey and in making subsequent interpretations of the results.

IV. MANAGEMENT IMPLICATIONS

Successful management of any game species such as the band-tailed pigeon, requires that a reasonable means for detecting changes in population levels be in place. Developing the ability to detect long and short-term population changes gives managers the chance to react to the variability of a given population. The power analysis we conducted on the historical and California data indicates, that of the methods examined, the mineral site surveys offer the most powerful means of detecting both short and long-term changes. When comparing the results of the different survey techniques used for the Pacific population of band-tailed pigeons, we saw that all three survey types (BBS, Mineral Site, Call Count) yielded similar data for most of the time period covered. This reinforces the premise that the mineral site surveys can provide an accurate index of the Pacific population of band-tailed pigeons as well as a more powerful means of detecting short-term population trends.

Combining mineral site counts during the breeding season in Washington, Oregon, and California may provide a suitable index for the Pacific population of band-tailed pigeons. The power tables we developed for the historical and California mineral site data (Figures 10b-11b, 24b) can provide a basis for the design of a range-wide survey for the Pacific population of band-tailed pigeons. Conducting counts at 20 mineral sites throughout their breeding range would offer a nearly 90% chance of detecting a three year trend of 20%. The ability to detect these short term changes in population status would be invaluable for managers trying to evaluate population status while implementing management strategies and also to begin to relate the critical factors affecting band-tailed pigeon populations such as disease outbreaks or harvest pressures.

The Four-corners population of band-tailed pigeons needs to be addressed using an improved survey methodology as well, but lack of consistent use of mineral sites by pigeons in this area may preclude a similar survey methodology. The power analysis indicates that the number of routes in a BBS type of survey would have to be greatly increased to achieve an acceptable level of power in detecting short-term changes in population level. With relatively few BBS routes in the Four-corners region having pigeons consistently counted (<10%), the possibility of increasing the sample size to an appropriate level is minimal. A species specific survey similar to the mineral site counts is needed for the interior population of band-tailed pigeons, as augmentation of the BBS survey will not offer much hope in detecting short-term population trends.

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Figure 1. Average band-tailed pigeon population indices by survey type and year.

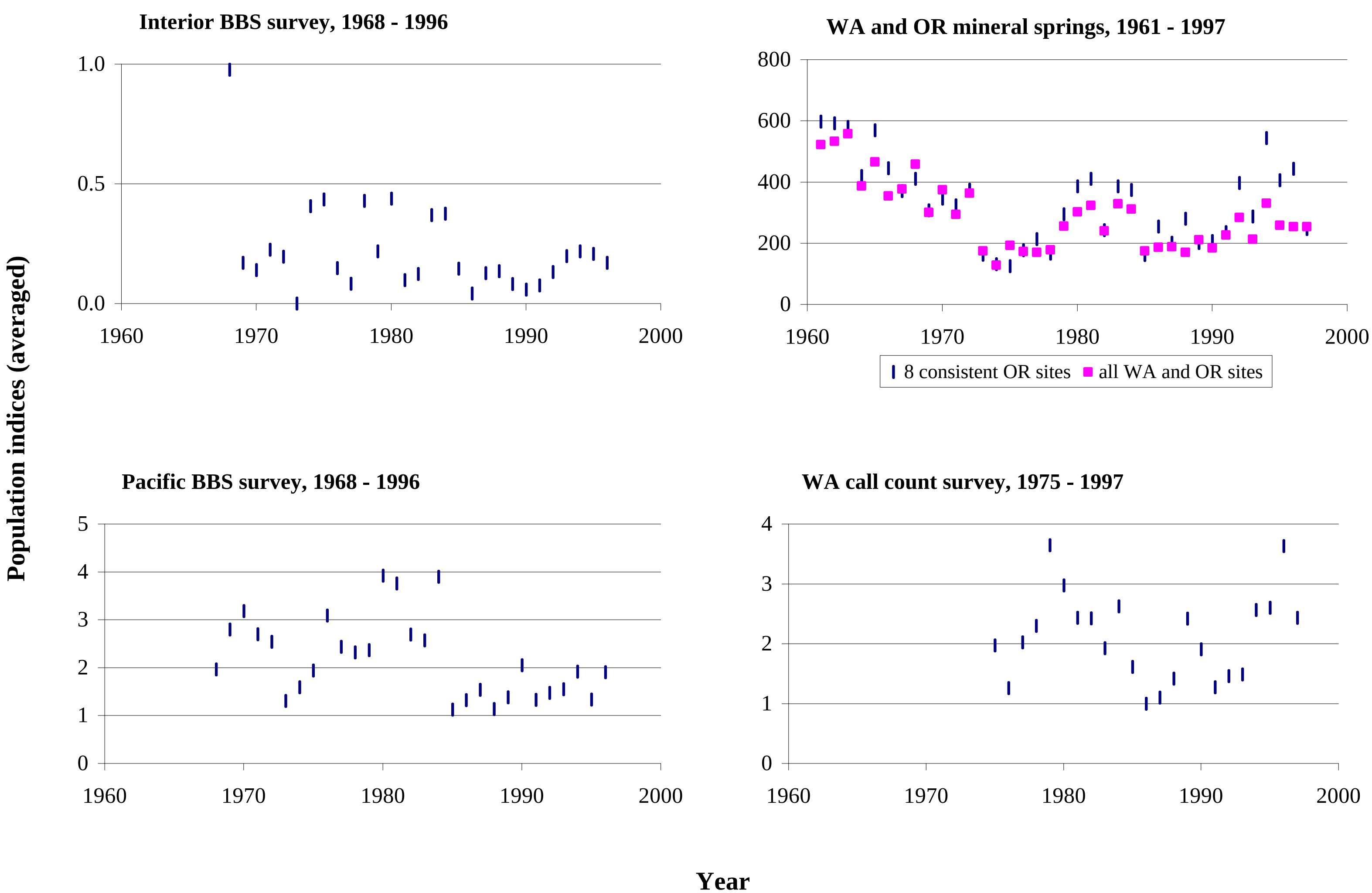


Figure 2. Estimation of long-term trends in abundance of band-tailed pigeons for Interior BBS, Pacific BBS, Washington Call Counts, and Oregon Mineral Site surveys.

Survey : All four surveys
Term length : All available years

Years	Sample size	Mean	SD	Standard error	95% CI for % change
		Percent per annum change			
INT BBS 1968-1996	43	0%	28%	5%	(-11% , 7%)
PAC BBS 1968-1996	171	-2%	9%	1%	(-4% , -1%)
WACC 1975-1997	78	-2%	8%	1%	(-4% , 0%)
ORMS 1961-1997	8	-2%	4%	2%	(-4% , 2%)
average	*43*	*0%*	*28%*		

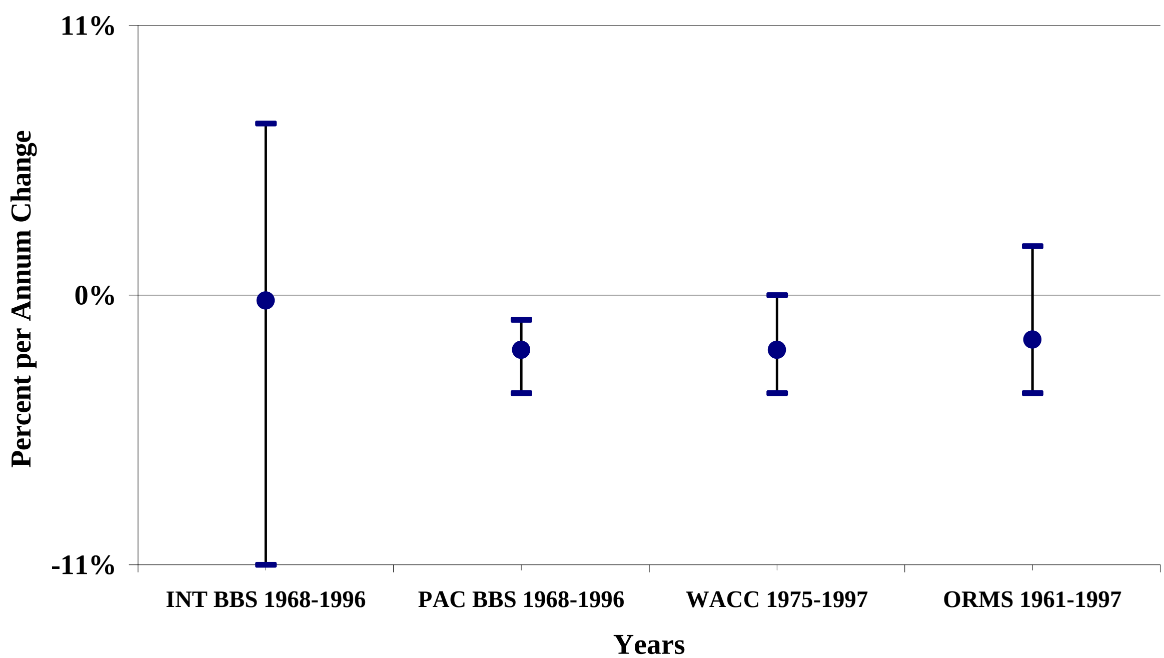


Figure 3. Estimation of long-term (1975-96) trends in abundance of band-tailed pigeons on Interior BBS, Pacific BBS, Washington Call Counts, and Oregon Mineral Site surveys.

Survey : All four surveys
Term length : 1975-1996

Years	Sample size	Percent per annum change Mean	SD	Standard error	95% CI for % change
INT BBS 1975-1996	41	3%	31%	5%	(-11% , 10%)
PAC BBS 1975-1996	156	-3%	13%	1%	(-5% , -1%)
WACC 1975-1996	75	-2%	10%	1%	(-4% , 0%)
ORMS 1975-1996	7	2%	7%	3%	(-2% , 10%)
average	*41*	*3%*	*31%*		

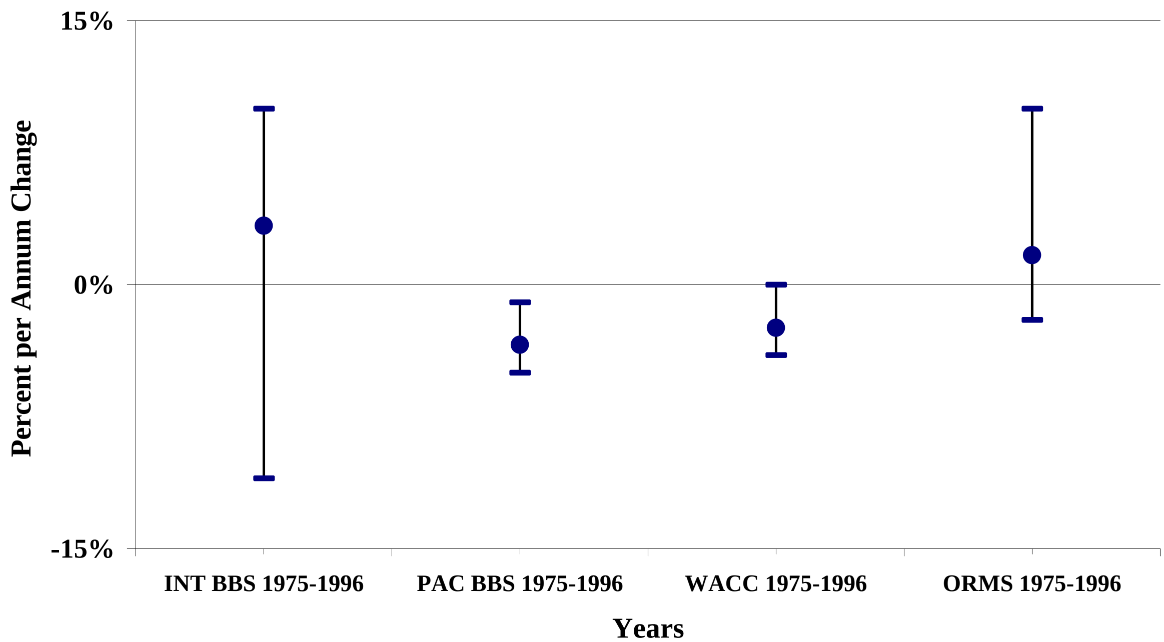


Figure 4a. Estimation of 5-year trends in abundance for band-tailed pigeons on Pacific BBS routes.

Survey : Pacific BBS
Term length : 5-year

Years	Sample size	Percent per annum change: Mean	Standard deviation	Standard error	95% CI for % change
1968-1972	44	-3%	57%	8%	(-18% , 14%)
1969-1973	61	-10%	44%	6%	(-24% , 0%)
1970-1974	67	-15%	56%	7%	(-29% , -2%)
1971-1975	75	-10%	46%	6%	(-24% , 0%)
1972-1976	87	5%	107%	11%	(-20% , 24%)
1973-1977	85	23%	68%	7%	(10% , 38%)
1974-1978	83	5%	53%	6%	(-8% , 14%)
1975-1979	86	2%	87%	10%	(-19% , 19%)
1976-1980	85	3%	93%	9%	(-17% , 23%)
1977-1981	88	11%	52%	6%	(0% , 22%)
1978-1982	84	6%	41%	4%	(-3% , 15%)
1979-1983	83	-2%	60%	7%	(-15% , 11%)
1980-1984	78	-4%	70%	8%	(-19% , 9%)
1981-1985	74	-6%	56%	7%	(-18% , 9%)
1982-1986	70	-15%	30%	4%	(-22% , -9%)
1983-1987	69	-26%	44%	5%	(-38% , -18%)
1984-1988	67	-20%	58%	8%	(-36% , -8%)
1985-1989	66	-5%	40%	5%	(-16% , 3%)
1986-1990	66	10%	99%	12%	(-19% , 29%)
1987-1991	71	7%	57%	7%	(-6% , 21%)
1988-1992	66	3%	49%	6%	(-8% , 14%)
1989-1993	83	-11%	57%	6%	(-25% , -2%)
1990-1994	94	-12%	110%	13%	(-36% , 8%)
1991-1995	108	2%	70%	7%	(-11% , 15%)
1992-1996	105	7%	81%	8%	(-12% , 20%)
average	*78*	*-2%*	*64%*		

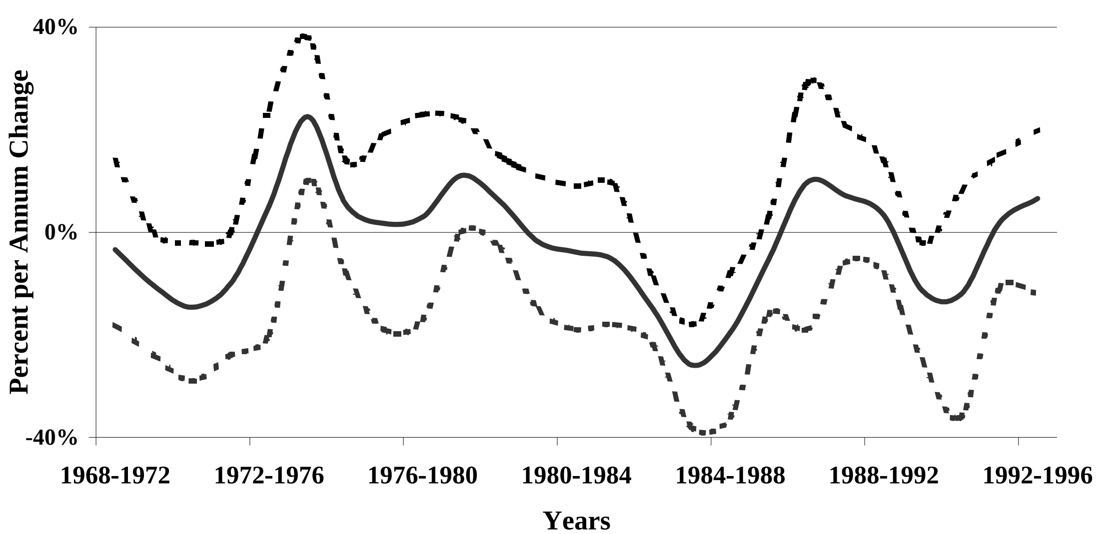


Figure 4b. Power for estimating 5-year trends in abundance for band-tailed pigeons on Pacific BBS routes.

Survey :	Pacific BBS
Term length :	5-year
Estimated standard deviation :	*64%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.10	0.11	0.12
	10%	0.07	0.10	0.14	0.17	0.20	0.23	0.26	0.29	0.32	0.35
	20%	0.17	0.29	0.41	0.51	0.61	0.68	0.75	0.80	0.85	0.88
	50%	0.70	0.94	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.08	0.10	0.11	0.13	0.14	0.15	0.16	0.17	0.18	0.20
	10%	0.13	0.17	0.22	0.26	0.30	0.34	0.37	0.41	0.44	0.47
	20%	0.26	0.41	0.53	0.64	0.72	0.79	0.84	0.88	0.91	0.93
	50%	0.80	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

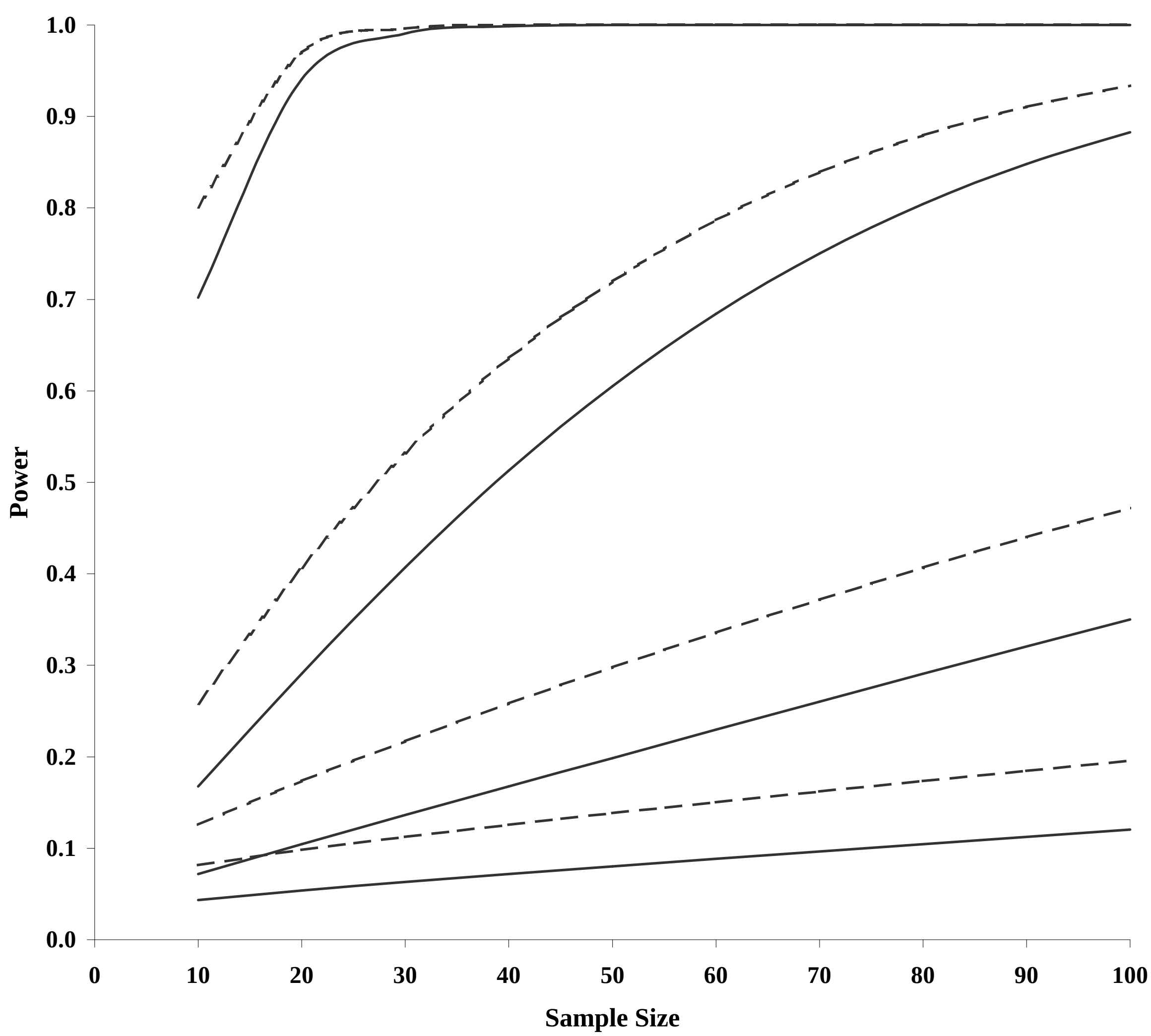


Figure 5a. Estimation of 3-year trends in abundance for band-tailed pigeons on Pacific BBS routes.

Survey : Pacific BBS
Term length : 3-year

Years	Sample size	Percent per annum change: Mean	Standard deviation	Standard error	95% CI for % change
1968-1970	14	-9%	64%	20%	(-69% , 17%)
1969-1971	33	-3%	103%	17%	(-33% , 33%)
1970-1972	41	-5%	155%	25%	(-64% , 32%)
1971-1973	49	-16%	49%	7%	(-32% , -4%)
1972-1974	53	-21%	70%	10%	(-43% , -7%)
1973-1975	56	18%	101%	14%	(-12% , 44%)
1974-1976	62	49%	305%	37%	(-28% , 99%)
1975-1977	62	11%	134%	17%	(-36% , 32%)
1976-1978	57	5%	63%	9%	(-14% , 20%)
1977-1979	62	-4%	95%	12%	(-30% , 17%)
1978-1980	64	28%	122%	15%	(0% , 56%)
1979-1981	65	8%	60%	7%	(-9% , 20%)
1980-1982	67	-14%	97%	12%	(-38% , 5%)
1981-1983	59	-4%	96%	13%	(-31% , 19%)
1982-1984	54	21%	97%	13%	(-2% , 45%)
1983-1985	51	-34%	48%	7%	(-48% , -22%)
1984-1986	42	-38%	79%	12%	(-69% , -19%)
1985-1987	40	10%	97%	15%	(-27% , 36%)
1986-1988	49	-13%	59%	9%	(-33% , 1%)
1987-1989	45	-15%	69%	10%	(-39% , 2%)
1988-1990	46	53%	267%	37%	(-30% , 114%)
1989-1991	54	-2%	74%	10%	(-25% , 14%)
1990-1992	51	-27%	62%	8%	(-44% , -11%)
1991-1993	63	-10%	83%	10%	(-30% , 9%)
1992-1994	71	15%	140%	17%	(-26% , 41%)
1993-1995	82	-2%	65%	7%	(-15% , 15%)
1994-1996	85	-2%	133%	15%	(-57% , 17%)
average	*55*	*0%*	*103%*		

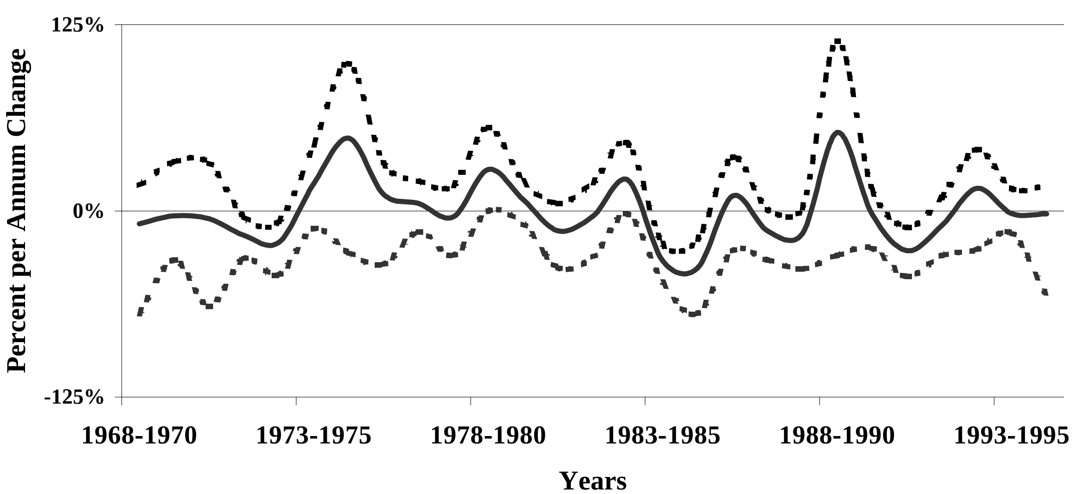


Figure 5b. Power for estimating 3-year trends in abundance for band-tailed pigeons on Pacific BBS routes.

Survey :	Pacific BBS
Term length :	3-year
Estimated standard deviation :	*103%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07
	10%	0.05	0.06	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.16
	20%	0.09	0.14	0.18	0.23	0.28	0.32	0.37	0.41	0.45	0.49
	50%	0.33	0.58	0.76	0.87	0.93	0.96	0.98	0.99	1.00	1.00
0.10	5%	0.07	0.08	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12
	10%	0.09	0.11	0.13	0.15	0.17	0.19	0.20	0.22	0.23	0.25
	20%	0.15	0.22	0.28	0.34	0.39	0.44	0.49	0.54	0.58	0.62
	50%	0.45	0.70	0.84	0.92	0.96	0.98	0.99	1.00	1.00	1.00

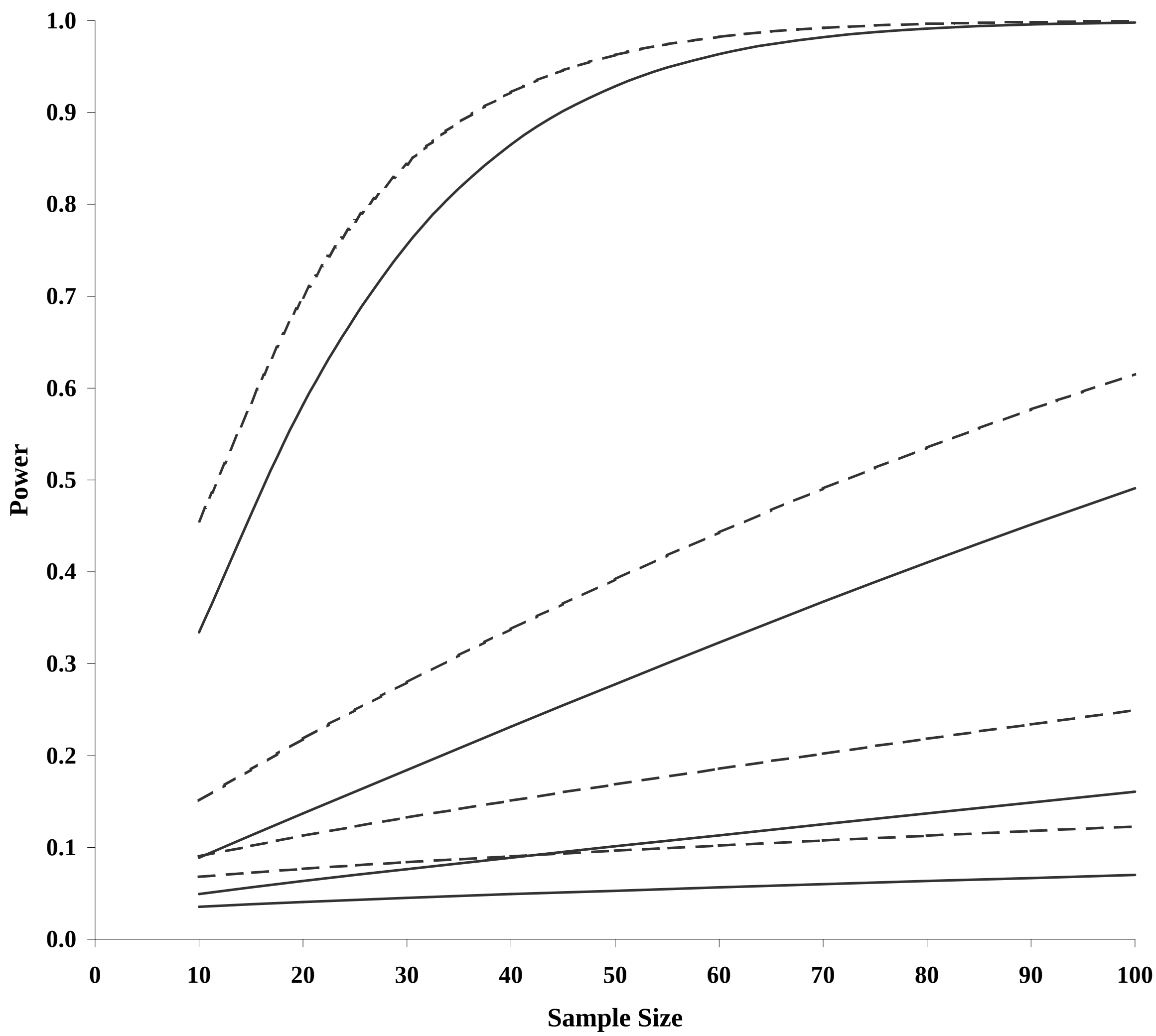


Figure 6a. Estimation of 5-year trends in abundance for band-tailed pigeons on Interior BBS routes.

Survey : Interior BBS
Term length : 5-year

Years	Sample size	Mean	Standard deviation	Standard error	95% CI for % change
		Percent per annum change			
1968-1972	4	14%	24%	16%	(-18% , 58%)
1969-1973	4	6%	14%	10%	(-3% , 33%)
1970-1974	4	-20%	26%	21%	(-88% , 7%)
1971-1975	5	-35%	43%	20%	(-79% , -12%)
1972-1976	3	27%	58%	39%	(-23% , 96%)
1973-1977	5	-13%	39%	18%	(-55% , 18%)
1974-1978	5	-10%	24%	13%	(-38% , 19%)
1975-1979	5	7%	40%	21%	(-11% , 57%)
1976-1980	6	8%	34%	25%	(-5% , 69%)
1977-1981	12	3%	41%	18%	(-46% , 23%)
1978-1982	9	-20%	18%	10%	(-48% , -14%)
1979-1983	9	-7%	16%	8%	(-21% , 12%)
1980-1984	7	16%	37%	23%	(-62% , 45%)
1981-1985	6	6%	31%	17%	(-48% , 21%)
1982-1986	5	-24%	12%	7%	(-39% , -11%)
1983-1987	6	-18%	21%	11%	(-52% , -5%)
1984-1988	5	13%	38%	22%	(-33% , 69%)
1985-1989	7	34%	33%	15%	(20% , 65%)
1986-1990	9	11%	40%	13%	(-13% , 34%)
1987-1991	10	-3%	56%	23%	(-64% , 29%)
1988-1992	9	4%	71%	25%	(-49% , 32%)
1989-1993	8	45%	81%	29%	(2% , 107%)
1990-1994	13	29%	29%	13%	(2% , 50%)
1991-1995	20	13%	41%	11%	(-15% , 32%)
1992-1996	26	19%	61%	14%	(-13% , 36%)
average	*8*	*4%*	*37%*		

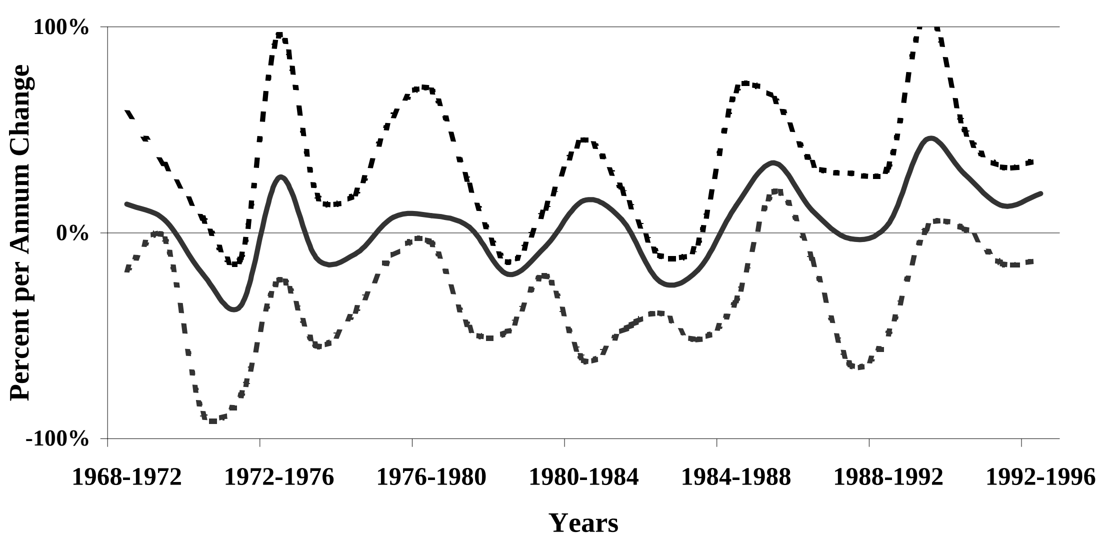


Figure 6b. Power for estimating 5-year trends in abundance for band-tailed pigeons on Interior BBS routes.

Survey :	Interior BBS
Term length :	5-year
Estimated standard deviation :	*37%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.06	0.09	0.11	0.13	0.16	0.18	0.20	0.23	0.25	0.27
	10%	0.13	0.23	0.31	0.40	0.48	0.55	0.62	0.67	0.72	0.77
	20%	0.40	0.67	0.84	0.93	0.97	0.99	0.99	1.00	1.00	1.00
	50%	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.11	0.15	0.18	0.21	0.24	0.27	0.30	0.33	0.36	0.38
	10%	0.21	0.33	0.43	0.52	0.60	0.67	0.73	0.78	0.82	0.85
	20%	0.52	0.78	0.90	0.96	0.98	0.99	1.00	1.00	1.00	1.00
	50%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

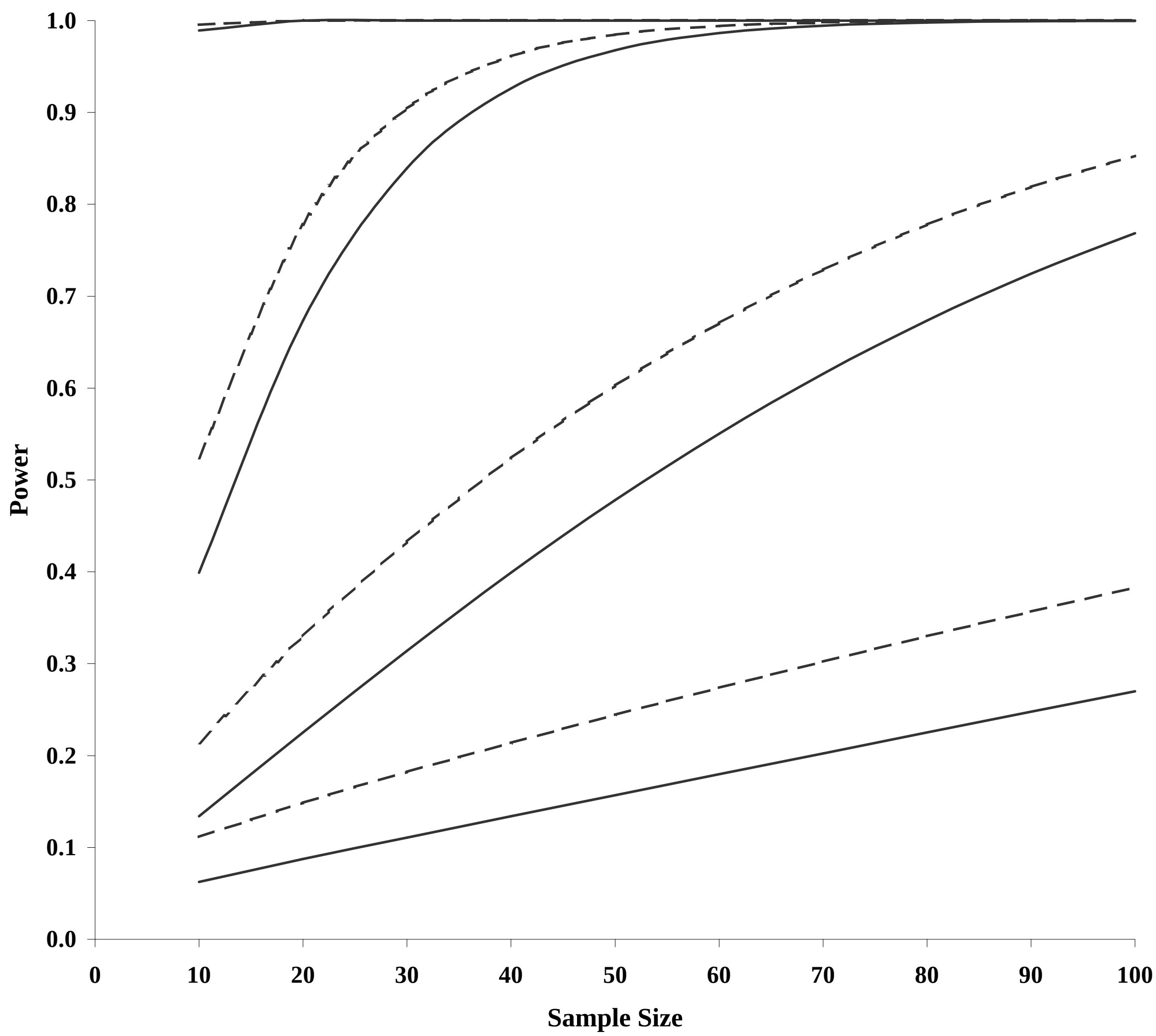


Figure 7a. Estimation of 3-year trends in abundance for band-tailed pigeons on Interior BBS routes.

Survey : Interior BBS
Term length : 3-year

Years	Sample size	Percent per annum change: Mean	Standard deviation	Standard error	95% CI for % change
1968-1970	2	-9%	9%	7%	(-18% , 2%)
1969-1971	2	-12%	13%	9%	(-23% , 3%)
1970-1972	3	29%	39%	29%	(3% , 80%)
1971-1973	3	-55%	34%	29%	(-111% , -36%)
1972-1974	1	-41%			
1973-1975	2	-30%	21%	16%	(-61% , -14%)
1974-1976	3	-37%	37%	27%	(-109% , -10%)
1975-1977	4	-27%	37%	18%	(-71% , 1%)
1976-1978	4	85%	207%	103%	(-156% , 219%)
1977-1979	4	33%	25%	30%	(21% , 117%)
1978-1980	2	-38%	13%	102%	(-276% , -32%)
1979-1981	6	-10%	28%	14%	(-42% , 6%)
1980-1982	2	9%	2%	4%	(8% , 18%)
1981-1983	3	23%	8%	11%	(19% , 46%)
1982-1984	4	25%	24%	24%	(-53% , 73%)
1983-1985	4	-22%	35%	23%	(-89% , -2%)
1984-1986	3	-61%	11%	7%	(-81% , -51%)
1985-1987	3	52%	85%	51%	(-27% , 144%)
1986-1988	2	52%	52%	34%	(0% , 103%)
1987-1989	3	6%	3%	3%	(4% , 12%)
1988-1990	5	-10%	18%	8%	(-21% , 5%)
1989-1991	5	47%	105%	52%	(-83% , 101%)
1990-1992	4	29%	89%	48%	(-27% , 117%)
1991-1993	6	35%	52%	22%	(-2% , 69%)
1992-1994	11	41%	107%	33%	(-41% , 84%)
1993-1995	17	-12%	48%	11%	(-42% , 4%)
1994-1996	14	9%	79%	23%	(-45% , 43%)
average	*5*	*4%*	*45%*		

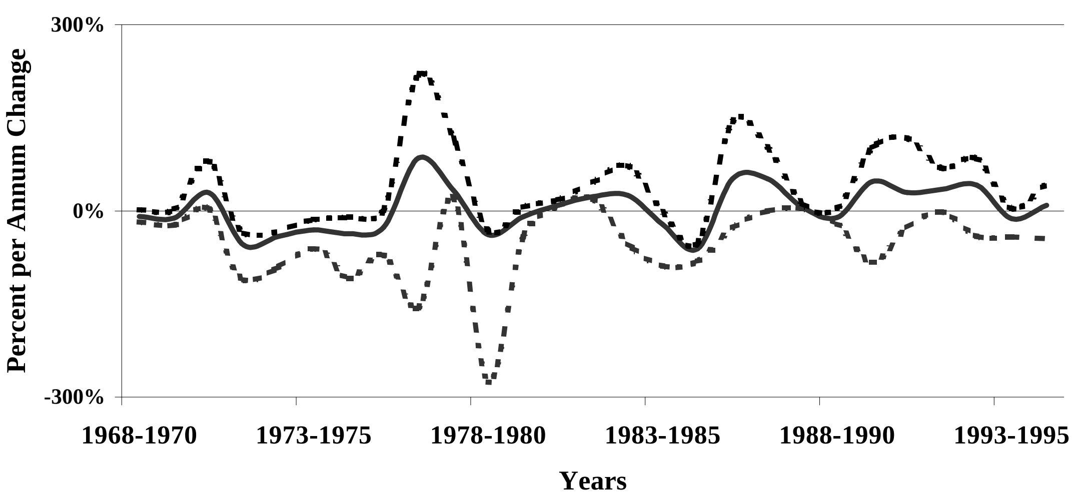


Figure 7b. Power for estimating 3-year trends in abundance for band-tailed pigeons on Interior BBS routes.

Survey :	Interior BBS
Term length :	3-year
Estimated standard deviation :	*45%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.05	0.07	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.20
	10%	0.10	0.16	0.23	0.29	0.34	0.40	0.45	0.50	0.55	0.60
	20%	0.29	0.50	0.68	0.80	0.88	0.93	0.96	0.98	0.99	0.99
	50%	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.10	0.12	0.15	0.17	0.19	0.21	0.23	0.25	0.27	0.29
	10%	0.17	0.25	0.33	0.40	0.47	0.52	0.58	0.63	0.67	0.71
	20%	0.40	0.63	0.78	0.87	0.93	0.96	0.98	0.99	0.99	1.00
	50%	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

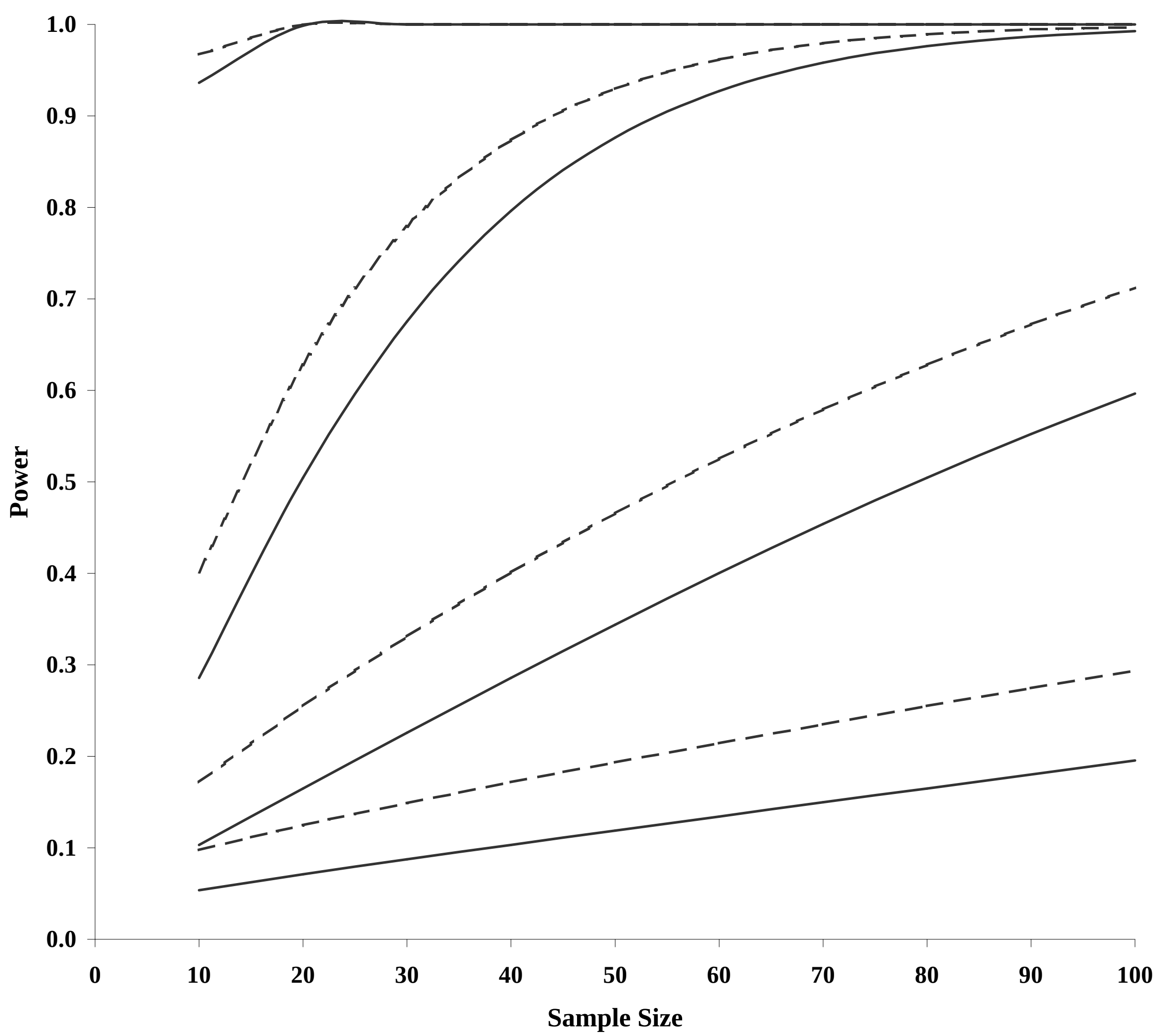


Figure 8a. Estimation of 5-year trends in abundance for band-tailed pigeons on Washington Call Count routes.

Survey : Washington Call Counts
Term length : 5-year

		Percent per annum change			
Years	Sample size	Mean	Standard deviation	Standard error	95% CI for % change
1975-1979	38	9%	49%	8%	(-7% , 23%)
1976-1980	39	19%	36%	6%	(7% , 29%)
1977-1981	39	1%	36%	6%	(-10% , 13%)
1978-1982	37	-2%	32%	6%	(-11% , 11%)
1979-1983	38	-11%	41%	7%	(-23% , 2%)
1980-1984	36	-3%	33%	6%	(-16% , 7%)
1981-1985	32	-3%	22%	4%	(-10% , 6%)
1982-1986	31	-18%	24%	5%	(-27% , -10%)
1983-1987	30	-23%	33%	6%	(-36% , -14%)
1984-1988	26	-21%	38%	8%	(-39% , -9%)
1985-1989	31	13%	49%	9%	(-6% , 29%)
1986-1990	33	20%	72%	12%	(-9% , 44%)
1987-1991	35	-2%	36%	6%	(-13% , 10%)
1988-1992	38	-8%	34%	6%	(-21% , 4%)
1989-1993	34	-12%	28%	5%	(-21% , -1%)
1990-1994	37	6%	49%	8%	(-12% , 19%)
1991-1995	40	16%	43%	7%	(2% , 28%)
1992-1996	43	34%	62%	9%	(11% , 50%)
1993-1997	46	16%	51%	8%	(-1% , 30%)
average	*36*	*2%*	*41%*		

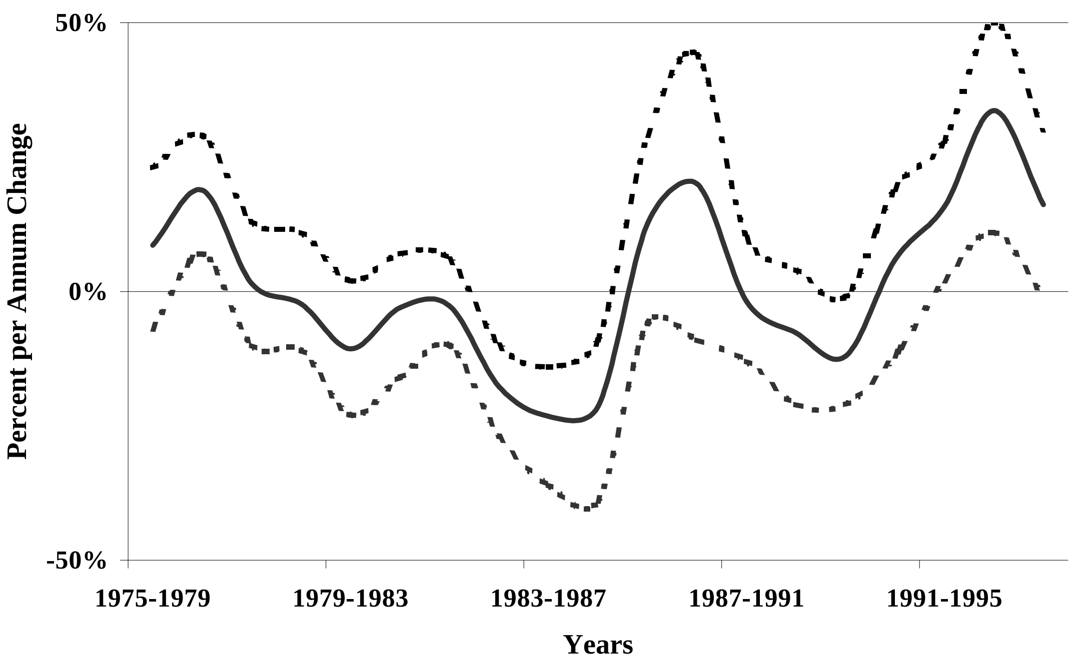


Figure 8b. Power for estimating 5-year trends in abundance for band-tailed pigeons on Washington Call Count routes.

Survey :	Washington Call Counts
Term length :	5-year
Estimated standard deviation :	*41%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.21	0.23
	10%	0.12	0.20	0.27	0.34	0.41	0.48	0.54	0.60	0.65	0.69
	20%	0.34	0.60	0.77	0.88	0.94	0.97	0.98	0.99	1.00	1.00
	50%	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.10	0.14	0.17	0.19	0.22	0.25	0.27	0.29	0.32	0.34
	10%	0.19	0.29	0.38	0.47	0.54	0.60	0.66	0.71	0.76	0.79
	20%	0.47	0.71	0.85	0.93	0.97	0.99	0.99	1.00	1.00	1.00
	50%	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

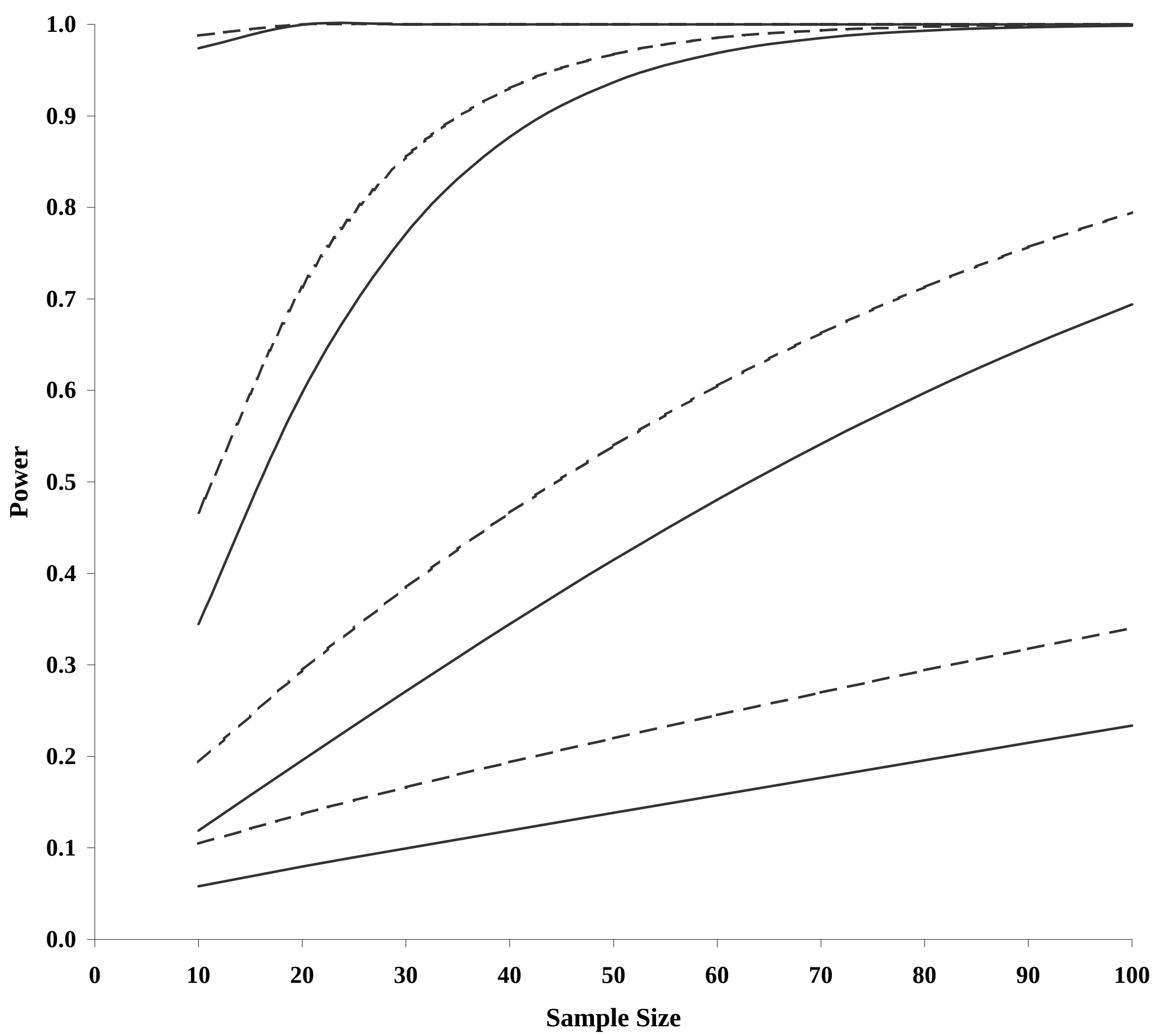


Figure 9a. Estimation of 3-year trends in abundance for band-tailed pigeons on Washington Call Count routes.

Survey : Washington Call Counts
Term length : 3-year

Years	Sample size	Percent per annum change Mean	Standard deviation	Standard error	95% CI for % change
1975-1977	24	-3%	77%	15%	(-37% , 25%)
1976-1978	29	31%	67%	13%	(5% , 57%)
1977-1979	28	20%	70%	13%	(-8% , 39%)
1978-1980	27	5%	66%	13%	(-21% , 25%)
1979-1981	29	-15%	70%	12%	(-44% , 5%)
1980-1982	27	-3%	50%	10%	(-27% , 16%)
1981-1983	27	5%	83%	16%	(-30% , 31%)
1982-1984	25	1%	67%	14%	(-26% , 25%)
1983-1985	20	-16%	45%	10%	(-38% , 1%)
1984-1986	18	-41%	51%	11%	(-64% , -21%)
1985-1987	12	-12%	70%	21%	(-59% , 25%)
1986-1988	12	7%	78%	23%	(-55% , 52%)
1987-1989	21	39%	100%	24%	(-23% , 76%)
1988-1990	26	16%	65%	12%	(-8% , 38%)
1989-1991	25	-29%	34%	7%	(-46% , -16%)
1990-1992	24	-19%	51%	10%	(-45% , -1%)
1991-1993	22	8%	84%	18%	(-33% , 35%)
1992-1994	23	34%	126%	27%	(-27% , 75%)
1993-1995	28	28%	91%	18%	(-11% , 54%)
1994-1996	35	16%	87%	15%	(-17% , 44%)
1995-1997	39	-4%	48%	8%	(-20% , 13%)
average	*25*	*3%*	*70%*		

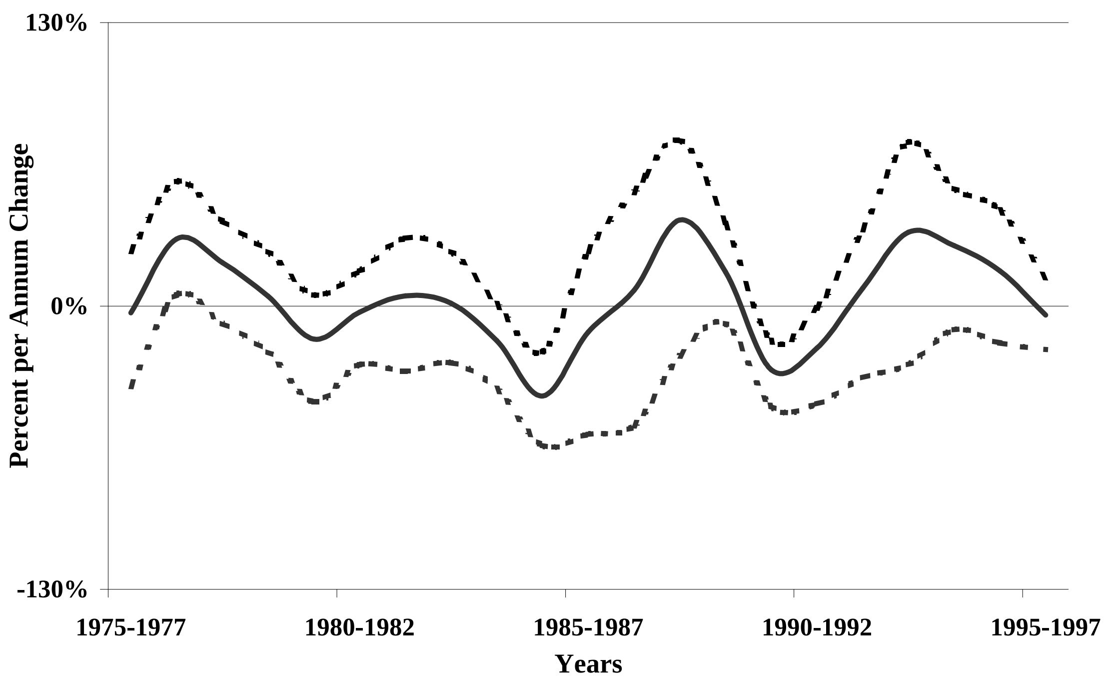


Figure 9b. Power for estimating 3-year trends in abundance for band-tailed pigeons on Washington Call Count routes.

Survey :	Washington Call Counts
Term length :	3-year
Estimated standard deviation :	*70%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.04	0.05	0.06	0.07	0.07	0.08	0.09	0.09	0.10	0.11
	10%	0.07	0.09	0.12	0.14	0.17	0.19	0.22	0.24	0.27	0.29
	20%	0.14	0.24	0.34	0.43	0.52	0.59	0.66	0.72	0.77	0.81
	50%	0.61	0.89	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.08	0.09	0.10	0.12	0.13	0.14	0.15	0.16	0.17	0.17
	10%	0.12	0.16	0.19	0.23	0.26	0.29	0.32	0.35	0.38	0.41
	20%	0.23	0.35	0.46	0.56	0.64	0.71	0.77	0.81	0.85	0.88
	50%	0.73	0.94	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00

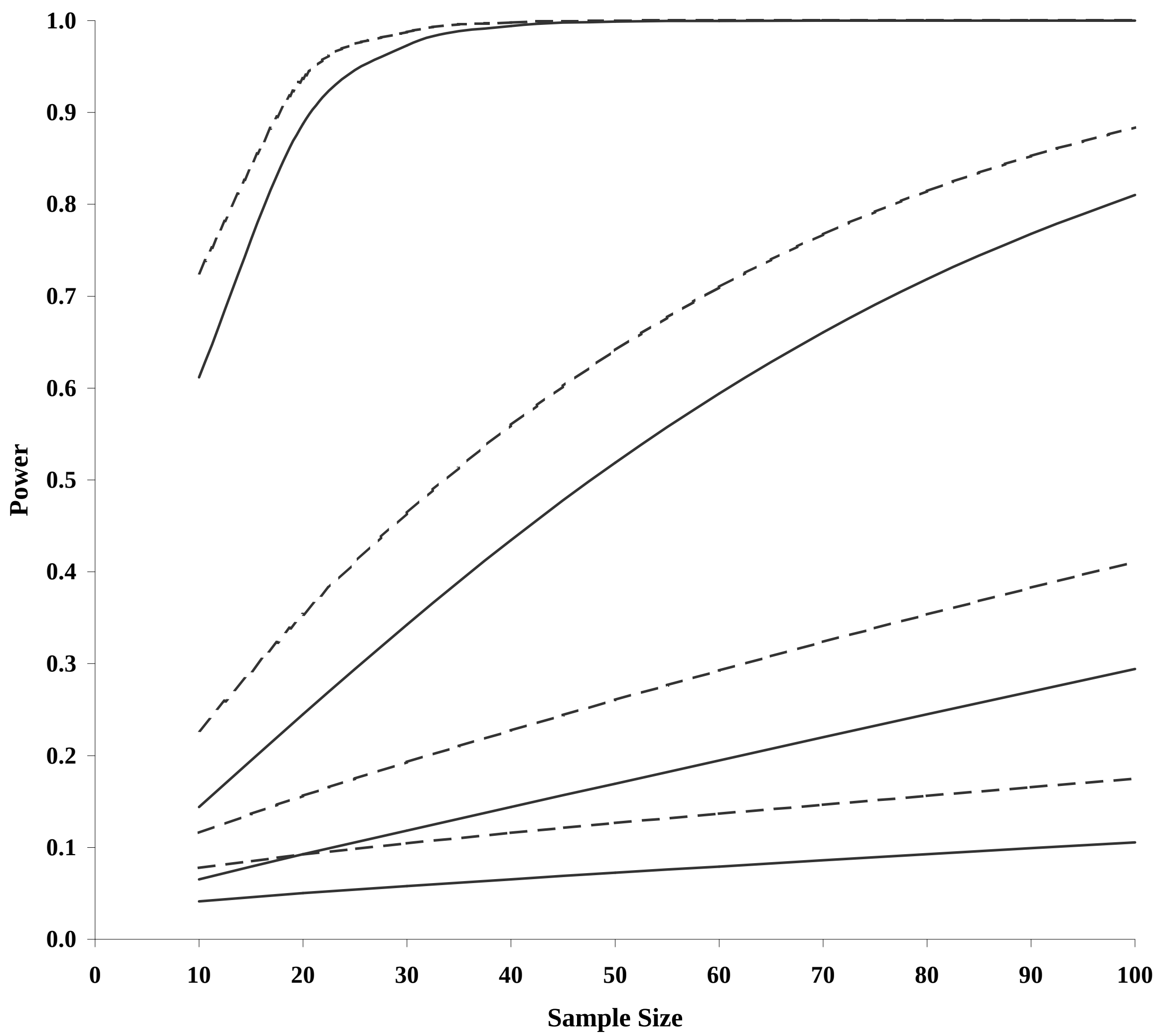


Figure 10a. Estimation of 5-year trends in abundance for band-tailed pigeons at Washington and Oregon Mineral Sites.

Survey : WA, OR Mineral Sites
Term length : 5-year

Years	Sample size	Percent per annum change Mean	SD	Standard error	95% CI for % change
1961-1965	9	-3%	13%	5%	(-15% , 4%)
1962-1966	11	-3%	18%	5%	(-14% , 6%)
1963-1967	11	-8%	23%	7%	(-19% , 9%)
1964-1968	14	-3%	20%	5%	(-12% , 8%)
1965-1969	18	-11%	16%	4%	(-19% , -3%)
1966-1970	20	-9%	11%	3%	(-15% , -4%)
1967-1971	21	-7%	14%	3%	(-15% , -2%)
1968-1972	21	-7%	17%	4%	(-14% , 0%)
1969-1973	21	-9%	10%	2%	(-13% , -5%)
1970-1974	22	-19%	8%	2%	(-22% , -15%)
1971-1975	21	-18%	19%	4%	(-27% , -10%)
1972-1976	21	-16%	19%	4%	(-25% , -9%)
1973-1977	22	0%	21%	5%	(-11% , 8%)
1974-1978	21	1%	24%	5%	(-8% , 12%)
1975-1979	20	2%	27%	6%	(-11% , 11%)
1976-1980	22	14%	27%	6%	(3% , 27%)
1977-1981	23	15%	15%	3%	(8% , 21%)
1978-1982	22	5%	13%	3%	(-1% , 9%)
1979-1983	22	1%	13%	3%	(-5% , 6%)
1980-1984	23	-1%	12%	3%	(-6% , 4%)
1981-1985	23	-10%	16%	3%	(-17% , -3%)
1982-1986	23	-12%	9%	2%	(-16% , -9%)
1983-1987	23	-15%	9%	2%	(-19% , -11%)
1984-1988	23	-13%	14%	3%	(-18% , -7%)
1985-1989	23	0%	20%	4%	(-8% , 7%)
1986-1990	27	-3%	20%	4%	(-10% , 4%)
1987-1991	29	4%	26%	5%	(-4% , 16%)
1988-1992	29	15%	30%	6%	(5% , 27%)
1989-1993	35	6%	23%	4%	(-1% , 16%)
1990-1994	45	14%	31%	5%	(5% , 24%)
1991-1995	46	6%	23%	3%	(-1% , 11%)
1992-1996	46	1%	18%	3%	(-4% , 7%)
1993-1997	46	1%	14%	2%	(-4% , 5%)
average	*24*	*-2%*	*18%*		

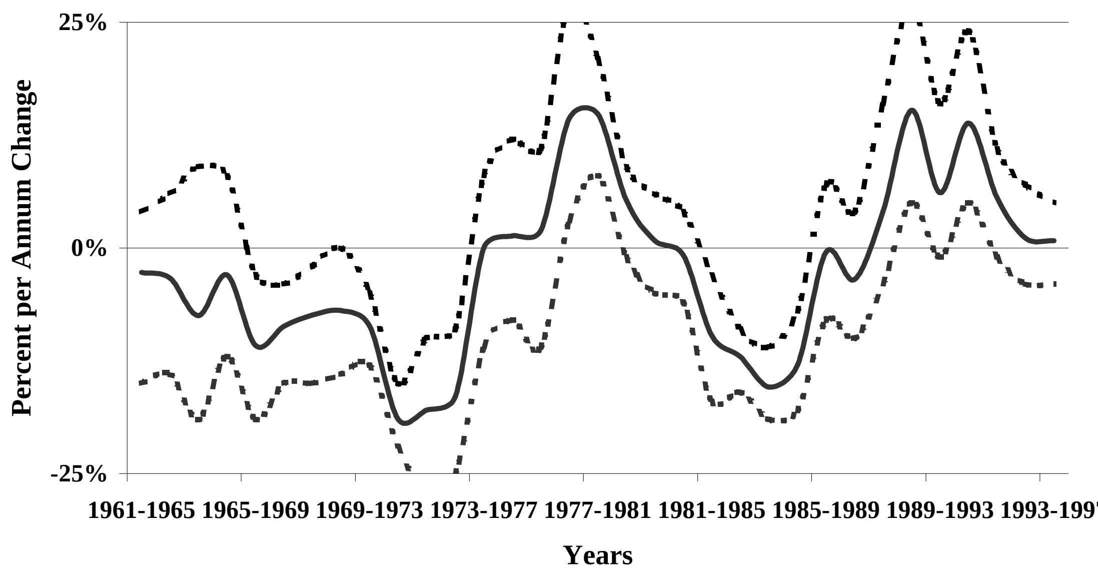


Figure 10b. Power for estimating 5-year trends in abundance for band-tailed pigeons at Washington and Oregon Mineral Sites.

Survey :	WA, OR Mineral Sites
Term length :	5-year
Estimated standard deviation :	*18%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.14	0.24	0.33	0.42	0.50	0.58	0.64	0.70	0.75	0.80
	10%	0.42	0.70	0.86	0.94	0.98	0.99	1.00	1.00	1.00	1.00
	20%	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	50%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.22	0.34	0.45	0.55	0.63	0.70	0.75	0.80	0.84	0.87
	10%	0.55	0.80	0.92	0.97	0.99	1.00	1.00	1.00	1.00	1.00
	20%	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	50%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

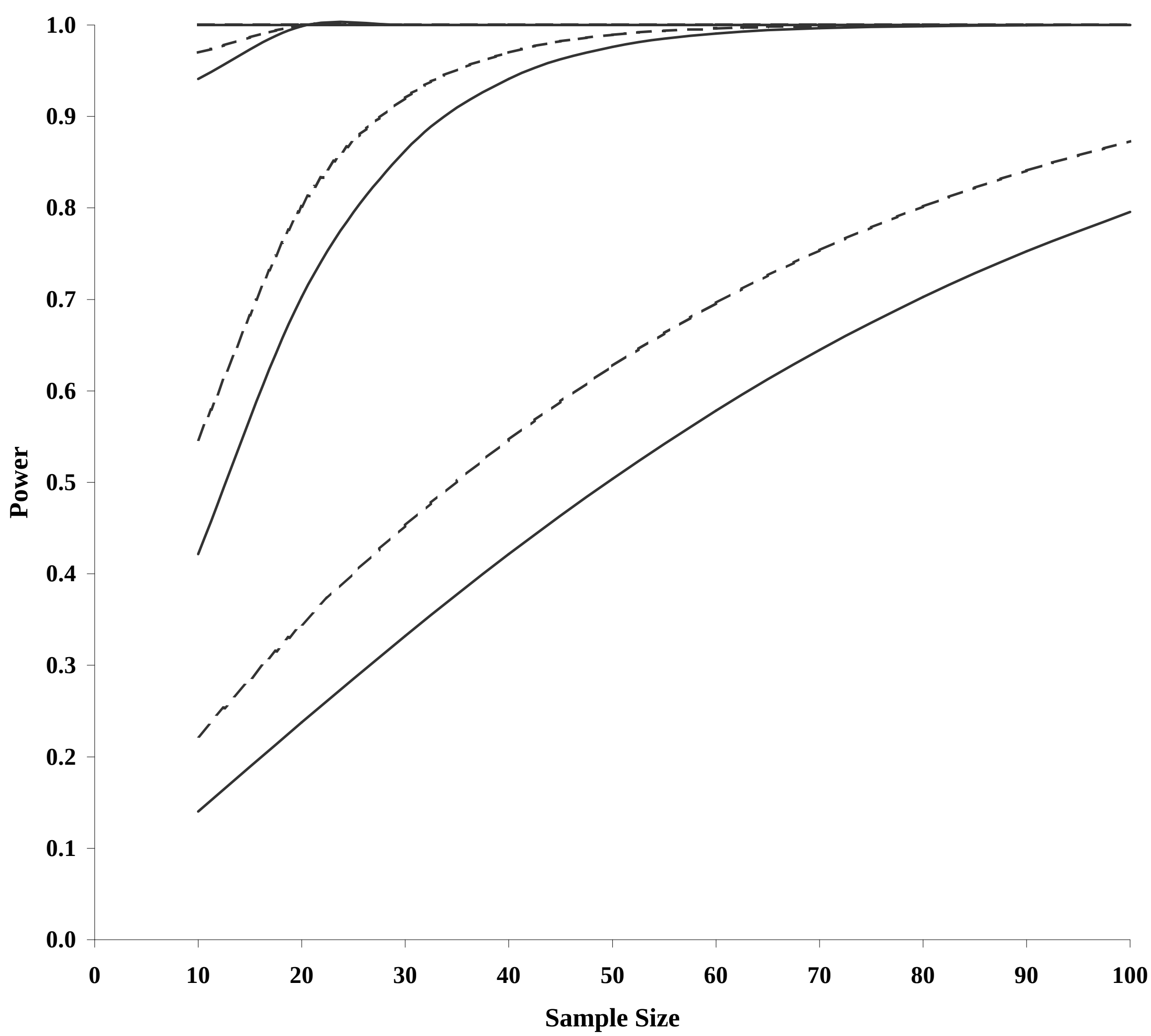


Figure 11a. Estimation of 3-year trends in abundance for band-tailed pigeons at Washington and Oregon Mineral Sites.

Survey : WA, OR Mineral Sites
Term length : 3-year

		Percent per annum change			
Years	Sample size	Mean	SD	Standard error	95% CI for % change
1961-1963	8	6%	21%	8%	(-13% , 22%)
1962-1964	8	-10%	30%	11%	(-37% , 7%)
1963-1965	9	-5%	32%	11%	(-29% , 13%)
1964-1966	11	-2%	24%	7%	(-15% , 14%)
1965-1967	11	-14%	30%	10%	(-33% , 6%)
1966-1968	14	-6%	34%	11%	(-26% , 12%)
1967-1969	18	-9%	24%	6%	(-23% , 1%)
1968-1970	18	-13%	20%	5%	(-23% , -4%)
1969-1971	19	-6%	36%	8%	(-24% , 9%)
1970-1972	21	-3%	23%	5%	(-12% , 8%)
1971-1973	20	-15%	19%	4%	(-23% , -5%)
1972-1974	21	-38%	18%	4%	(-46% , -31%)
1973-1975	21	1%	51%	11%	(-21% , 22%)
1974-1976	20	8%	32%	7%	(-7% , 21%)
1975-1977	20	-5%	49%	11%	(-29% , 13%)
1976-1978	20	1%	36%	8%	(-15% , 17%)
1977-1979	19	16%	57%	13%	(-8% , 39%)
1978-1980	19	21%	27%	7%	(9% , 37%)
1979-1981	21	10%	36%	7%	(-5% , 24%)
1980-1982	22	-9%	19%	4%	(-17% , -1%)
1981-1983	21	-2%	20%	4%	(-10% , 7%)
1982-1984	21	7%	20%	4%	(-2% , 14%)
1983-1985	23	-26%	27%	6%	(-38% , -15%)
1984-1986	23	-24%	23%	5%	(-34% , -16%)
1985-1987	22	6%	41%	9%	(-13% , 24%)
1986-1988	21	-6%	17%	4%	(-13% , 2%)
1987-1989	22	-2%	31%	7%	(-14% , 11%)
1988-1990	26	-4%	34%	7%	(-16% , 11%)
1989-1991	25	2%	48%	10%	(-15% , 22%)
1990-1992	25	25%	52%	10%	(3% , 46%)
1991-1993	34	-1%	26%	5%	(-11% , 7%)
1992-1994	45	12%	63%	9%	(-5% , 29%)
1993-1995	46	9%	26%	4%	(0% , 16%)
1994-1996	46	-12%	27%	4%	(-20% , -4%)
1995-1997	44	0%	23%	4%	(-8% , 7%)
average	*22*	*-3%*	*31%*		

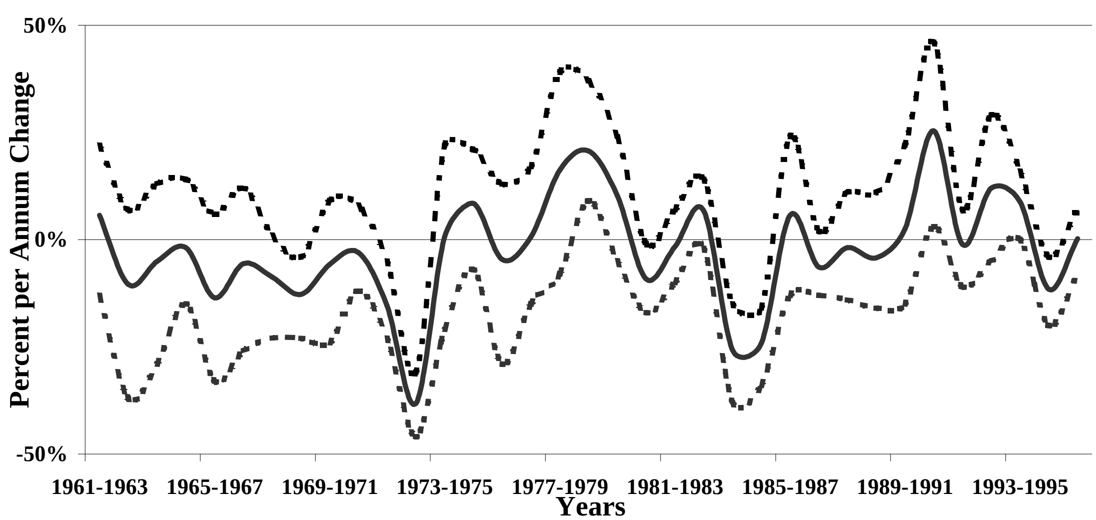


Figure 11b. Power for estimating 3-year trends in abundance for band-tailed pigeons at Washington and Oregon Mineral Sites.

Survey :	WA, OR Mineral Sites
Term length :	3-year
Estimated standard deviation :	*31%*

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.07	0.11	0.14	0.17	0.20	0.23	0.27	0.30	0.33	0.36
	10%	0.17	0.30	0.42	0.52	0.62	0.70	0.76	0.81	0.86	0.89
	20%	0.52	0.81	0.94	0.98	0.99	1.00	1.00	1.00	1.00	1.00
	50%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.13	0.18	0.22	0.26	0.30	0.34	0.38	0.41	0.45	0.48
	10%	0.26	0.41	0.54	0.65	0.73	0.80	0.85	0.89	0.92	0.94
	20%	0.65	0.89	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	50%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

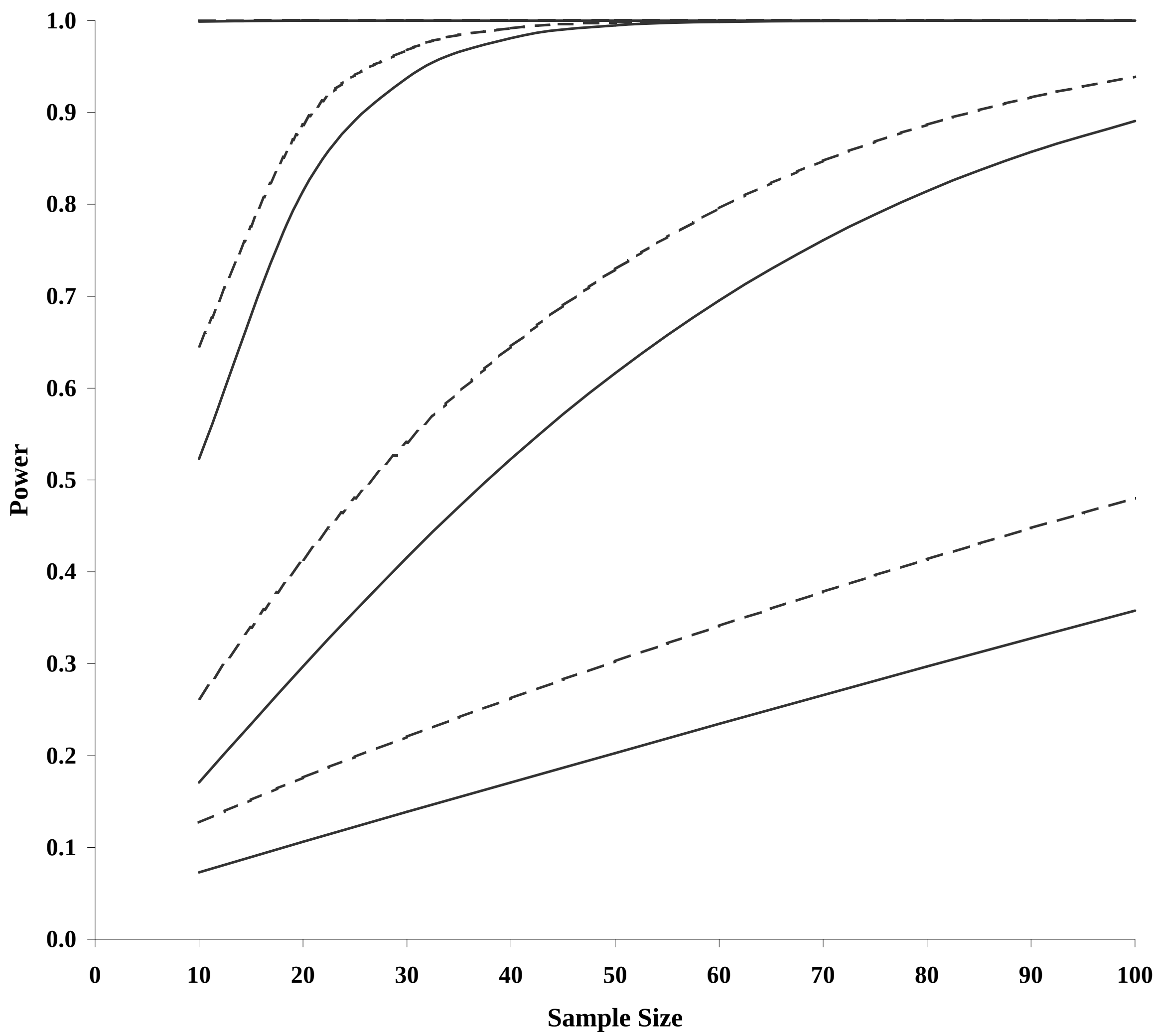


Figure 11b. Power for estimating 3-year trends in abundance for band-tailed pigeons at Washington and Oregon Mineral Sites.

Survey :	WA, OR Mineral Sites
Term length :	3-year
Estimated standard deviation :	*31%* 31%

Sig level	Percent per annum change	Sample Size									
		10	20	30	40	50	60	70	80	90	100
0.05	5%	0.07	0.11	0.14	0.17	0.20	0.23	0.27	0.30	0.33	0.36
	10%	0.17	0.30	0.42	0.52	0.62	0.70	0.76	0.81	0.86	0.89
	20%	0.52	0.81	0.94	0.98	0.99	1.00	1.00	1.00	1.00	1.00
	50%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	5%	0.13	0.18	0.22	0.26	0.30	0.34	0.38	0.41	0.45	0.48
	10%	0.26	0.41	0.54	0.65	0.73	0.80	0.85	0.89	0.92	0.94
	20%	0.65	0.89	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	50%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

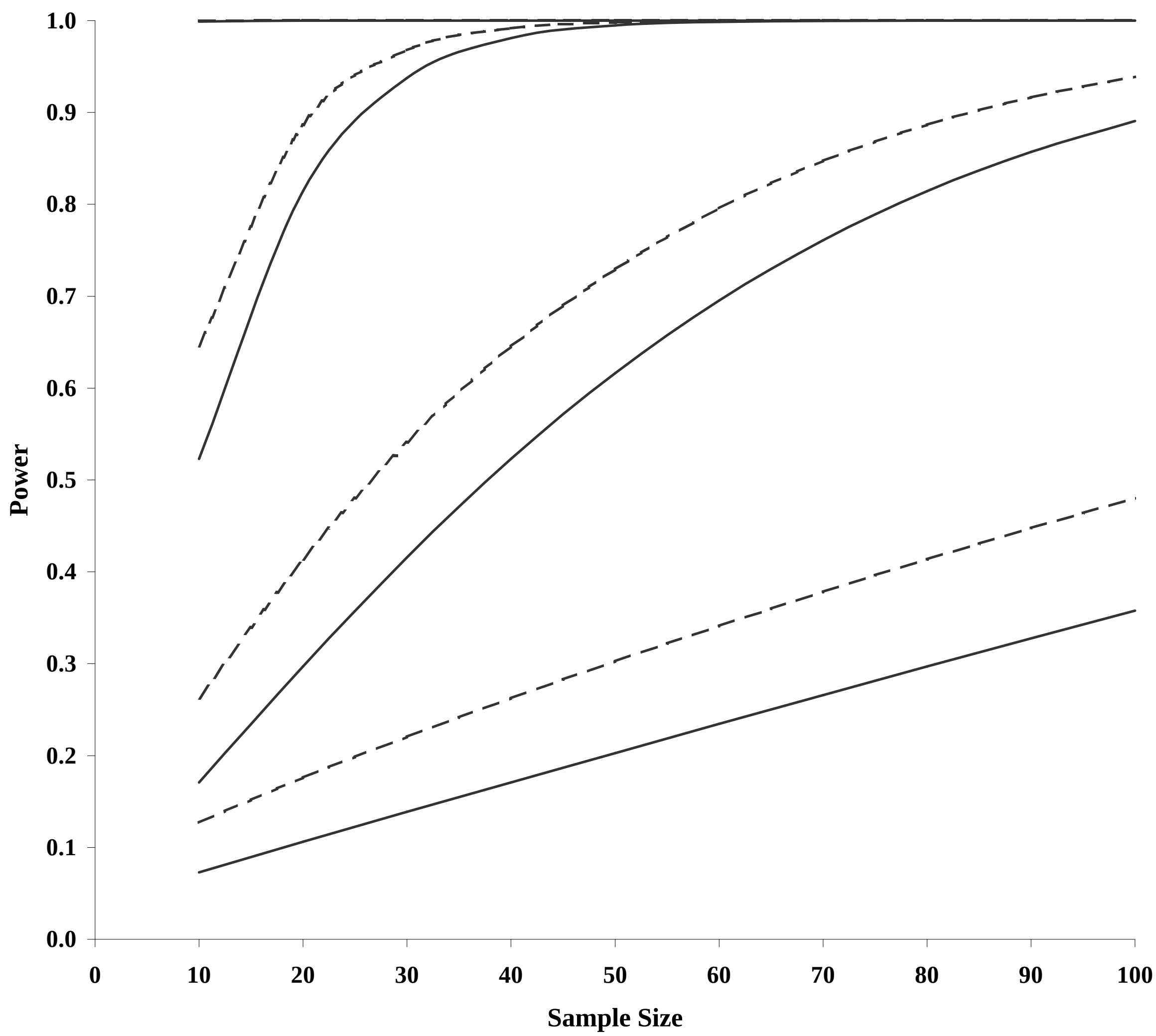
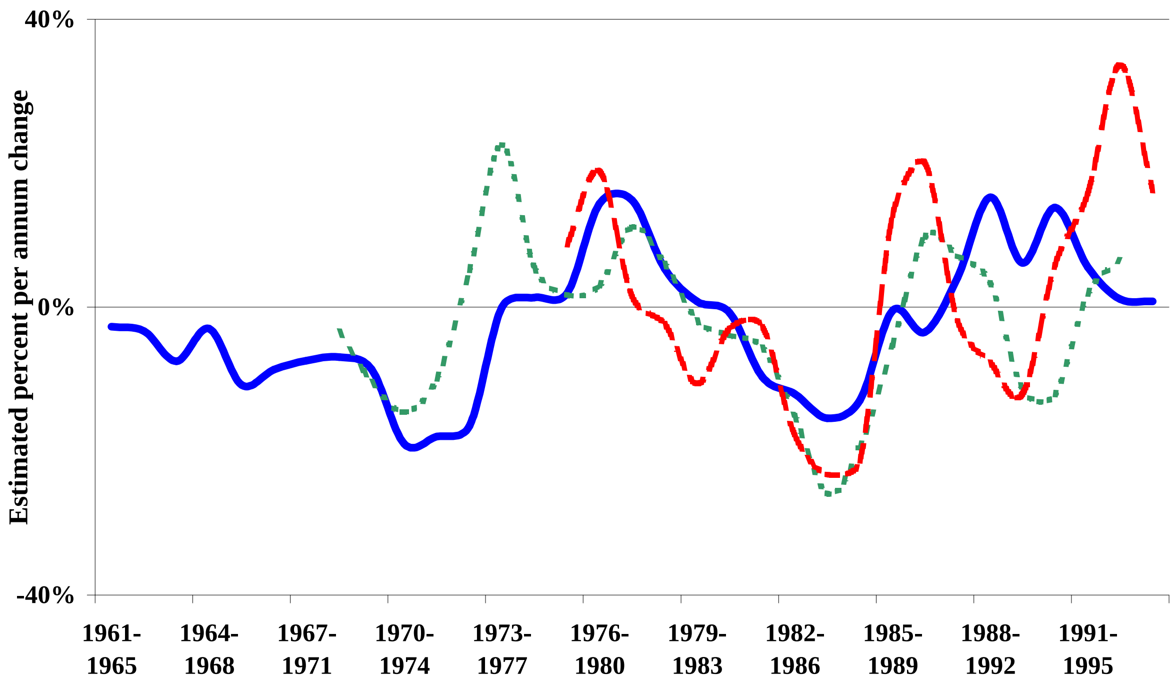


Figure 12. Estimated 5-year breeding population trends in percent annual change of band-tailed pigeon numbers at mineral sites, along BBS routes, and on Washington Call Count routes in Washington, Oregon, and California. Surveys include Pacific states when available: Pacific BBS data includes surveys in all 3 Pacific states, mineral site surveys include Washington and Oregon, and WA Call Count surveys include Washington state only.



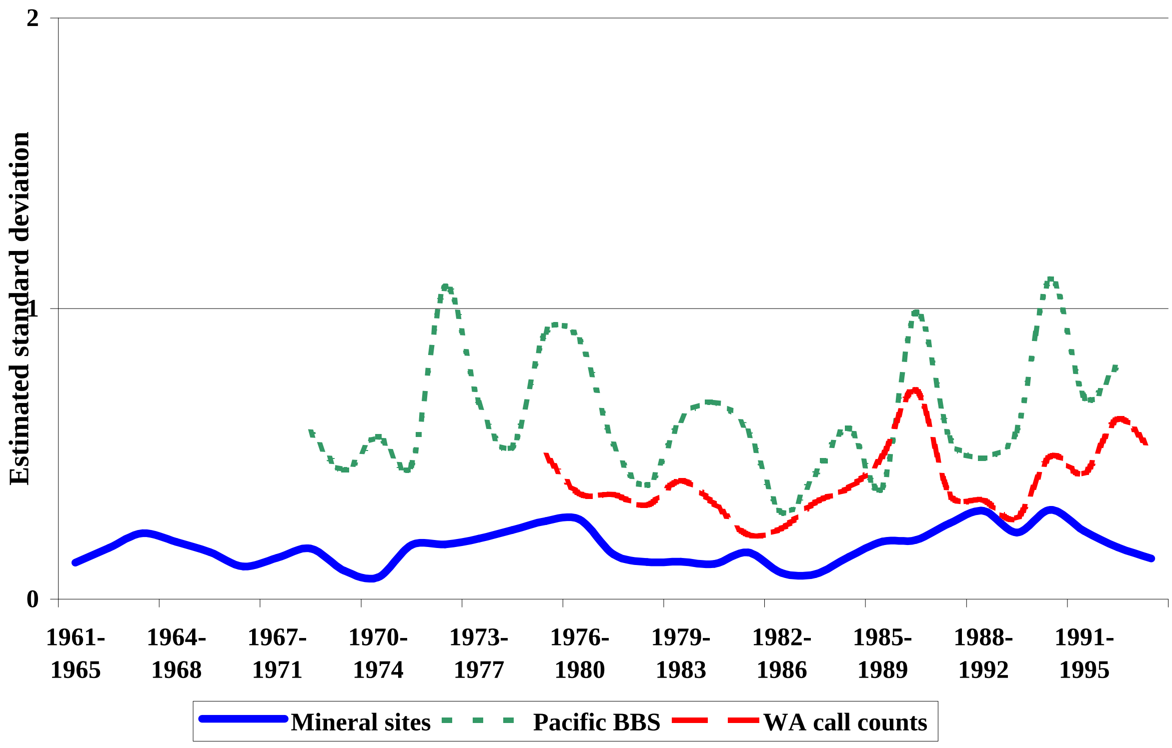


Figure 13. Estimated 3-year breeding population trends in percent annual change of band-tailed pigeon numbers at mineral sites, along BBS routes, and on Washington Call Count routes in Washington, Oregon, and California. Surveys include Pacific states when available: Pacific BBS data includes surveys in all 3 Pacific states, mineral site surveys include Washington and Oregon, and WA Call Count surveys include Washington state only.

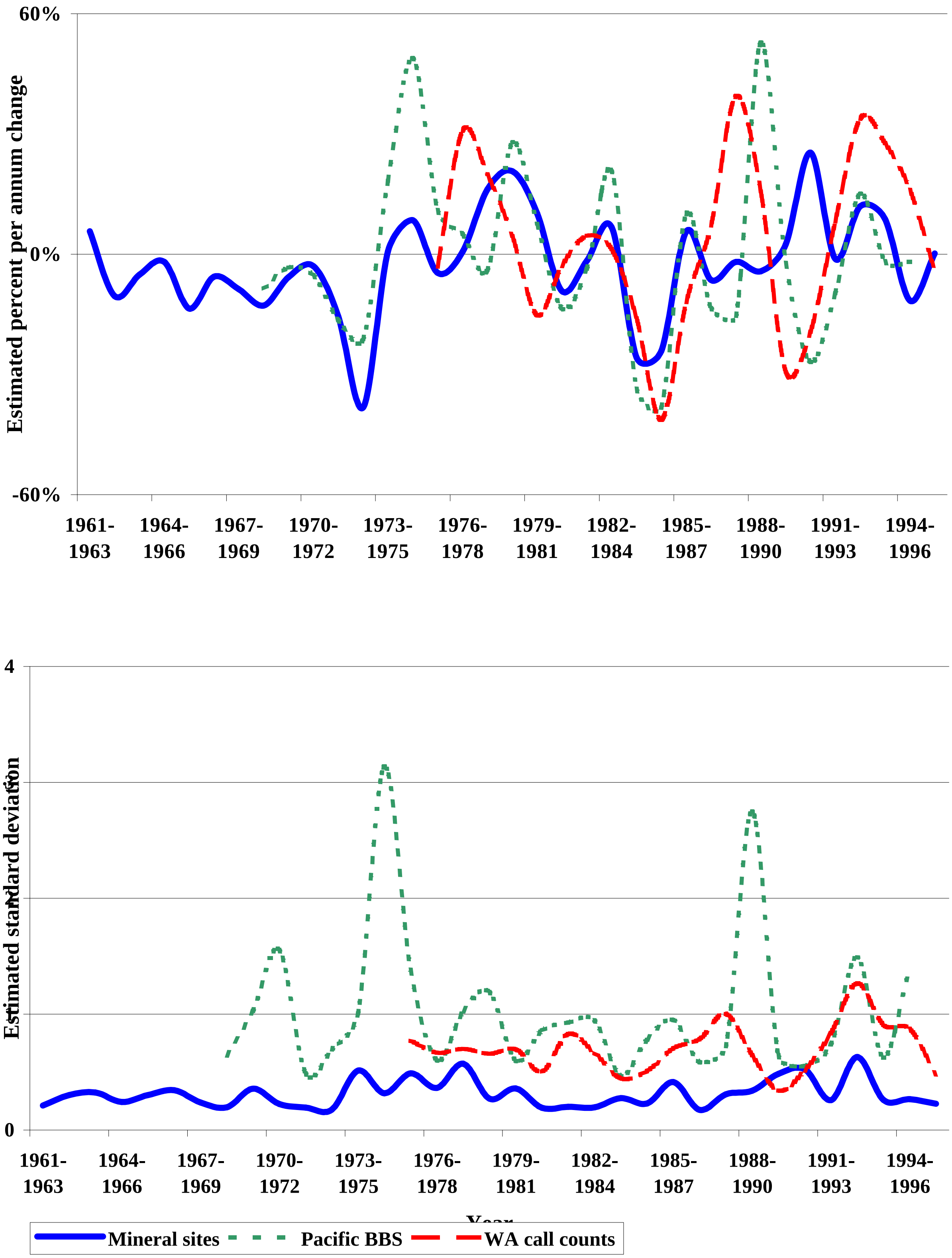


Figure 14. The relationship between power and term duration for Pacific and Interior BBS routes.

Effect size:	0.100	Number of routes:	100
Sig level:	0.100		

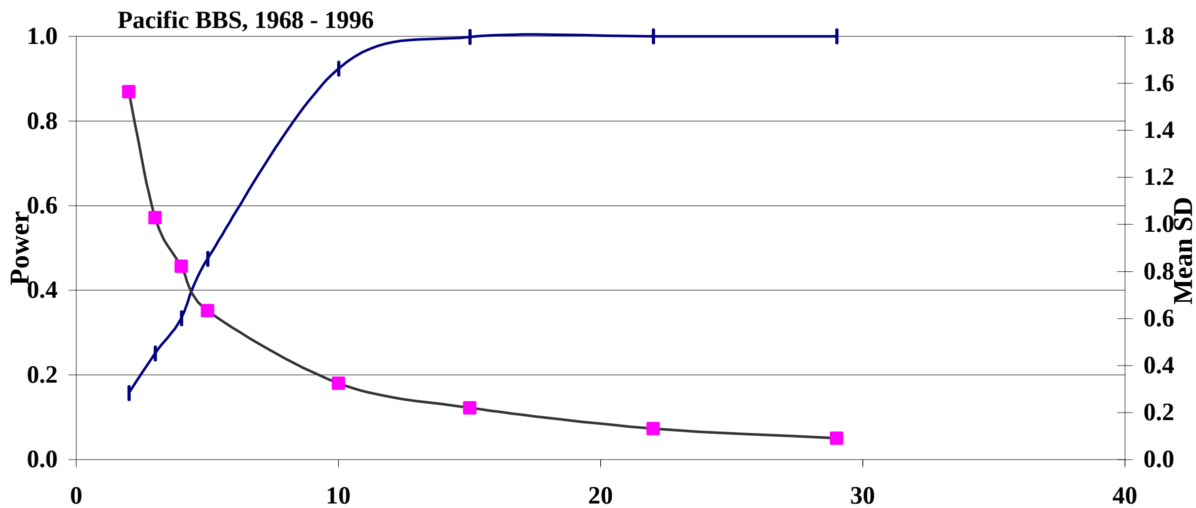
31%

Pacific BBS

Years	Mean SD	Power
2	1.565	0.157
3	1.029	0.250
4	0.822	0.334
5	0.633	0.474
10	0.325	0.924
15	0.220	0.998
22	0.131	1.000
29	0.091	1.000

Interior BBS

Years	Mean SD	Power
2	0.743	0.383
3	0.444	0.728
4	0.382	0.834
5	0.376	0.844
10	0.263	0.985
15	0.247	0.992
22	0.310	0.943
29	0.278	0.975



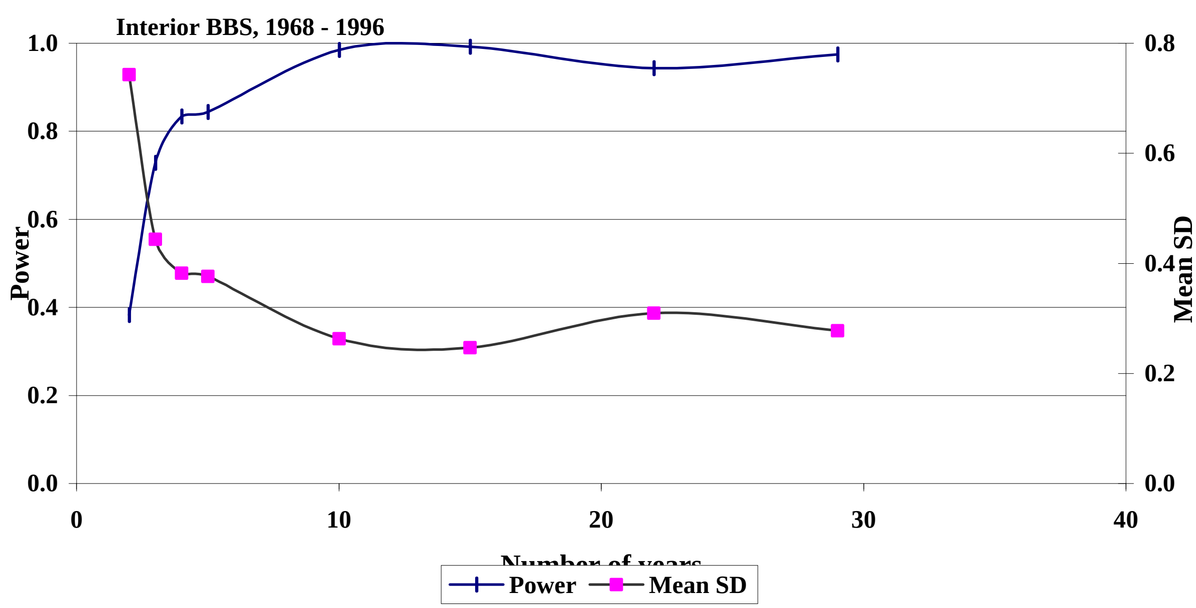


Figure 15. The relationship between power and term duration for Washington Call Counts and Washington and Oregon Mineral Site counts.

Effect size:	0.100	Number of routes:	100
Sig level:	0.100		

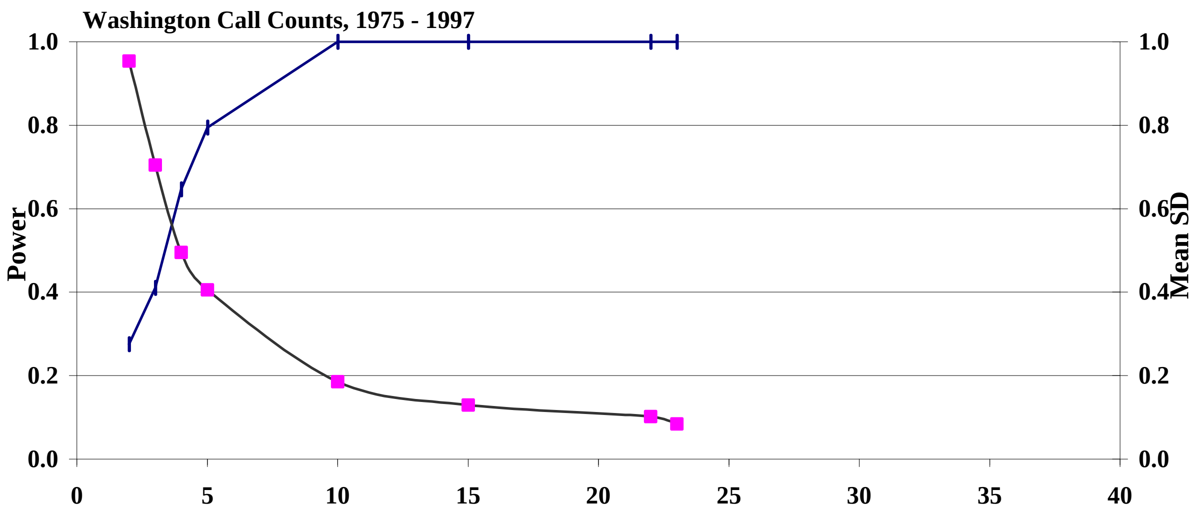
31%

Washington Call Count Survey

Years	Mean SD	Power
2	0.954	0.276
3	0.705	0.411
4	0.495	0.646
5	0.405	0.794
10	0.185	1.000
15	0.130	1.000
22	0.102	1.000
23	0.085	1.000

Mineral Sites

Years	Mean SD	Power	
2	0.540	0.582	(WAORMS)
3	0.313	0.939	(WAORMS)
4	0.224	0.998	(WAORMS)
5	0.179	1.000	(WAORMS)
10	0.084	1.000	(ORMS)
15	0.061	1.000	(ORMS)
22	0.070	1.000	(ORMS)
37	0.042	1.000	(ORMS)



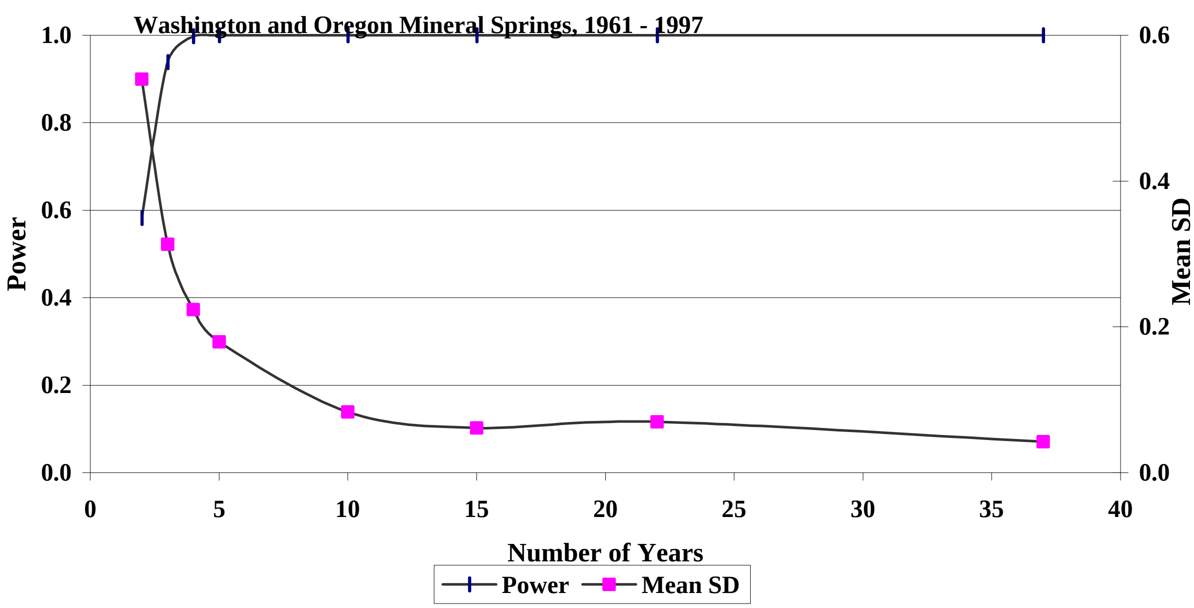


Figure 16. The relationship between power and route length for BBS surveys.

Effect size:	0.100	Number of routes:	100
Sig level:	0.100	Term length:	5 years

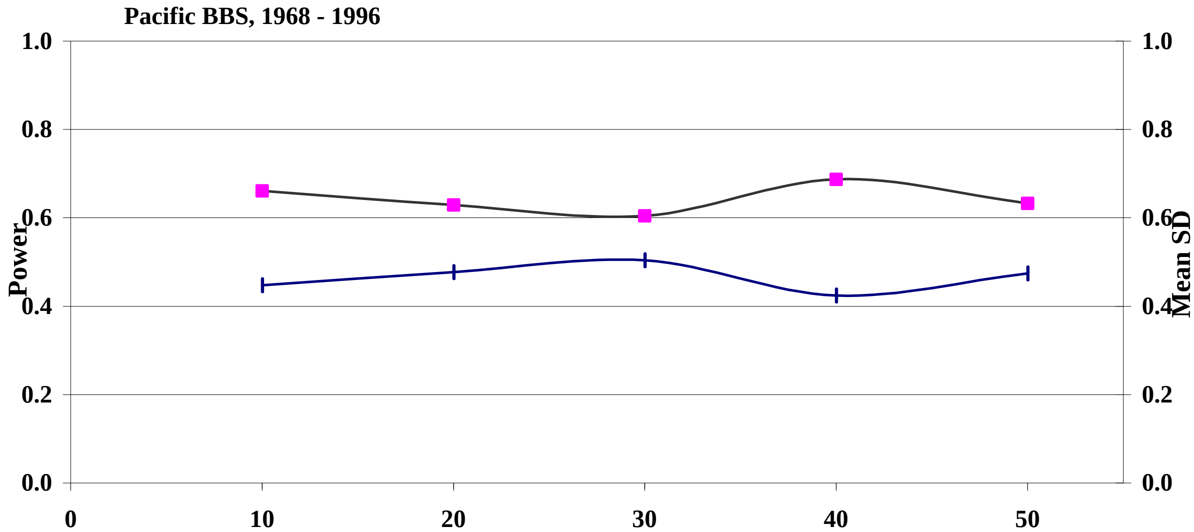
31%

Pacific BBS

Stops	Mean SD	Power
10	0.661	0.447
20	0.630	0.477
30	0.605	0.504
40	0.687	0.425
50	0.633	0.474

Interior BBS

Stops	Mean SD	Power
10	0.414	0.779
20	0.339	0.904
30	0.424	0.762
40	0.378	0.842
50	0.376	0.844



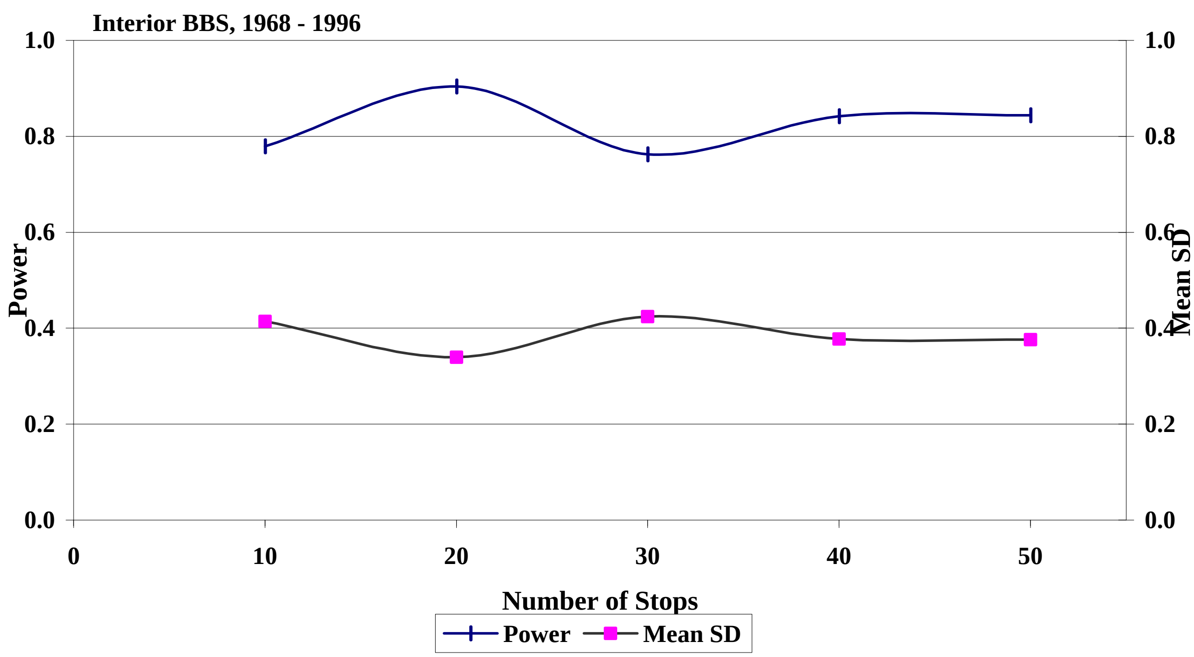


Figure 17. The relationship between power and route length for Washington Call Count surveys.

Effect size:	0.100	Number of routes:	100
Sig level:	0.100	Term length:	5 years

31%

Washington Call Count Survey

Stops	Mean SD	Power
5	0.478	0.673
6	0.465	0.693
7	0.462	0.699
8	0.467	0.690
9	0.446	0.725
10	0.442	0.732
11	0.415	0.777
12	0.415	0.777
13	0.405	0.795
14	0.410	0.786
15	0.411	0.784
16	0.408	0.790
17	0.400	0.804
18	0.403	0.799
19	0.413	0.781
20	0.405	0.794

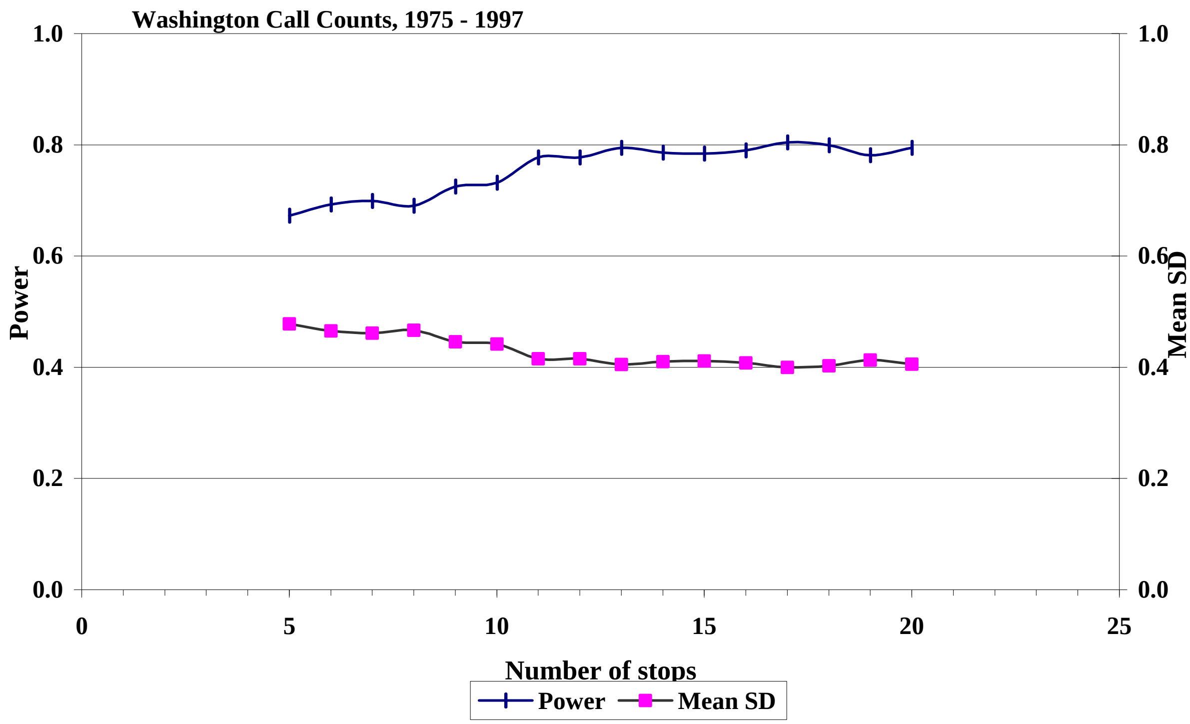


Figure 18. Maximum number of band-tailed pigeons counted arriving or departing from eight different mineral sites in Northern California in 1998 and 1999.

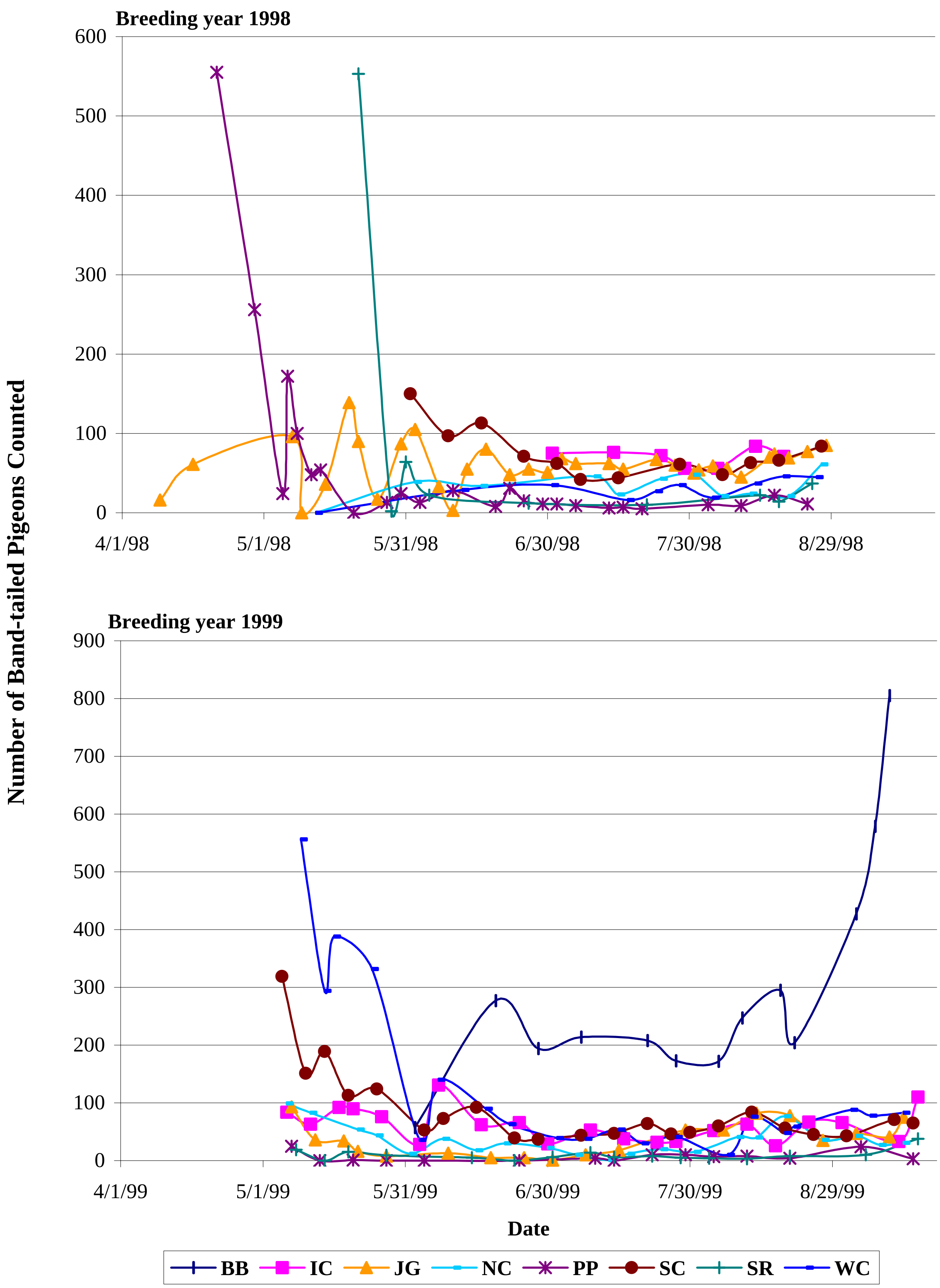


Figure 19. Counts of band-tailed pigeons at eight Northern California mineral sites in 1998 and 1999, by survey date.

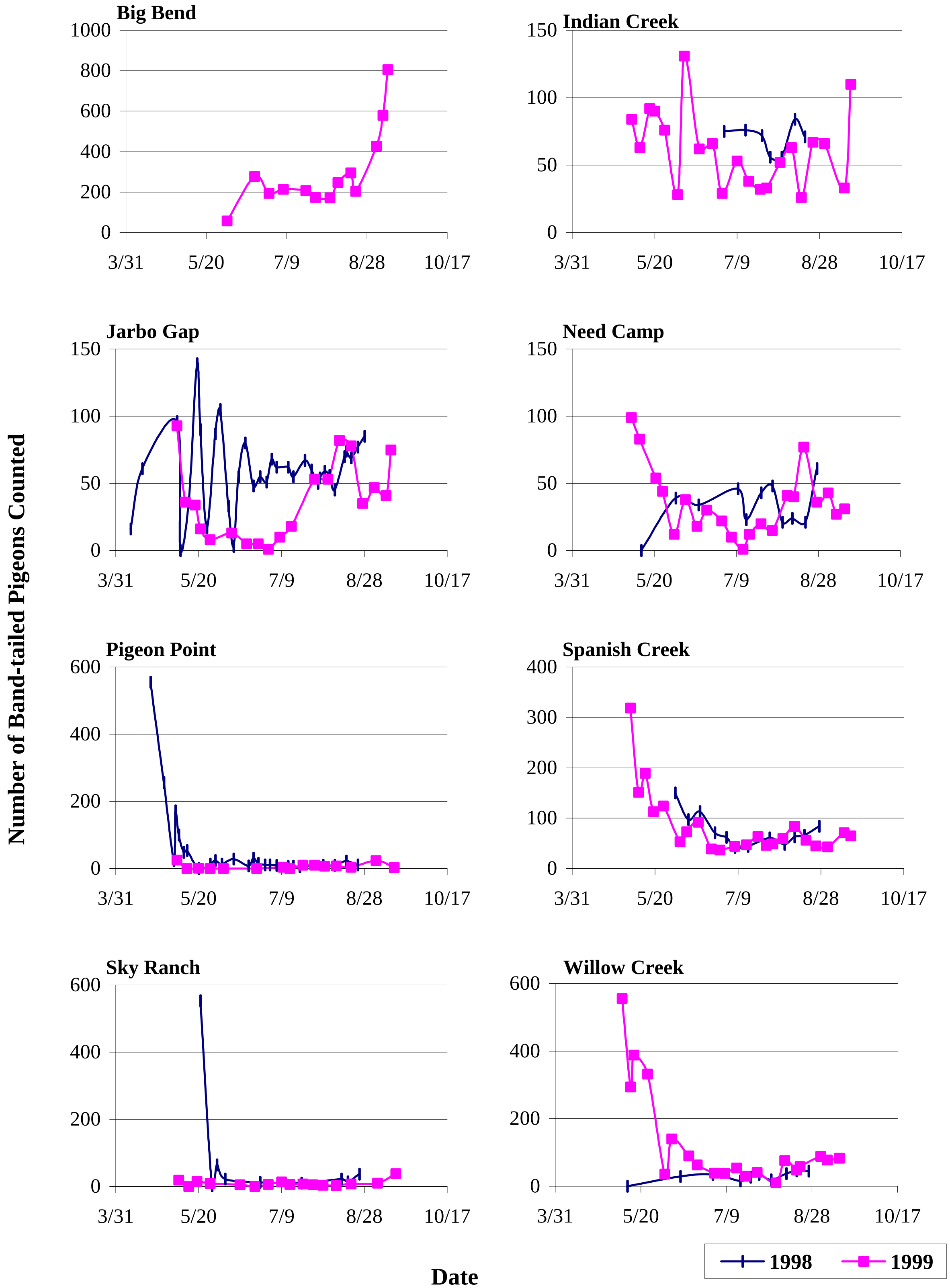


Figure 20. Number of band-tailed pigeons arriving and departing at eight California mineral sites.

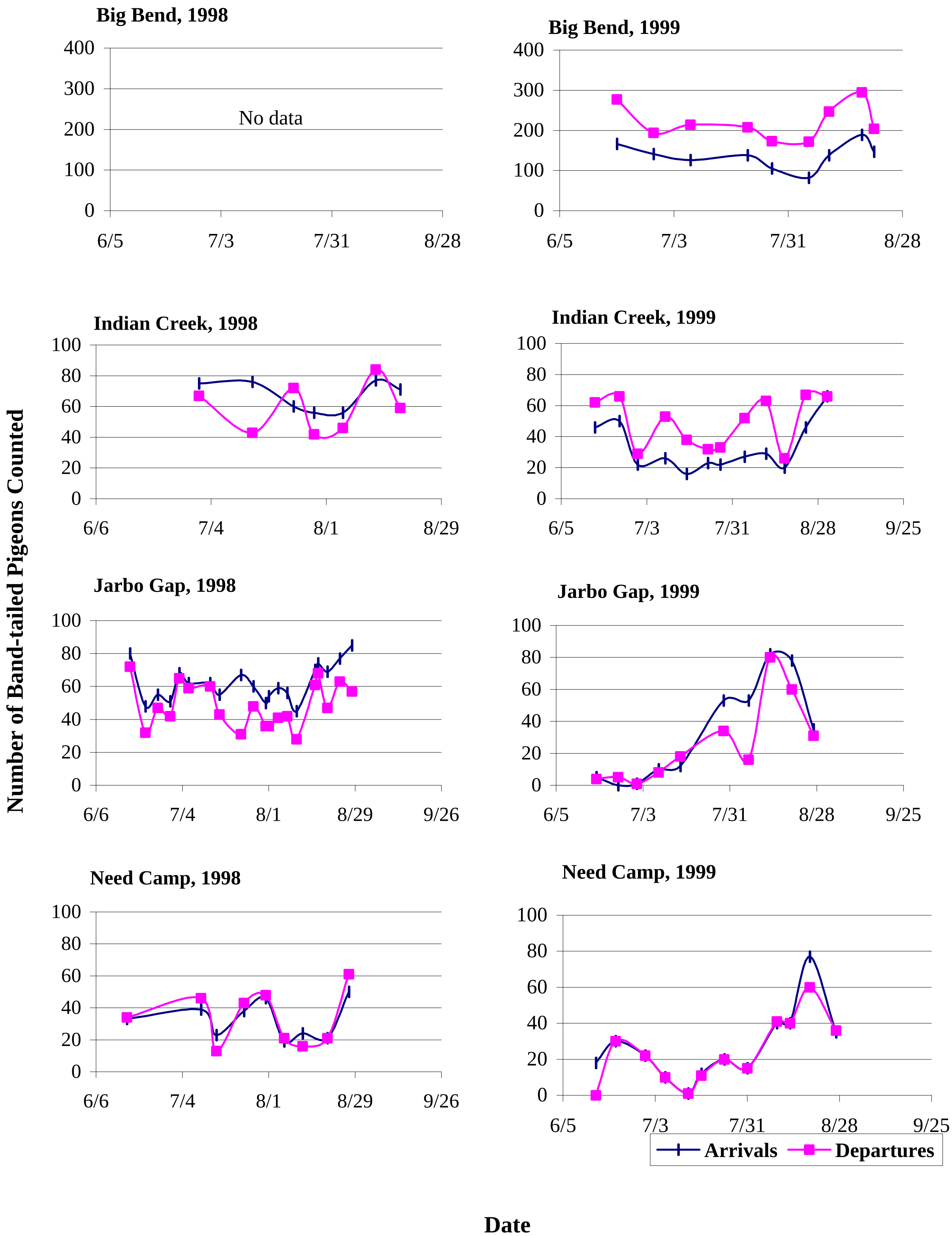


Figure 20 (continued). Number of band-tailed pigeons arriving and departing at eight California mineral sites.

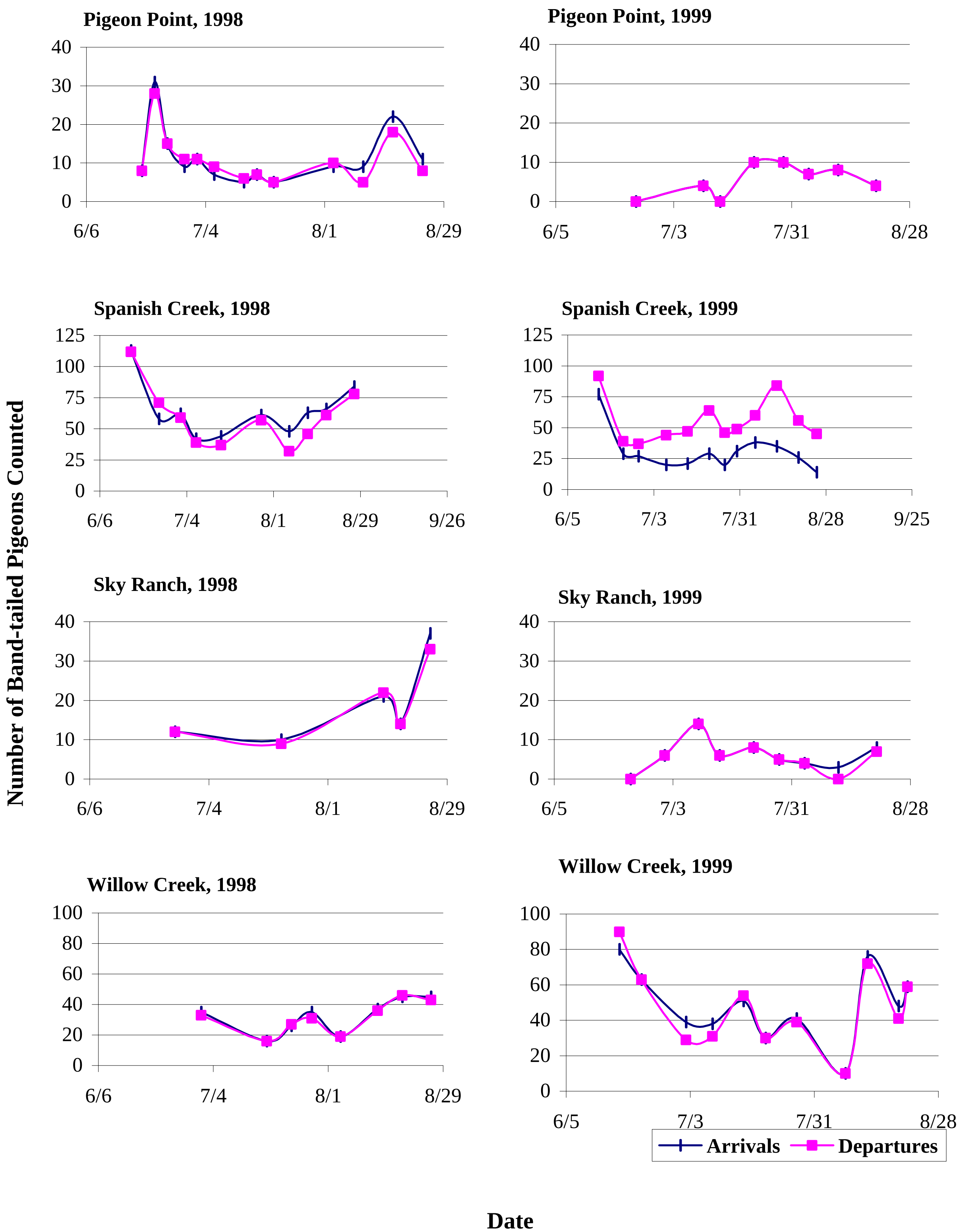


Figure 21. Average number of band-tailed pigeon arrivals during 1-hour intervals from June15-August 31, 1998 and 1999.

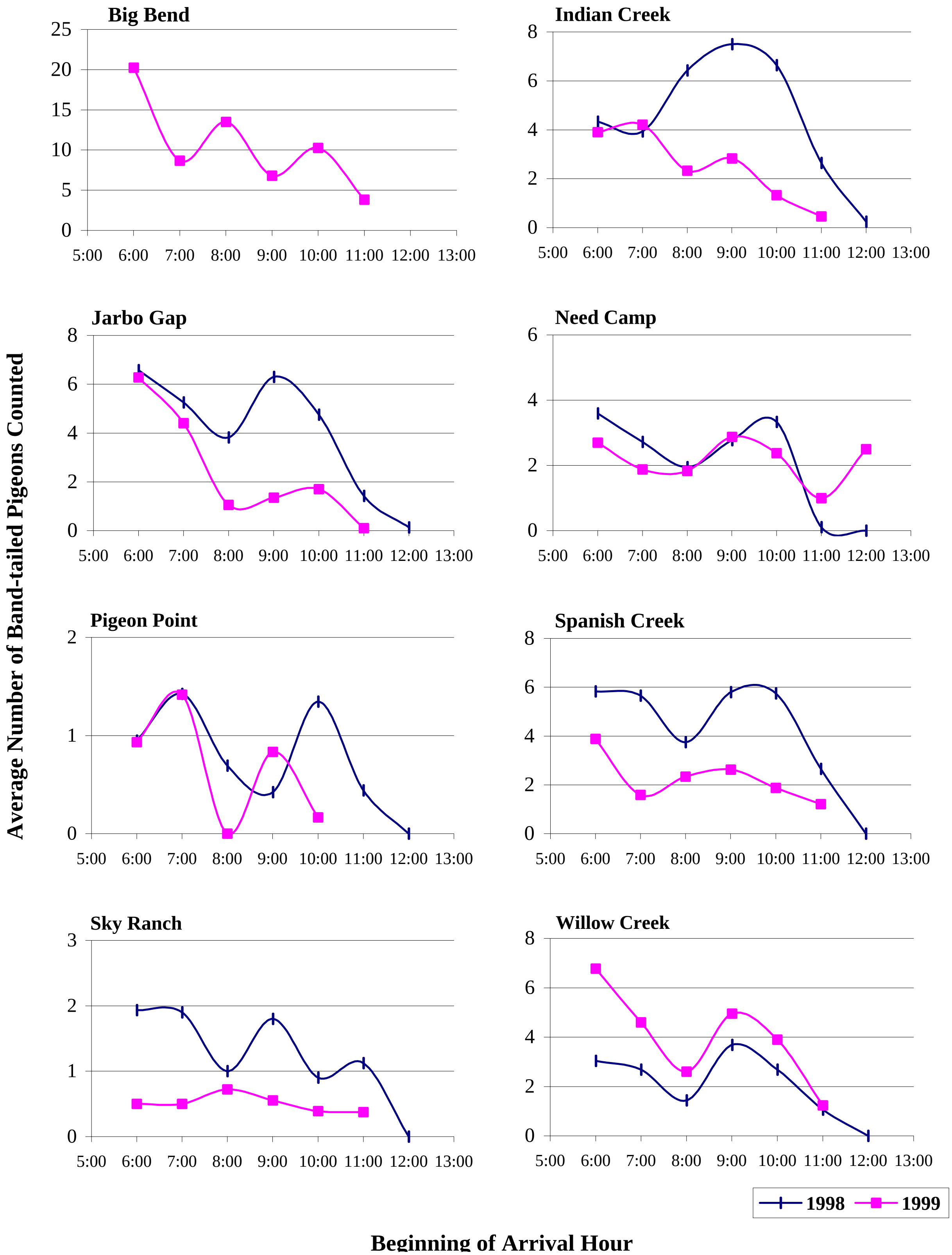


Figure 22. Average number of band-tailed pigeon departures during 1-hour intervals from June 15 - August 31, 1998 and 1999.

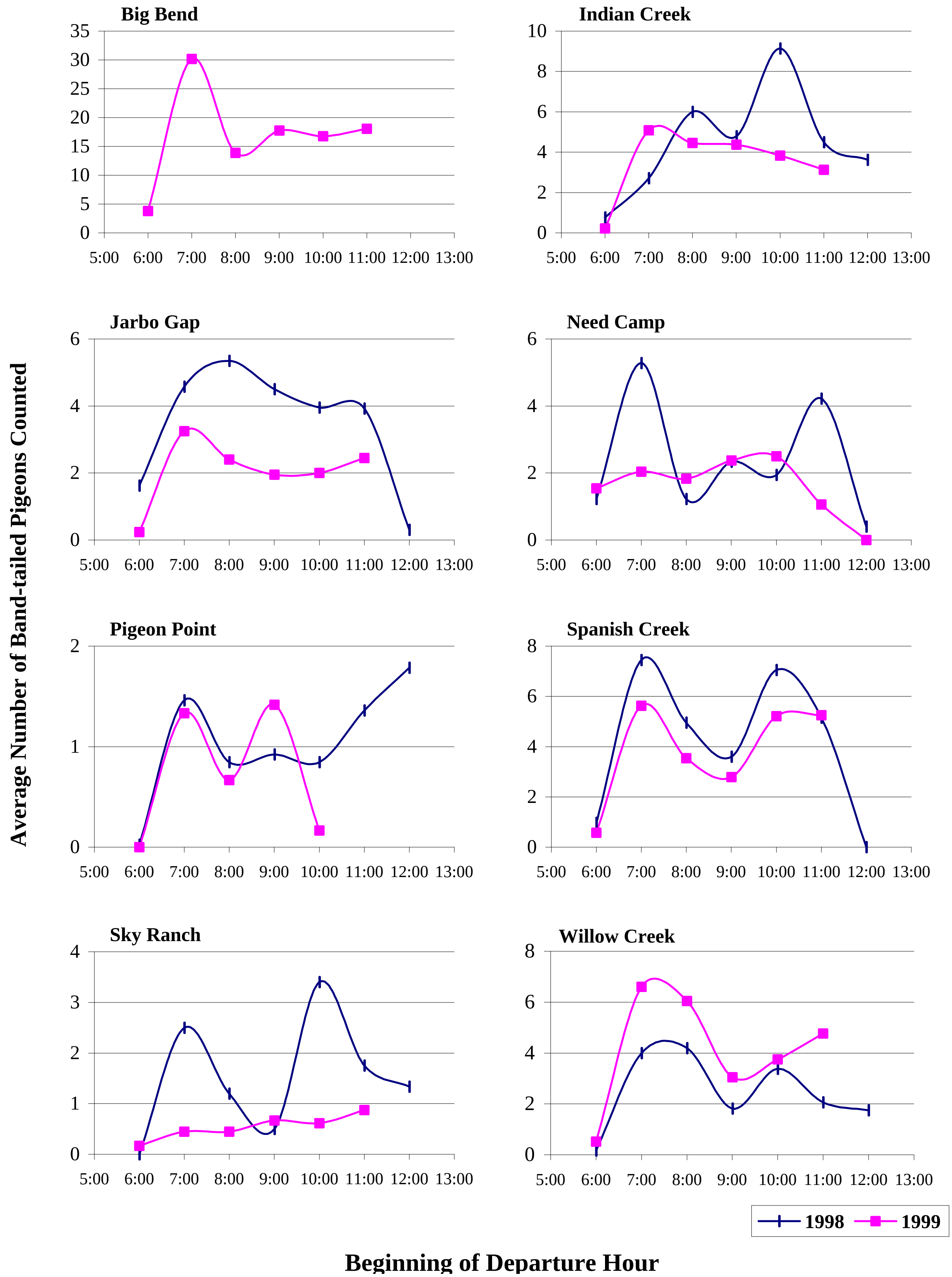


Figure 23. Maximum total number of band-tailed pigeons at California mineral sites compared to estimated maximum number of adults.

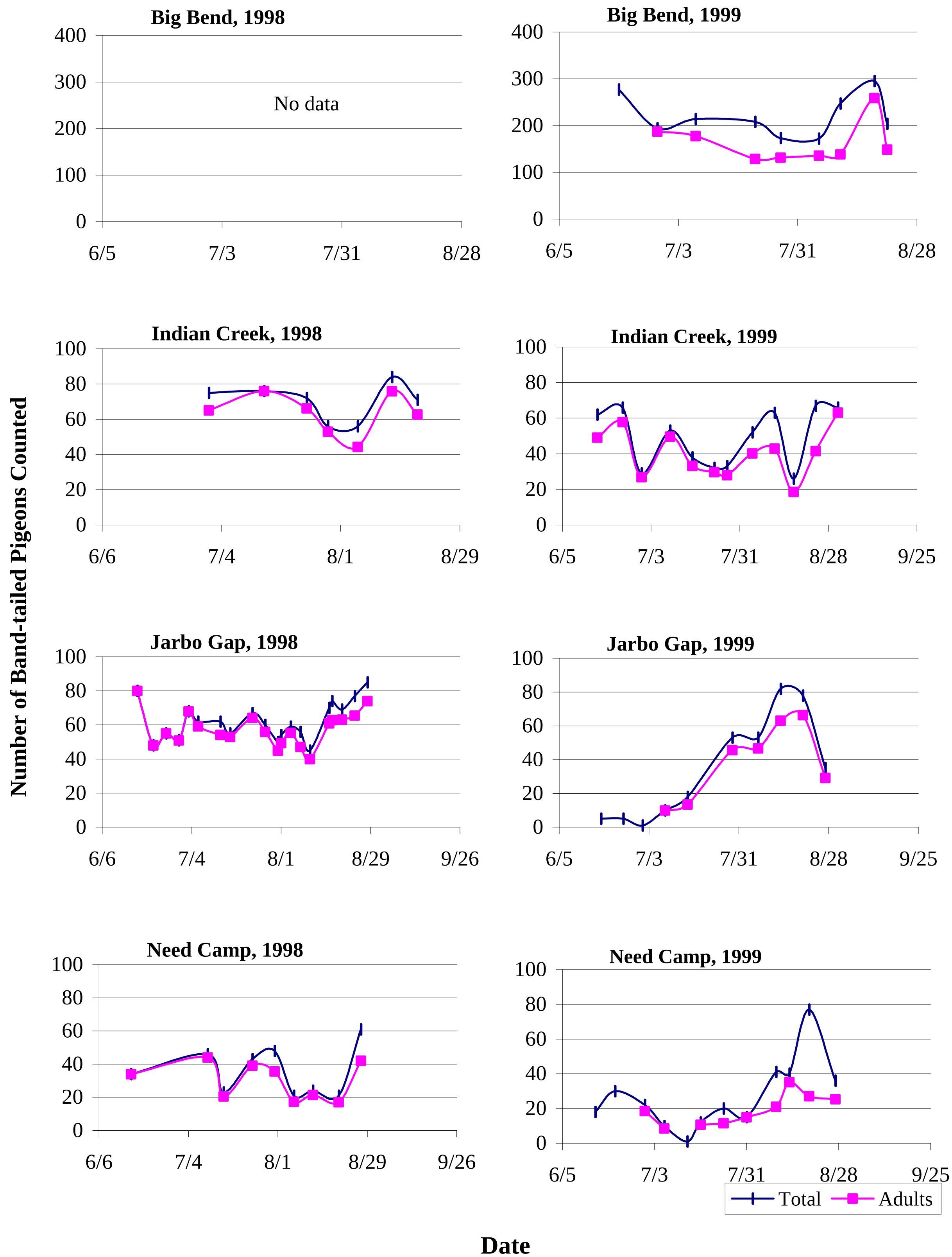


Figure 23 (continued). Maximum total number of band-tailed pigeons at California mineral sites compared to estimated maximum number of adults.

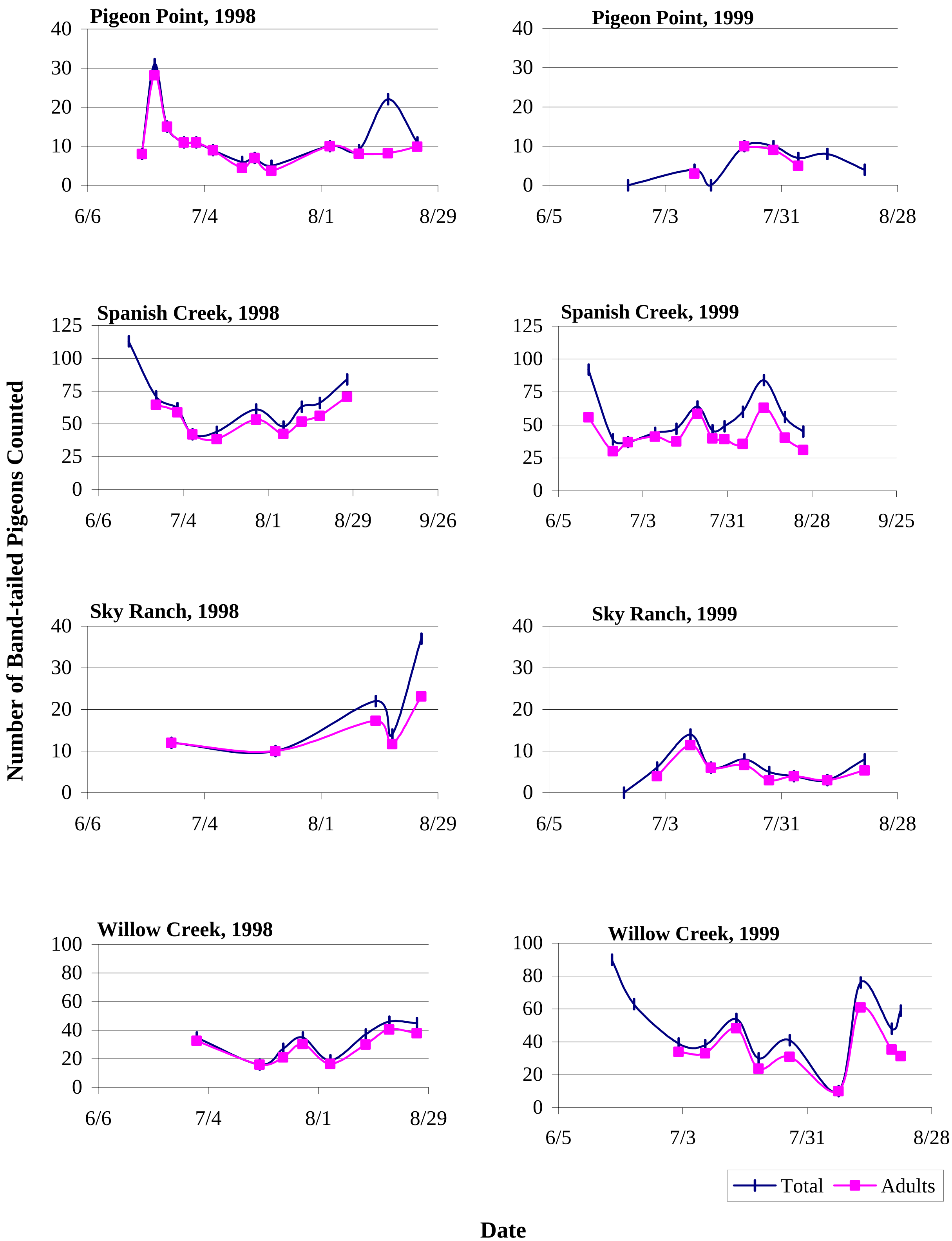


Figure 24a. Effects of replication on estimation of 2-year trends in abundance for band-tailed pigeons at California mineral sites.

Survey : CA mineral sites, 6/21 - 8/10
Term length : 2-year

Number of replicates	sample size	Percent per annum change: mean	standard deviation	standard error	95% CI for % change
1	7	-37%	48%	19%	(-73% , 0%)
2	7	-40%	44%	18%	(-80% , -10%)
3	7	-38%	41%	16%	(-74% , -9%)
4	7	-38%	43%	17%	(-75% , -9%)
5	7	-33%	37%	14%	(-66% , -9%)
10	7	-30%	30%	12%	(-57% , -10%)
all	7	-29%	30%	12%	(-58% , -10%)

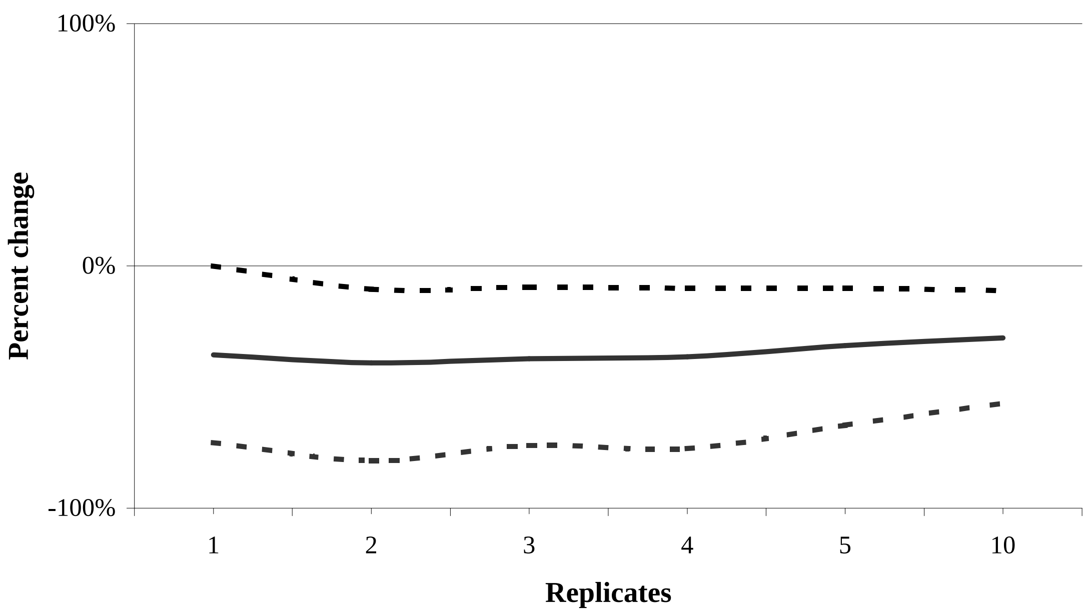


Figure 24b. Effects of replication on power for estimating 2-year trends in abundance of band-tailed pigeons at California mineral sites during June-August, 1998-99 (CH=level of change

Survey :	CA mineral sites, 6/21 - 8/1(	CAMS, 6/21 - 8/10
Term length :		2-year
Estimated standard deviation using 1 replicate:		*48%*
Estimated standard deviation using 2 replicates:		*41%*
Significance level:		*5%*

Replicates	Percent change	Sample Size 10	20	30	40	50	60	70	80	90	100
1	10%	0.10	0.15	0.21	0.26	0.32	0.37	0.42	0.47	0.51	0.55
	20%	0.26	0.47	0.63	0.76	0.84	0.90	0.94	0.96	0.98	0.99
	30%	0.51	0.80	0.93	0.98	0.99	1.00	1.00	1.00	1.00	1.00
3	10%	0.12	0.19	0.27	0.34	0.41	0.47	0.53	0.59	0.64	0.68
	20%	0.34	0.59	0.76	0.87	0.93	0.96	0.98	0.99	1.00	1.00
	30%	0.64	0.90	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00

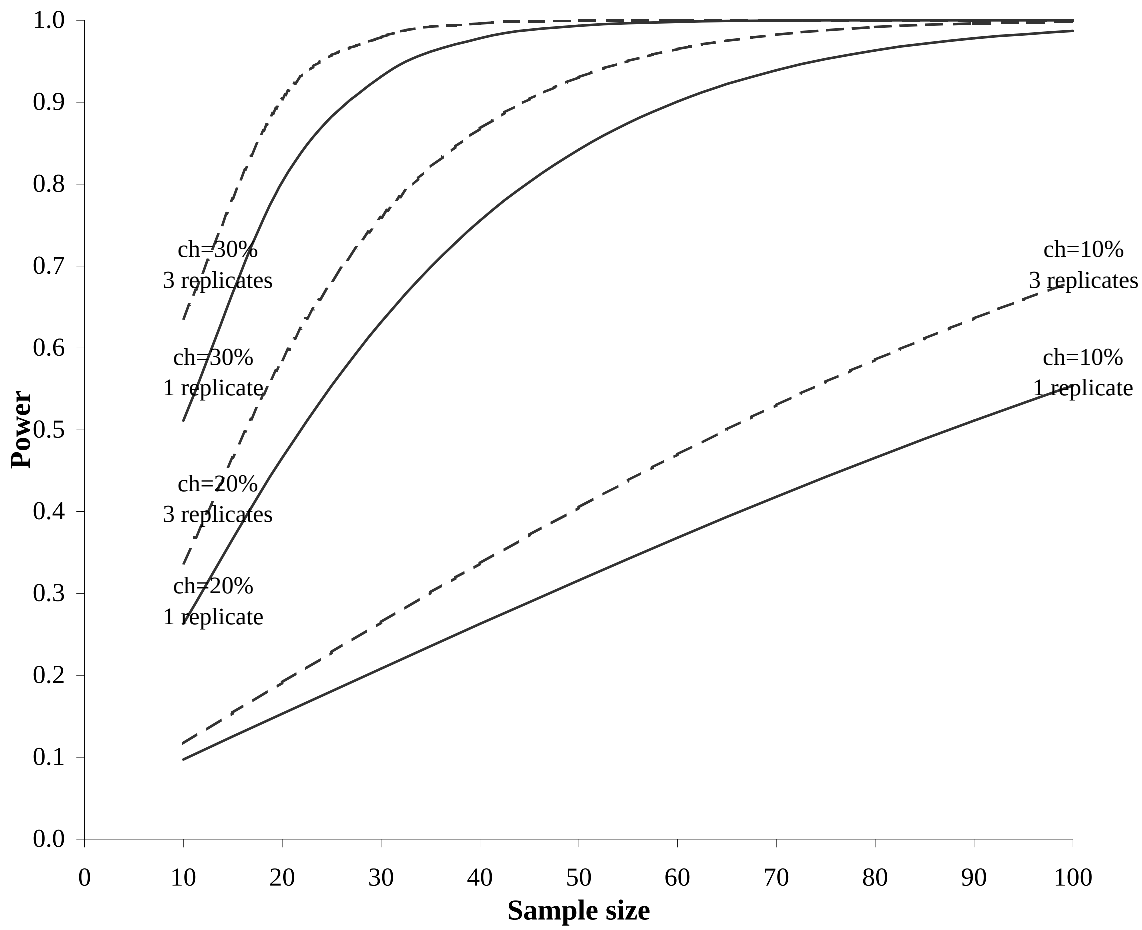


Figure 25. Estimation of 2-year trends in abundance for band-tailed pigeons at California mineral springs during May-August, 1998-99.

Survey : CA mineral sites, 6/21 - 8/10
Term length : 2-year

Timing of survey	sample size	Percent per annum change: mean	standard deviation	standard error	95% CI for % change
MAY 1-31	3	-80%	19%	13%	(-123% , -72%)
JUN 1-30	6	-31%	72%	32%	(-111% , 13%)
JUN 15 - JUL 14	7	-38%	45%	17%	(-74% , -6%)
JUL 1-31	7	-34%	37%	14%	(-69% , -10%)
JUL 15 - AUG 14	7	-8%	30%	12%	(-31% , 14%)
AUG 1-31	7	-7%	28%	11%	(-31% , 17%)
average	*6*	*-33%*	*39%*