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# Landbird Monitoring Results from the Monitoring Avian Productivity and Survivorship (MAPS) Program in the Sierra Nevada

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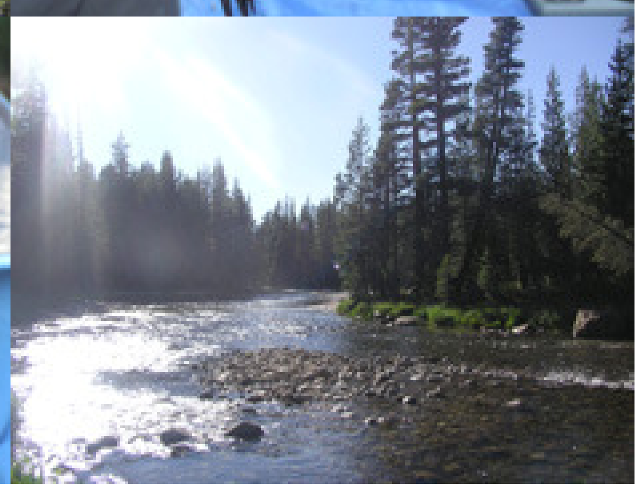

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## SUMMARY

The Monitoring Avian Productivity and Survivorship (MAPS) program was established by The Institute for Bird Populations in 1989 as a cooperative effort among public agencies, private organizations, and individual bird banders in North America to operate a continent-wide network of constant-effort mist-netting and banding stations that provide long-term demographic data on landbirds. Since 1990, numerous stations have operated in the Sierra Nevada, many of them on national forests. We analyzed data from 29 MAPS stations that operated within the Sierra Nevada between 1992-2005. Pooling data from across the Sierra Nevada region, we

- calculated mean Sierra-wide indices of adult population size and productivity for all 101 species captured within their breeding range at Sierra MAPS stations, including 13 Management Indicator Species for the Sierran forests.

- assessed multi-year trends in Sierra-wide adult population size and productivity for 39 species with adequate numbers of captures, including seven Management Indicator Species.

- estimated Sierra-wide, annual adult survival rates for 42 species, including nine Management Indicator Species.

We also assessed historical and current distribution of MAPS stations across the Sierra Nevada, and provide recommendations for establishing future stations to enhance the value of MAPS results across the region.

## INTRODUCTION

Population-trend data on Neotropical migrant birds, while suggesting severe declines in some species, provide no information on primary demographic parameters (productivity and survivorship). Without demographic information, population-trend data alone provide no means for determining at what point(s) in the life cycles problems are occurring, or to what extent population trends are driven by causal factors that affect birth rates, death rates, or both (DeSante 1995). The lack of such information for migratory birds in particular is an obstacle to effective conservation actions, as it leaves unresolved whether critical problems that drive population declines are occurring primarily on temperate breeding grounds or distant tropical wintering grounds. Lack of data on productivity and survivorship thus impedes the formulation of effective management and conservation strategies to reverse population declines (DeSante 1992).

Moreover, environmental factors and management actions affect primary demographic parameters directly and these effects can be observed over a short time period (Temple and Wiens 1989). Because of the buffering effects of floater individuals and density-dependent responses of populations, there may be substantial time lags between changes in primary parameters and resulting changes in population size or density as measured by census or survey methods (DeSante and George 1994). Thus, a population could be in trouble long before this becomes evident from population trend data. Perhaps even more importantly, because of the vagility of many bird species, local variation in secondary parameters (e.g., population size or density) may be masked by recruitment from a wider region (George et al. 1992) or accentuated by lack of recruitment from a wider area (DeSante 1990). Local abundance can sometimes be a poor indicator of reproductive success, particularly in habitats that have been modified substantially by humans (Bock and Jones 2004).

To address these shortcoming in population-trend monitoring that neglects demographic factors, in 1989 The Institute for Bird Populations (IBP) established the Monitoring Avian Productivity and Survivorship (MAPS) program, a cooperative effort among public agencies, private organizations, and individual bird banders in North America to operate a continent-wide network of constant-effort mist-netting and banding stations that provide long-term demographic data on landbirds (DeSante et al. 1995). The design of the MAPS program was patterned after the British Constant Effort Sites (CES) Scheme that has been operated by the British Trust for Ornithology since 1981 (Peach et al. 1996). The MAPS program was endorsed in 1991 by both the Monitoring Working Group of PIF and the USDI Bird Banding Laboratory, and a four-year pilot project (1992-1995) was approved by the USDI Fish and Wildlife Service and National Biological Service (now the Biological Resources Division [BRD] of the U.S. Geological Survey [USGS]) to evaluate its utility and effectiveness for monitoring demographic parameters of landbirds. The MAPS program has subsequently expanded greatly from 178 stations in 1992 to nearly 500 stations, in part due to its endorsement by PIF and the subsequent involvement of various federal agencies in PIF, including the National Park Service, Department of Defense, Department of the Navy, Department of the Army, Texas Army National Guard, USDA Forest Service, and US Fish and Wildlife Service.

The MAPS Program is organized to fulfill three sets of goals and objectives: monitoring, research, and management:

> *Monitoring goals.* For over 100 target species, including Neotropical-wintering migrants, temperate-wintering migrants, and permanent residents, MAPS provides: (a) annual indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured; and (b) annual estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from modified Cormack- Jolly-Seber analyses of mark-recapture data on adult birds.
>
> *Research goals*. MAPS identifies and describes: (a) temporal and spatial patterns in these demographic indices and estimates at a variety of spatial scales ranging from the local landscape to the entire continent; and (b) relationships between these patterns and ecological characteristics of the target species, population trends of the target species, station-specific and landscape-level habitat characteristics, and spatially-explicit weather variables.
>
> *Management goals*. MAPS uses these patterns and relationships to: (a) identify thresholds and trigger points to notify appropriate agencies and organizations of the need for further research and/or management actions; (b) determine the proximate demographic cause(s) of population change; (c) suggest management actions and conservation strategies to reverse population declines and maintain stable or increasing populations; and (d) evaluate the effectiveness of the management actions and conservation strategies actually implemented through an adaptive management framework.

**MAPS in the Sierra Nevada**

The MAPS program began in the Sierra Nevada, with the first MAPS station established at Hodgdon Meadow in Yosemite National Park. After some experimentation with methodology, the current MAPS standardized protocol was developed and adopted there in 1992. Numerous reports have detailed annual results from the MAPS stations located in Yosemite National Park (Pyle et al. 2006), Sequoia and Kings Canyon National Parks (DeSante et al. 2005b) and Devils Postpile National Monument (Gates and Heath 2003). Numerous other MAPS stations have been established and operated by independent contributors, primarily in the northern half of the Sierra Nevada. However the only synthetic analysis from MAPS stations across the entire Sierra (including not just NPS stations, but also stations located on lands managed by the USDA Forest Service and others) was conducted by DeSante (1995b) in conjunction with the Sierra Nevada Ecosystems Project's Final Report to Congress. DeSante's results were later incorporated into the Sierra Nevada Habitat Conservation Plan for California Partners in Flight (Siegel and DeSante 1999). Even those efforts at summarizing MAPS demographic data from the Sierra, however, had a somewhat restricted scope, as they were based only on data collected through 1995. The present report is thus the first summary of Sierra-wide MAPS results in over a decade.

## Purview of this report

The purpose of this report is to summarize results through 2005 from MAPS stations within the Sierra Nevada, which we defined as conforming to the boundaries of the North American Bird Conservation Initiative's (NABCI) Sierra Nevada Bird Conservation Region (http://www.nabci-us.org/bcrs.html). We sought to pool results from across the region to produce MAPS-derived trends in indices of population size and productivity, and to provide range-wide estimates of survivorship ($\phi$) for each species with adequate numbers of recaptures. We were particularly interested in assessing demographic indices, estimates, and trends for landbird species that have been identified by the Forest Service as Management Indicator Species (MIS) for the Sierran forests, but we also sought to analyze data for all landbird species in the Sierra for which MAPS has yielded an adequate dataset. Finally, we sought to assess how any future opportunities to establish more MAPS stations in the Sierra Nevada could be harnessed to most effectively enhance MAPS results for the region.

# METHODS

## Data collection

With few exceptions, all birds captured at MAPS stations are identified to species, age, and sex. If unbanded, the birds are banded with USGS/BRD numbered aluminum bands. Birds are released immediately upon capture and before being banded or processed if situations arise where bird safety would be comprised. Such situations involve exceptionally large numbers of birds being captured at once, or the sudden onset of adverse weather conditions such as high winds or rainfall. MAPS guidelines (DeSante et al. 2005) request that the following data be taken on all birds captured, including recaptures:

- capture code (newly banded, recaptured, band changed, unbanded);
- band number
- species
- age and how aged
- sex (if possible) and how sexed (if applicable)
- extent of skull pneumaticization
- breeding condition of adults (i.e., extent of cloacal protuberance or brood patch)
- extent of juvenal plumage in young birds
- extent of body and flight-feather molt
- extent of primary-feather wear
- presence of molt limits and plumage characteristics
- wing chord
- fat class and body mass
- date and time of capture (net-run time)
- station and net site where captured
- any pertinent notes

Effort data, i.e., the number and timing of net-hours on each day of operation, are also collected in a standardized manner. In order to allow constant-effort comparisons of data, the times of opening and closing the array of mist nets and of beginning each net check are recorded to the nearest ten minutes. The breeding (summer residency) status (confirmed breeder, likely breeder, non-breeder) of each species seen, heard, or captured at each MAPS station on each day of operation is recorded using techniques similar to those employed for breeding bird atlas projects.

**Computer data entry and verification**

After computer entry of all data, banding data are run through a series of verification programs as follows:

- Clean-up programs to check the validity of all codes entered and the ranges of all numerical data.
- Cross-check programs to compare station, date, and net fields from the banding data with those from the summary of mist netting effort data.
- Cross-check programs to compare species, age, and sex determinations against degree of skull pneumaticization, breeding condition (extent of cloacal protuberance and brood patch), and extent of body and flight-feather molt, primary-feather wear, and juvenal plumage.
- Screening programs which allow identification of unusual or duplicate band numbers or unusual band sizes for each species.
- Verification programs to screen banding and recapture data from all years of operation for inconsistent species, age, or sex determinations for each band number.

Any discrepancies or suspicious data identified by any of these programs are examined manually and corrected if necessary. Wing chord, weight, station of capture, date, and any pertinent notes are used as supplementary information for the correct determination of species, age, and sex in all of these verification processes.

**Data analysis**

To facilitate analyses, we first classified all landbird species captured into six groups based upon their breeding or summer residency status. Each species was classified as one of the following: a regular breeder (B) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS station *during all years* that the station was operated; a usual breeder (U) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS station *during more than half but not all of the years* that the station was operated; an occasional breeder (O) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS station *during half or fewer of the years* that the station was operated; a transient (T) if the species was *never* a breeder or summer resident at the station, but the station was within the overall breeding range of the species; an altitudinal disperser (A) if the species breeds only at lower elevation than that of the station but disperses to higher elevations after breeding; and a migrant (M) if the station was not located within the overall breeding range of the species. Data for a given species from a given station were included in productivity analyses if the station was within the breeding range of the species;

that is, data were included from stations where the species was a breeder (B, U, or O) or transient (T), but not where the species was an altitudinal disperser (A) or a migrant (M). Data for a given species from a given station were included in trend and survivorship analyses only if the species was classified as a regular (B) or usual (U) breeder at the station.

Adult population index and productivity analyses

The proofed, verified, and corrected banding data from all fourteen years of data collection were run through a series of analysis programs that calculated for each species:

- the numbers of newly banded birds, recaptured birds, and birds released unbanded.

- the numbers and capture rates (per 600 net-hours) of first captures (in a given year) of individual adult and young birds.

- the reproductive index. Following the procedures pioneered by the British Trust for Ornithology (BTO) in their CES Scheme (Peach et al. 1996), we used the number of adult birds captured as an index of adult population size. For each species each year, we calculated a yearly reproductive index as the number of young divided by the number of adults. In addition to assessing trends in the annual reproductive indices (see below), we also averaged the yearly indices to yield a single productivity index, covering the fourteen-year time period, for each species.

Analyses of trends in adult population size and productivity

We calculated year-to year changes in number of adult birds and in indices of post-fledging productivity following statistical methods developed by the BTO in their CES scheme (Peach et al. 1996), with an analysis program that used actual net-run (capture) times and net-opening and -closing times on a net-by-net and period-by-period basis. We excluded captures that occurred in a given net in a given period in one year if that net was not operated at the same time in the same period in the other year.

We assessed multi-year trends in indices of adult population size and productivity for each species for which an average of at least 2.5 individuals per year (i.e. at least 35 'year-unique' captures) were captured during the fourteen years under consideration. For trends in adult population size, we first calculated adult population indices for each species for each of the 14 years based on an arbitrary starting index of 1.0 in the first year. Constant-effort changes were used to calculate these "chain" indices in each subsequent year by multiplying the proportional change (percent change divided by 100) between the two years times the index of the previous year and adding that figure to the index of the previous year:

$$PSI_{i+1} = PSI_i + PSI_i * (d_i/100),$$

where $PSI_i$ is the population size index for year i and $d_i$ is the percentage change in constant effort numbers from year i to year i+1.

A regression analysis was then run to determine the slope (*PT*) of the trend in the population size indices. Because the indices for adult population size are based on percentage changes, we further calculated the annual percent change (*APC*), defined as the average change per year, to provide an estimate of the population trend for the species. *APC* was calculated as:

(actual year-one value of *PSI* / predicted year-one value of *PSI* based on the regression) * *PT*

We present the *APC*, the standard error of the slope (*SE*), the correlation coefficient (*r*), and the significance of the correlation (*P*) to describe each trend.

We calculated trends in Productivity, *PrT*, in an analogous manner, by starting with actual productivity values in 1992 and calculating each successive year's value based on the actual constant-effort changes in productivity between each pair of consecutive years. For trends in productivity, we present the slope (*PrT*) and its standard error (*SE*), along with the correlation coefficient (*r*), and the significance of the correlation (*P*).

Survivorship analysis

Modified Cormack-Jolly-Seber (CJS) mark-recapture analyses (Pollock et al. 1990, Lebreton et al. 1992) were conducted using 14 years (1992-2005) of capture histories of adult birds. We attempted survival analysis on all species for which an average of at least 2.5 individuals per year were captured (i.e. at least 35 'year-unique' captures during the fourteen years under consideration), and at least two between-year returns were recorded. We included data only from stations that operated for at least four consecutive years between 1992 and 2005, and at those stations, only for years which were part of chains of at least four consecutive years of operation. If a station stopped collecting data before 2005, the capture records from the last year of operation were marked as lost on capture, so that the failure to recapture any of those birds in subsequent years would not cause a downward bias in survival estimates.

Using the computer program TMSURVIV (White 1983, Hines et al. 2003), we calculated, for each target species, maximum-likelihood estimates and standard errors (*SE*s) for time-constant adult survival probability ($\varphi$), adult recapture probability ($p$), and the proportion of residents among newly captured adults ($\tau$) using a between- and within-year transient model (Pradel et al. 1997, Nott and DeSante 2002, Hines et al. 2003). We used a time-constant (rather than annually varying) model of survival probability because extensive analyses of data from MAPS stations in Yosemite National Park (Pyle et al. 2005) have shown that model selection criteria such as the Akaike Information Criterion (AIC) nearly always select the time-constant model over temporally variable models for similar data (Pyle et al. 2006). The use of the transient model ($\varphi p \tau$) accounts for the existence of transient adults (dispersing and floater individuals which are only captured once) in the sample of newly captured birds, and provides survival estimates that are unbiased with respect to these transient individuals (Pradel et al. 1997). Recapture probability is defined as the conditional probability of recapturing a bird in a subsequent year that was banded in a previous year, given that it survived and returned to the place it was originally banded.

We discarded estimates for a few species in which models yielded survival or recapture probability estimates that were equal to 0 or 1, or estimates of proportion of residents that were equal to 0, biologically unrealistic values that indicate the model is not performing properly with the available data.

Throughout this report, we use an alpha level of 0.05 for statistical significance.

## RESULTS

Twenty-nine MAPS stations were established and operated in the Sierra Nevada between 1992 and 2005 (Table 1). Ten of these stations were established on national park units, one was on private land, one was on state-managed land, and the remaining 17 were located on national forests (Table 1). While the 29 stations are generally well-distributed across the region (Figure 1), many of the stations on national forests in the northern half of the Sierra Nevada are no longer running, yielding a present-day distribution that is rather clumped on national park units in the southern half of the Sierra (Figure 1).

### Mean indices of adult population size and productivity

Table 2 presents mean annual numbers (per 600 net-hours) of individual adult and young birds captured, and reproductive index during the 14-year period.

The ten most frequently captured species at MAPS stations in the Sierra Nevada over the 14-year period, with overall capture rates greater than 6.0 adults per 600 net-hours (at stations where the species was captured) were, in descending order: Dark-eyed Junco, MacGillivray's Warbler, Yellow-rumped Warbler, Warbling Vireo, Wilson's Warbler, Song Sparrow, Lincoln's Sparrow, American Robin, Yellow Warbler, and Dusky Flycatcher (Table 2).

The list of the ten species with the most frequently captured young birds at MAPS stations in the Sierra was somewhat similar, but included some notable differences. In decreasing order, species with at least 2.5 young per 600 net-hours (at stations where the species was captured) were: Dark-eyed Junco, Yellow-rumped Warbler, Song Sparrow, MacGillivray's Warbler, Lincoln's Sparrow, Hermit Warbler, Wilson's Warbler, Golden-crowned Kinglet, Mountain Chickadee, and Yellow Warbler (Table 2).

### Multi-year trends in adult population size and productivity

"Chain" indices of adult population size for the 14-year period 1992-2005 are presented for 39 species that met our criteria (see Methods), and for all species pooled, in Figure 2. We used annual percent change (*APC*) for each species as an estimate of the mean annual population trend for that species. These estimates of *APC*, along with the standard error of the slope (in parentheses), the correlation coefficient ($r$), and the significance of the correlation ($P$), are included for each species and for all species pooled on each graph.

Populations of 11 species showed statistically significant declining trends (Table 3). Of these declining species, those with the steepest declines ($APC < -6.0$) include: Downy Woodpecker, Chipping Sparrow, Lazuli Bunting, Purple Finch, Cassin's Finch, and Lesser Goldfinch (Fig. 2).

In contrast, populations of 10 species showed statistically significant increasing trends (Table 3). Of these increasing species, those with the steepest increases (*APC* > 6.0) include: Hairy Woodpecker, Northern Flicker, Brown Creeper, and Western Tanager. Hairy Woodpecker and Northern Flicker both exhibited extremely steep increases (*APC* = 68.4 and 54.7, respectively), but it should be noted that the number of captures and returns for both species were quite low (Table 4), a circumstance that can produce very large changes when the changes are represented as percentages. The 14-year trend for all species pooled is slightly decreasing (APC = -0.4) but not statistically significant ($P = 0.37$).

"Chain" indices of productivity for each of the 14 years are shown in Figure 3 for the same 39 species and all species pooled. Four species showed significantly declining productivity trends: Hairy Woodpecker, Brown Creeper, House Wren, and Song Sparrow. In contrast, five species exhibited statistically significant increasing trends in productivity: Red-breasted Sapsucker, Downy Woodpecker, Lazuli Bunting, Red-winged Blackbird, and Purple Finch. The productivity trend for all species pooled was slightly decreasing ($PrT = -0.014$), but not statistically significant ($P = 0.45$).

**Estimates of adult survivorship**

Using 14 years of data, we were able to obtain estimates of adult survival and recapture probabilities using transient, time-constant ($\varphi p\tau$) models, for 42 species breeding in the Sierra Nevada (Table 4). Estimates of annual adult survival rate ranged from a low of 0.142 for Golden-crowned Kinglet to a high of 0.739 for Pacific-slope Flycatcher, with a mean value (all species pooled) of 0.472. Recapture probability varied from a low of 0.006 for Cassin's Finch to a high of 0.679 for Black Phoebe, with a mean value (all species pooled) of 0.317. Proportion of residents varied from a low of 0.043 for Pacific-slope Flycatcher to a high of 1.000 for four species (Brown-headed Cowbird, Red-breasted Nuthatch, Red-winged Blackbird, and Cassin's Finch), with a mean value (all species pooled) of 0.542.

**Summary results for Forest Service Management Indicator Species for the Sierran forests**

Below we provide summary information, gleaned from Tables 2-4 and Figures 2-3 for 13 Forest Service Management Indicator Species for the Sierran forests (Patricia Krueger, *personal communication*) for which we have data.

Acorn Woodpecker
Number of stations with captures: **1**
Adult capture rate: **0.044 birds/600 net-hours**
Adult population trend: **n/a**
Young capture rate: **0 birds/600 net-hours**
Reproductive index: **n/a**
Trend in reproductive index: **n/a**
Adult annual survival probability: **n/a**

Williamson's Sapsucker
Number of stations with captures: **10**

Adult capture rate: **0.448 birds/600 net-hours**
Adult population trend: **n/a**
Young capture rate: **0.121 birds/600 net-hours**
Reproductive index: **0.287**
Trend in reproductive index: **n/a**
Adult annual survival probability: **0.536(0.103)**

Red-breasted Sapsucker
Number of stations with captures: **25**
Adult capture rate: **3.118 birds/600 net-hours**
Adult population trend: **no discernible trend**
Young capture rate: **1.353 birds/600 net-hours**
Reproductive index: **0.440**
Trend in reproductive index: **significantly increasing**
Adult annual survival probability: **0.485(0.048)**

Hairy Woodpecker
Number of stations with captures: **23**
Adult capture rate: **0.573 birds/600 net-hours**
Adult population trend: **significantly increasing**
Young capture rate: **0.280 birds/600 net-hours**
Reproductive index: **0.599**
Trend in reproductive index: **significantly decreasing**
Adult annual survival probability: **0.719(0.089)**

Olive-sided Flycatcher
Number of stations with captures: **12**
Adult capture rate: **0.161 birds/600 net-hours**
Adult population trend: **n/a**
Young capture rate: **0 birds/600 net-hours**
Reproductive index: **n/a**
Trend in reproductive index: **n/a**
Adult annual survival probability: **n/a**

Willow Flycatcher
Number of stations with captures: **14**
Adult capture rate: **0.794 birds/600 net-hours**
Adult population trend: **n/a**
Young capture rate: **0.099 birds/600 net-hours**
Reproductive index: **0.092**
Trend in reproductive index: **n/a**
Adult annual survival probability: **0.547(0.094)**

Warbling Vireo
Number of stations with captures: **27**
Adult capture rate: **11.446 birds/600 net-hours**

Adult population trend: **non-significantly decreasing**
Young capture rate: **1.637 birds/600 net-hours**
Reproductive index: **0.151**
Trend in reproductive index: **no discernible trend**
Adult annual survival probability: **0.454(0.026)**

Oak Titmouse
Number of stations with captures: **2**
Adult capture rate: **0.042 birds/600 net-hours**
Adult population trend: **n/a**
Young capture rate: **0.050 birds/600 net-hours**
Reproductive index: **1.150**
Trend in reproductive index: **n/a**
Adult annual survival probability: **n/a**

Blue-gray Gnatcatcher
Number of stations with captures: **1**
Adult capture rate: **0 birds/600 net-hours**
Adult population trend: **n/a**
Young capture rate: **0.007 birds/600 net-hours**
Reproductive index: **n/a**
Trend in reproductive index: **n/a**
Adult annual survival probability: **n/a**

Yellow Warbler
Number of stations with captures: **21**
Adult capture rate: **5.652 birds/600 net-hours**
Adult population trend: **no discernible trend**
Young capture rate: **2.697 birds/600 net-hours**
Reproductive index: **0.501**
Trend in reproductive index: **no discernible trend**
Adult annual survival probability: **0.468(0.025)**

Wilson's Warbler
Number of stations with captures: **25**
Adult capture rate: **11.312 birds/600 net-hours**
Adult population trend: **no discernible trend**
Young capture rate: **4.465 birds/600 net-hours**
Reproductive index: **0.422**
Trend in reproductive index: **non-significantly decreasing**
Adult annual survival probability: **0.360(0.020)**

Western Tanager
Number of stations with captures: **27**
Adult capture rate: **3.546 birds/600 net-hours**
Adult population trend: **significantly increasing**

Young capture rate: **1.334 birds/600 net-hours**
Reproductive index: **0.416**
Trend in reproductive index: **no discernible trend**
Adult annual survival probability: **0.562(0.067)**

White-crowned Sparrow
Number of stations with captures: **6**
Adult capture rate: **2.265 birds/600 net-hours**
Adult population trend: **no discernible trend**
Young capture rate: **1.195 birds/600 net-hours**
Reproductive index: **0.648**
Trend in reproductive index: **non-significantly increasing**
Adult annual survival probability: **0.443(0.042)**

## DISCUSSION

### Demographic rates of Management Indicator Species and other Sierran landbirds

Results from 14 years of MAPS monitoring in the Sierra Nevada suggest that frequently captured landbird species in the Sierra may be faring somewhat better than landbird populations elsewhere in North America. We found nearly the same number of species with statistically significantly declining population trends as increasing population trends, and nearly the same number of significantly decreasing trends in productivity as increasing productivity trends. Nevertheless, it should be noted that some of the Sierran bird species about which concern is greatest—such as Willow Flycatcher—are not captured in adequate numbers by existing MAPS stations to allow for trend assessment. Were we able to provide trend information for the region's rarest and perhaps most imperiled species, the overall picture for the Sierran avifauna might look considerably less encouraging.

Of the seven management indicator species for which we were able to evaluate temporal trends in adult population size and productivity, none exhibited a statistically significant population decline over the study period, although Warbling Vireo's non-significant decline would seem to merit continued attention. As for trends in productivity, Hairy Woodpecker was the only species with a significant decline, and even this result must be considered in the light of the species' significantly *increasing* population trend.

At first glance it may be surprising to see increasing population indices and decreasing productivity indices in the same species, but at least two scenarios can explain such a situation:

- Increasing survival rates may be more than compensating for decreasing productivity rates over time.

- Perhaps more likely, an increasing adult population may include proportionately more 'floaters'—individuals who do not have an opportunity to breed—over time. A higher proportion of non-breeding adults will drive the reproductive index down, even if the absolute number of young birds produced each year is not declining.

Results from several non-indicator species also merit attention, in particular strongly declining species for which we have relatively robust sample sizes, particularly Dusky Flycatcher, Chipping Sparrow, Fox Sparrow, Lazuli Bunting, and Purple Finch. These five species merit further study, as they appear to be declining, are fairly widely distributed across the Sierra and have proven relatively easy to monitor.

**Additional analyses of Sierra MAPS data**

Although beyond the scope of this report, additional analyses and inquiries could make further use of existing data from the Sierra Nevada MAPS stations. In particular, more information could be gleaned for many of the 42 species for which we were able to estimate annual adult survival rates in addition to producing reproductive indices. For the most frequently captured species, sample sizes appear adequate to allow modeling of covariates of survival probability—landscape variables such as habitat type, latitude, management history, etc., at multiple spatial scales. Additionally, MAPS data have been used successfully to investigate the effects of weather and climate on demographic parameters (e.g. Nott et al. 2002), and conducting similar analyses on the Sierra Nevada dataset would likely be instructive.

**Establishing additional MAPS stations on national forests in the Sierra Nevada**

In general, MAPS stations have been relatively well distributed across the Sierra Nevada, but several deficiencies in the distribution are apparent:

- Many of the stations established on national forests in the northern half of the Sierra are no longer operating. Restoring or replacing these stations would do much to bolster the long-term usefulness of MAPS in the Sierra.

- At the other end of the north-south gradient, there have never been any stations established in the Sierra south of Sequoia National Park; a few new stations on or adjacent to Sequoia National Forest could fill this gap in coverage.

- With the exception of the very southern tip of the Sierra, the southern half of the range is currently fairly well represented by nine MAPS stations operated on National Park units. However, one of the explicit goals of natural resource monitoring in national parks is to provide reference sites for comparison with areas outside the national parks (Silsbee and Peterson 1991). Additional stations sited on the Stanislaus, Sierra, Inyo, and/or Sequoia National Forests could make use of nearby NPS stations as controls for examining the effects of more intensive landscape management practices.

- Nearly all the existing and historical stations have been established in the mid-elevation zone. High-elevation areas have likely been avoided because of access problems and other logistic difficulties associated with late-lingering winter conditions. However low-elevation areas have also been neglected, and foothill-associated species are poorly represented in the dataset. A few well-placed stations in foothill vegetation communities could collect valuable information on numerous bird species that have been somewhat neglected by extant monitoring efforts, including several of the FS Management Indicator Species (e.g. Acorn Woodpecker, Oak Titmouse, and Blue-gray Gnatcatcher).

- Few stations have been established on the eastern slope of the Sierra. Additional east-side stations would extend the area of inference for numerous species, and also yield enough data for estimating survivorship and monitoring trends in population and productivity of eastside-affiliated species for which we currently do not have enough data to do so.

- Finally, additional MAPS stations anywhere in the Sierra may be especially useful if they are sited to answer specific management-related questions—for example, to monitor the effectiveness of habitat restoration efforts, to compare the changes in bird population dynamics effected by different timber harvest regimes, or to assess the impact of prescribed fire on bird populations.

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Table 1. All MAPS stations operated in the North American Bird Conservation Initiative (NABCI) Sierra Nevada Bird Conservation Region between 1989 and 2005. Only data from 1992-2005 were used in the present analysis.

| Station number | Station code | Station Name | Land-holder[1] | UTM – NAD83 Zone | Easting | Northing | Nearest Town | County | Years of operation[2] |
|---|---|---|---|---|---|---|---|---|---|
| 11107 | HODG | Hodgdon Meadow | NPS | 11 | 247743 | 4186898 | El Portal | Tuolumne | 90- |
| 11109 | LIME | Lion Meadow | NPS | 11 | 322925 | 4068506 | Pinehurst | Fresno/Tulare | 91-93,01- |
| 11110 | ZUME | Zumwalt Meadow | NPS | 11 | 357226 | 4073782 | Hume | Fresno | 91-93,01- |
| 11111 | YUBA | Yuba Pass | USFS | 10 | 719519 | 4388326 | Sattley | Sierra | 91-04 |
| 11112 | SNFC | Sierra Nevada | USFS | 10 | 712348 | 4388743 | Sierra City | Sierra | 91-04 |
| 11130 | FREE | Freeman Meadow | USFS | 10 | 705777 | 4393501 | Clio | Sierra | 92-04 |
| 11131 | CAVA | Carman Valley | USFS | 10 | 718541 | 4397556 | Calpine | Sierra | 92- |
| 11132 | PZAZ | Perazzo Meadow | USFS | 10 | 725012 | 4371820 | Sierraville | Sierra | 92-04 |
| 11204 | KILN | Kiln Meadow | USFS | 10 | 735665 | 4368403 | Truckee | Nevada | 98-99 |
| 11224 | DEPO | Devils Postpile NM | NPS | 11 | 315978 | 4166710 | Mammoth Lakes | Madera | 02- |
| 11246 | KKDZ | KKDZ | PRIV | 10 | 670574 | 4357166 | North San Juan | Nevada | 95-97 |
| 11904 | WHWO | White Wolf | NPS | 11 | 266623 | 4194732 | Yosemite Village | Tuolumne | 93- |
| 11905 | BIME | Big Meadow | NPS | 11 | 257308 | 4176583 | El Portal | Mariposa | 93- |
| 11906 | TAME | Tamarack Meadow | NPS | 11 | 258309 | 4184822 | El Portal | Mariposa | 93-96 |
| 11907 | CRFL | Crane Flat | NPS | 11 | 252922 | 4182390 | El Portal | Mariposa | 93- |
| 11929 | FROF | Little Valley | S/C | 11 | 251664 | 4349147 | Crystal Bay | Washoe | 95-05 |
| 11931 | BGOK | Big Oak Flat | USFS | 10 | 703246 | 4325865 | Foresthill | Placer | 95-01 |
| 11935 | SCRE | Sagehen Creek | USFS | 10 | 737271 | 4368123 | Truckee | Nevada | 92-00,02- |
| 11936 | TMEA | Taylor Meadow | USFS | 10 | 737999 | 4368577 | Truckee | Nevada | 93-00,03,04 |
| 11944 | BIGO | Big Oak Flat 2 | USFS | 10 | 702525 | 4325846 | Foresthill | Placer | 96-01 |
| 11945 | WHIT | Whitmore Meadows | USFS | 10 | 720662 | 4261541 | West Point | Amador | 96 |
| 11946 | BUCK | Buck Ranch | USFS | 10 | 736311 | 4249027 | Camp Connell | Calaveras | 96 |
| 11947 | MORR | Morrison | USFS | 10 | 732752 | 4287802 | Kyburz | El Dorado | 96 |
| 11968 | SAVE | Savercool Place | USFS | 10 | 610772 | 4450292 | Butte Meadows | Tehama | 97 |
| 11969 | GUCR | Gurnsey Creek | USFS | 10 | 633011 | 4463328 | Mill Creek | Tehama | 97- |
| 11970 | DRAK | Drakesbad | NPS | 10 | 611781 | 4477786 | Butte Meadows | Tehama | 97- |
| 11980 | GFEM | Gin Flat East Meadow | NPS | 11 | 256775 | 4183479 | El Portal | Mariposa | 98- |
| 11989 | RARA | Ramelli Ranch | USFS | 10 | 721170 | 4410281 | Beckwouth | Plumas | 98-04 |
| 11998 | MICR | Mill Creek | USFS | 10 | 626240 | 4467190 | Mill Creek | Tehama | 98-00 |

[1] The owner or manager of the land on which the station is located. USFS - U.S. Forest Service, NPS - National Park Service, S/C - State or County Jurisdictions, PRIV - Private Landholder

[2] The years in which the station was operated. If the grouping ends in a dash the station was expected to have continued operations through at least the 2006 MAPS season.

Table 2. Mean numbers of aged individual birds captured per 600 net-hours and reproductive index at the 29 individual MAPS stations operated in the Sierra Nevada between 1992-2005. Data for each species are included only from stations where at least one individual was captured. Species outside their breeding range (i.e. species encountered in the Sierra only as migrants or altitudinal dispersers) are excluded from the table.

| Species | No. of stations | Aged individuals per 600 net-hours | | Reproductive Index[1] |
|---|---|---|---|---|
| | | Adults | Young | |
| Sharp-shinned Hawk | 4 | 0.015 | 0.005 | 0.333 |
| American Kestrel | 1 | 0.005 | 0.000 | 0.000 |
| Spotted Sandpiper | 5 | 0.049 | 0.005 | 0.050 |
| Wilson's Snipe | 1 | 0.005 | 0.010 | 2.000 |
| Mourning Dove | 1 | 0.008 | 0.000 | 0.000 |
| Northern Pygmy-Owl | 2 | 0.010 | 0.000 | 0.000 |
| Belted Kingfisher | 2 | 0.013 | 0.000 | 0.000 |
| Acorn Woodpecker | 1 | 0.044 | 0.000 | 0.000 |
| Williamson's Sapsucker | 10 | 0.448 | 0.121 | 0.287 |
| Red-breasted Sapsucker | 25 | 3.118 | 1.353 | 0.440 |
| Downy Woodpecker | 13 | 0.314 | 0.153 | 0.599 |
| Hairy Woodpecker | 23 | 0.573 | 0.280 | 0.599 |
| White-headed Woodpecker | 17 | 0.396 | 0.075 | 0.219 |
| Black-backed Woodpecker | 5 | 0.023 | 0.005 | 0.000 |
| Northern Flicker | 20 | 0.394 | 0.120 | 0.287 |
| Olive-sided Flycatcher | 12 | 0.161 | 0.000 | 0.000 |
| Western Wood-Pewee | 24 | 3.178 | 0.441 | 0.147 |
| Willow Flycatcher | 14 | 0.794 | 0.099 | 0.092 |
| Hammond's Flycatcher | 21 | 2.096 | 1.058 | 0.545 |
| Gray Flycatcher | 3 | 0.317 | 0.368 | 1.180 |
| Dusky Flycatcher | 26 | 5.556 | 1.024 | 0.198 |
| Pacific-slope Flycatcher | 21 | 1.442 | 0.813 | 0.640 |
| Black Phoebe | 6 | 0.397 | 0.599 | 2.383 |
| Ash-throated Flycatcher | 1 | 0.009 | 0.000 | 0.000 |
| Western Kingbird | 1 | 0.008 | 0.000 | 0.000 |
| Cassin's Vireo | 25 | 2.076 | 0.789 | 0.387 |
| Hutton's Vireo | 5 | 0.040 | 0.037 | 0.375 |
| Warbling Vireo | 27 | 11.446 | 1.637 | 0.151 |
| Steller's Jay | 23 | 0.367 | 0.104 | 0.318 |
| Western Scrub-Jay | 3 | 0.018 | 0.000 | 0.000 |

Table 2, continued

| Species | No. of stations | Aged individuals per 600 net-hours | | Reproductive Index[1] |
|---|---|---|---|---|
| | | Adults | Young | |
| Black-billed Magpie | 1 | 0.010 | 0.000 | 0.000 |
| Tree Swallow | 3 | 0.005 | 0.010 | 1.000 |
| Violet-green Swallow | 1 | 0.008 | 0.000 | 0.000 |
| Northern Rough-winged Swallow | 4 | 0.056 | 0.017 | 0.000 |
| Cliff Swallow | 1 | 0.026 | 0.000 | 0.000 |
| Mountain Chickadee | 27 | 4.543 | 3.379 | 0.876 |
| Chestnut-backed Chickadee | 3 | 0.058 | 0.041 | 0.286 |
| Oak Titmouse | 2 | 0.042 | 0.050 | 1.150 |
| Bushtit | 9 | 0.473 | 0.680 | 2.087 |
| Red-breasted Nuthatch | 23 | 0.999 | 1.472 | 2.147 |
| White-breasted Nuthatch | 13 | 0.167 | 0.054 | 0.520 |
| Pygmy Nuthatch | 2 | 0.000 | 0.015 | und.[2] |
| Brown Creeper | 27 | 1.956 | 2.216 | 1.176 |
| Canyon Wren | 1 | 0.000 | 0.005 | und.[2] |
| Bewick's Wren | 6 | 0.010 | 0.134 | 1.429 |
| House Wren | 8 | 0.704 | 0.805 | 1.340 |
| Winter Wren | 8 | 0.099 | 0.193 | 1.324 |
| Marsh Wren | 1 | 0.000 | 0.008 | und.[2] |
| American Dipper | 6 | 0.021 | 0.010 | 0.000 |
| Golden-crowned Kinglet | 16 | 1.852 | 3.488 | 1.848 |
| Ruby-crowned Kinglet | 2 | 0.036 | 0.015 | 0.000 |
| Blue-gray Gnatcatcher | 1 | 0.000 | 0.007 | und.[2] |
| Western Bluebird | 3 | 0.162 | 0.051 | 0.147 |
| Mountain Bluebird | 1 | 0.000 | 0.008 | und.[2] |
| Townsend's Solitaire | 13 | 0.151 | 0.058 | 0.450 |
| Swainson's Thrush | 9 | 0.430 | 0.048 | 0.199 |
| Hermit Thrush | 19 | 0.841 | 0.199 | 0.294 |
| American Robin | 29 | 6.022 | 1.372 | 0.262 |
| Wrentit | 3 | 0.206 | 0.153 | 0.872 |
| European Starling | 2 | 0.000 | 0.016 | und.[2] |
| Cedar Waxwing | 2 | 0.015 | 0.000 | 0.000 |
| Orange-crowned Warbler | 2 | 0.152 | 0.032 | 0.167 |
| Nashville Warbler | 14 | 2.191 | 2.116 | 1.072 |
| Yellow Warbler | 21 | 5.652 | 2.697 | 0.501 |

Table 2, continued

| Species | No. of stations | Aged individuals per 600 net-hours | | Reproductive Index[1] |
|---|---|---|---|---|
| | | Adults | Young | |
| Yellow-rumped Warbler | 26 | 12.229 | 12.074 | 1.027 |
| Black-throated Gray Warbler | 17 | 0.313 | 0.426 | 1.317 |
| Hermit Warbler | 26 | 4.129 | 4.963 | 1.182 |
| MacGillivray's Warbler | 25 | 12.691 | 6.844 | 0.585 |
| Common Yellowthroat | 5 | 0.038 | 0.000 | 0.000 |
| Wilson's Warbler | 25 | 11.312 | 4.465 | 0.422 |
| Yellow-breasted Chat | 1 | 0.026 | 0.005 | 0.200 |
| Western Tanager | 27 | 3.546 | 1.334 | 0.416 |
| Green-tailed Towhee | 14 | 1.322 | 0.486 | 0.417 |
| Spotted Towhee | 12 | 1.222 | 0.523 | 0.536 |
| Chipping Sparrow | 20 | 2.006 | 0.717 | 0.380 |
| Brewer's Sparrow | 5 | 0.331 | 0.128 | 0.345 |
| Vesper Sparrow | 3 | 0.281 | 0.123 | 0.610 |
| Black-throated Sparrow | 1 | 0.005 | 0.000 | 0.000 |
| Sage Sparrow | 1 | 0.008 | 0.000 | 0.000 |
| Savannah Sparrow | 6 | 0.234 | 0.331 | 2.026 |
| Fox Sparrow | 18 | 1.801 | 0.349 | 0.259 |
| Song Sparrow | 24 | 9.523 | 8.786 | 0.963 |
| Lincoln's Sparrow | 23 | 9.237 | 5.746 | 0.643 |
| White-crowned Sparrow | 6 | 2.265 | 1.195 | 0.648 |
| Dark-eyed Junco | 28 | 19.741 | 19.050 | 1.022 |
| Black-headed Grosbeak | 27 | 3.873 | 1.381 | 0.381 |
| Lazuli Bunting | 26 | 2.888 | 1.207 | 0.514 |
| Red-winged Blackbird | 6 | 0.376 | 0.061 | 0.169 |
| Brewer's Blackbird | 11 | 0.340 | 0.086 | 0.216 |
| Brown-headed Cowbird | 21 | 0.533 | 0.142 | 0.252 |
| Bullock's Oriole | 7 | 0.165 | 0.030 | 0.200 |
| Pine Grosbeak | 6 | 0.389 | 0.071 | 0.108 |
| Purple Finch | 22 | 4.234 | 1.433 | 0.341 |
| Cassin's Finch | 21 | 2.767 | 0.661 | 0.302 |
| House Finch | 4 | 0.066 | 0.046 | 0.429 |
| Red Crossbill | 8 | 0.096 | 0.010 | 0.033 |
| Pine Siskin | 23 | 3.336 | 2.142 | 0.716 |
| Lesser Goldfinch | 16 | 1.471 | 1.885 | 0.997 |

Table 2, continued

| Species | No. of stations | Aged individuals per 600 net-hours | | Reproductive Index[1] |
|---|---|---|---|---|
| | | Adults | Young | |
| Lawrence's Goldfinch | 5 | 0.124 | 0.021 | 0.014 |
| Evening Grosbeak | 15 | 1.072 | 0.093 | 0.092 |
| House Sparrow | 1 | 0.005 | 0.000 | 0.000 |
| | | | | |
| ALL SPECIES POOLED | 29 | 174.290 | 105.258 | 0.612 |
| | | | | |
| Number of Species | | 95 | 84 | |

[1] Years for which the reproductive index was undefined (no adult birds were captured in the year) are not included in the mean reproductive index.

[2] The reproductive index is undefined at this station because no young individual of the species was ever captured in the same year as an adult individual of the species.

Table 3. Species with significantly ($P < 0.05$) increasing or decreasing trends in indices of adult population size across the Sierra Nevada.

| Increasing population trend | Decreasing population trend |
|---|---|
| Hairy Woodpecker | Downy Woodpecker |
| Northern Flicker | Dusky Flycatcher |
| Western Wood-Pewee | Cassin’s Vireo |
| Brown Creeper | Golden-crowned Kinglet |
| American Robin | Chipping Sparrow |
| Yellow-rumped Warbler | Fox Sparrow |
| MacGillivray’s Warbler | Lazuli Bunting |
| Western Tanager | Purple Finch |
| Song Sparrow | Cassin’s Finch |
| Lincoln’s Sparrow | Pine Siskin |
| | Lesser Goldfinch |

Table 4. Estimates of adult annual survival and recapture probabilities and proportion of residents among newly captured adults using a time-constant model for 42 species breeding at 22[1] MAPS stations in the Sierra Nevada. Results were obtained from 14 years (1992-2005) of mark-recapture data.

| Species | No. stations[2] | No. birds[3] | No. Captures[4] | No. returns[5] | Survival probability[6] | | Survival C.V.[7] | Recapture probability[8] | | Proportion of residents[9] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Williamson's Sapsucker | 6 | 66 | 92 | 11 | 0.536 | (0.103) | 19.3 | 0.240 | (0.104) | 0.311 | (0.232) |
| Red-breasted Sapsucker | 15 | 405 | 622 | 69 | 0.485 | (0.048) | 10.0 | 0.315 | (0.059) | 0.611 | (0.134) |
| Hairy Woodpecker | 13 | 76 | 97 | 12 | 0.719 | (0.089) | 12.4 | 0.110 | (0.048) | 0.408 | (0.298) |
| Northern Flicker | 13 | 56 | 65 | 5 | 0.480 | (0.183) | 38.0 | 0.119 | (0.097) | 0.865 | (0.756) |
| Western Wood-Pewee | 18 | 431 | 578 | 67 | 0.571 | (0.047) | 8.3 | 0.241 | (0.047) | 0.538 | (0.120) |
| Willow Flycatcher | 2 | 46 | 74 | 15 | 0.547 | (0.094) | 17.1 | 0.414 | (0.132) | 0.638 | (0.282) |
| Hammond's Flycatcher | 10 | 294 | 394 | 42 | 0.486 | (0.057) | 11.8 | 0.386 | (0.082) | 0.344 | (0.097) |
| Dusky Flycatcher | 14 | 715 | 988 | 83 | 0.444 | (0.041) | 9.2 | 0.333 | (0.056) | 0.371 | (0.075) |
| Pacific-slope Flycatcher | 4 | 148 | 158 | 6 | 0.739 | (0.198) | 26.7 | 0.591 | (0.227) | 0.043 | (0.029) |
| Black Phoebe | 2 | 51 | 67 | 7 | 0.432 | (0.163) | 37.8 | 0.679 | (0.252) | 0.283 | (0.189) |
| Cassin's Vireo | 10 | 318 | 367 | 17 | 0.545 | (0.092) | 16.8 | 0.114 | (0.057) | 0.413 | (0.209) |
| Warbling Vireo | 20 | 1628 | 2401 | 204 | 0.454 | (0.026) | 5.6 | 0.315 | (0.033) | 0.317 | (0.045) |
| Mountain Chickadee | 19 | 676 | 848 | 70 | 0.378 | (0.045) | 12.0 | 0.287 | (0.058) | 0.537 | (0.124) |
| Red-breasted Nuthatch *† | 13 | 153 | 162 | 3 | 0.445 | (0.236) | 53.0 | 0.029 | (0.039) | 1.000 | (1.211) |
| Brown Creeper | 14 | 278 | 358 | 26 | 0.349 | (0.074) | 21.1 | 0.274 | (0.095) | 0.633 | (0.236) |
| House Wren | 3 | 110 | 131 | 7 | 0.324 | (0.138) | 42.4 | 0.281 | (0.190) | 0.355 | (0.261) |
| Golden-crowned Kinglet * | 10 | 306 | 360 | 10 | 0.142 | (0.088) | 61.8 | 0.332 | (0.245) | 0.165 | (0.173) |
| Swainson's Thrush | 2 | 41 | 95 | 16 | 0.461 | (0.087) | 18.9 | 0.637 | (0.155) | 0.733 | (0.474) |
| Hermit Thrush | 5 | 103 | 135 | 14 | 0.344 | (0.097) | 28.1 | 0.316 | (0.141) | 0.821 | (0.429) |
| American Robin | 20 | 795 | 1058 | 122 | 0.530 | (0.034) | 6.4 | 0.205 | (0.029) | 0.633 | (0.118) |
| Yellow Warbler | 12 | 692 | 1359 | 195 | 0.468 | (0.025) | 5.4 | 0.527 | (0.042) | 0.337 | (0.068) |
| Yellow-rumped Warbler | 18 | 1881 | 2218 | 161 | 0.387 | (0.031) | 7.9 | 0.197 | (0.028) | 0.598 | (0.095) |
| Hermit Warbler | 13 | 622 | 678 | 25 | 0.643 | (0.075) | 11.7 | 0.034 | (0.012) | 0.682 | (0.269) |
| MacGillivray's Warbler | 18 | 1560 | 3594 | 461 | 0.425 | (0.016) | 3.9 | 0.593 | (0.030) | 0.484 | (0.058) |
| Wilson's Warbler | 14 | 1465 | 2558 | 277 | 0.360 | (0.020) | 5.6 | 0.492 | (0.039) | 0.402 | (0.066) |
| Western Tanager | 18 | 537 | 592 | 35 | 0.562 | (0.067) | 11.9 | 0.088 | (0.026) | 0.468 | (0.170) |
| Green-tailed Towhee | 3 | 166 | 318 | 52 | 0.571 | (0.048) | 8.5 | 0.307 | (0.057) | 0.641 | (0.194) |
| Spotted Towhee | 6 | 162 | 247 | 32 | 0.372 | (0.059) | 15.8 | 0.554 | (0.118) | 0.332 | (0.153) |
| Chipping Sparrow | 10 | 291 | 379 | 28 | 0.397 | (0.070) | 17.7 | 0.175 | (0.059) | 0.795 | (0.293) |
| Vesper Sparrow | 2 | 39 | 56 | 11 | 0.662 | (0.097) | 14.7 | 0.238 | (0.098) | 0.388 | (0.279) |
| Fox Sparrow | 8 | 244 | 458 | 65 | 0.459 | (0.044) | 9.6 | 0.455 | (0.071) | 0.459 | (0.140) |
| Song Sparrow | 15 | 1160 | 2505 | 352 | 0.443 | (0.019) | 4.2 | 0.557 | (0.033) | 0.522 | (0.068) |
| Lincoln's Sparrow | 13 | 1102 | 2635 | 353 | 0.416 | (0.018) | 4.4 | 0.615 | (0.035) | 0.570 | (0.076) |
| White-crowned Sparrow | 3 | 181 | 343 | 67 | 0.443 | (0.042) | 9.6 | 0.578 | (0.075) | 0.770 | (0.190) |

Table 4, continued

| Species | No. stations[2] | No. birds[3] | No. Captures[4] | No. returns[5] | Survival probability[6] | | Survival C.V.[7] | Recapture probability[8] | | Proportion of residents[9] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dark-eyed Junco | 20 | 2596 | 4648 | 638 | 0.427 | (0.014) | 3.3 | 0.474 | (0.024) | 0.510 | (0.048) |
| Black-headed Grosbeak | 8 | 504 | 694 | 85 | 0.509 | (0.039) | 7.7 | 0.223 | (0.037) | 0.725 | (0.156) |
| Lazuli Bunting | 2 | 346 | 421 | 25 | 0.558 | (0.072) | 12.8 | 0.092 | (0.030) | 0.272 | (0.146) |
| Red-winged Blackbird † | 4 | 53 | 63 | 5 | 0.476 | (0.187) | 39.4 | 0.124 | (0.110) | 1.000 | (0.864) |
| Brown-headed Cowbird † | 12 | 69 | 102 | 17 | 0.391 | (0.094) | 24.1 | 0.482 | (0.162) | 1.000 | (0.431) |
| Pine Grosbeak * | 3 | 57 | 63 | 3 | 0.315 | (0.214) | 68.0 | 0.183 | (0.203) | 0.463 | (0.553) |
| Purple Finch | 9 | 637 | 703 | 30 | 0.423 | (0.073) | 17.3 | 0.107 | (0.035) | 0.316 | (0.142) |
| Cassin's Finch *† | 8 | 320 | 330 | 4 | 0.700 | (0.174) | 24.8 | 0.006 | (0.006) | 1.000 | (0.995) |

[1] Only data from stations that ran at least four contiguous years, in which the effort for the years was considered usable for survivorship, between 1992 and 2005, are included.

[2] Number of stations where the species was a regular or usual breeder and at which adults of the species were captured. Stations within 1km of each other were combined into a single 'super-station' to prevent individuals whose home ranges included portions of two or more stations from being counted as multiple individuals.

[3] Number of adult individuals captured at stations where the species was a regular or usual breeder (i.e., number of capture histories).

[4] Total number of captures of adult birds of the species at stations where the species was a regular or usual breeder.

[5] Total number of returns. A return is the first recapture in a given year of a bird originally banded at the same station in a previous year.

[6] Survival probability ($\varphi$) presented as the maximum likelihood estimate (standard error of the estimate).

[7] The coefficient of variation for survival probability, CV($\varphi$).

[8] Recapture probability (p) presented as the maximum likelihood estimate (standard error of the estimate).

[9] The proportion of residents among newly captured adults ($\tau$) presented as the maximum likelihood estimate (standard error of the estimate).

* The estimate for survival probability should be viewed with caution because it is based on fewer than five between-year recaptures or the estimate is very imprecise (SE($\varphi$)≥0.200 or CV($\varphi$)≥50.0%)

† The estimate for survival probability, recapture probability, or both may be biased low because the estimate for $\tau$ was 1.00.

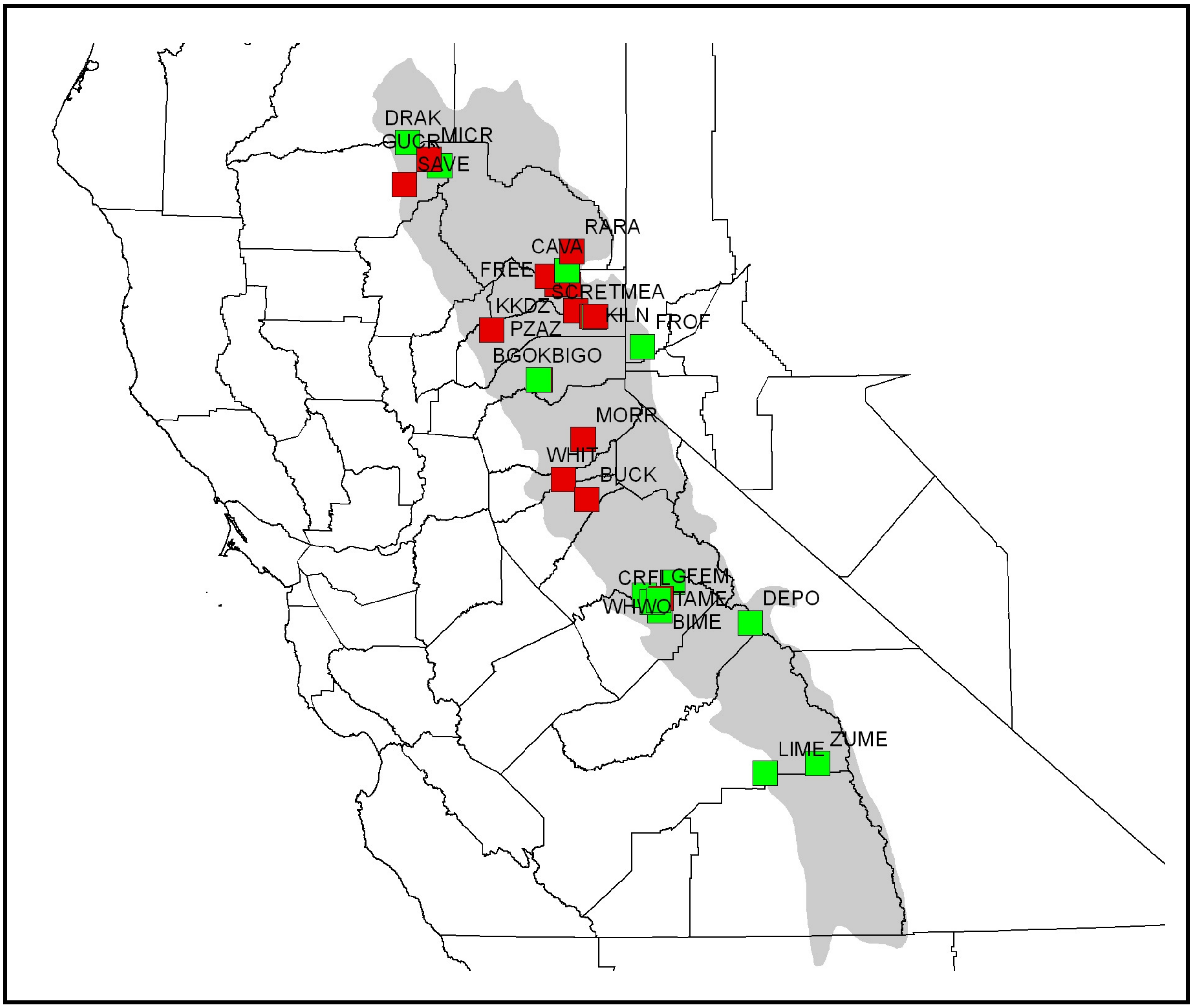


Figure 1. Locations of all MAPS station operated in the Sierra Nevada between 1992 and 2005. Green squares indicate stations that were still active and submitted data in 2005; red squares indicate stations that were discontinued and/or stopped submitting data prior to 2005. Four-letter station codes (Table 1) are provided next to the corresponding squares. Gray shading indicates the North American Bird Conservation Initiative (NABCI) Sierra Nevada Bird Conservation Region.

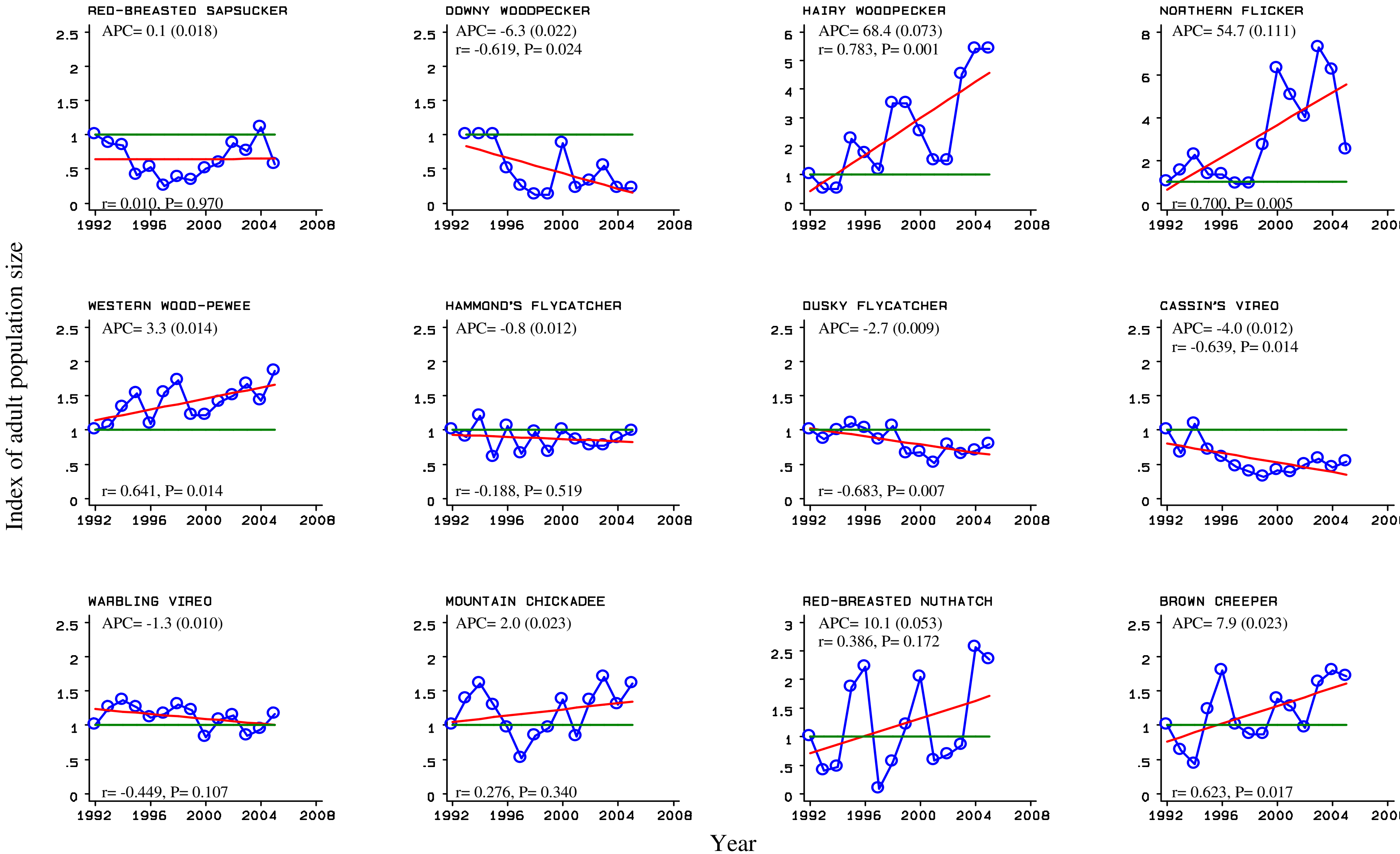


Figure 2. Population trends for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The index of population size was arbitrarily defined as 1.0 in 1992. Indices for subsequent years were determined from constant-effort between-year changes in the number of adult birds captured from stations where the species was a regular or usual breeder and summer resident. The annual percentage change in the index of adult population size was used as the measure of the population trend (*APC*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

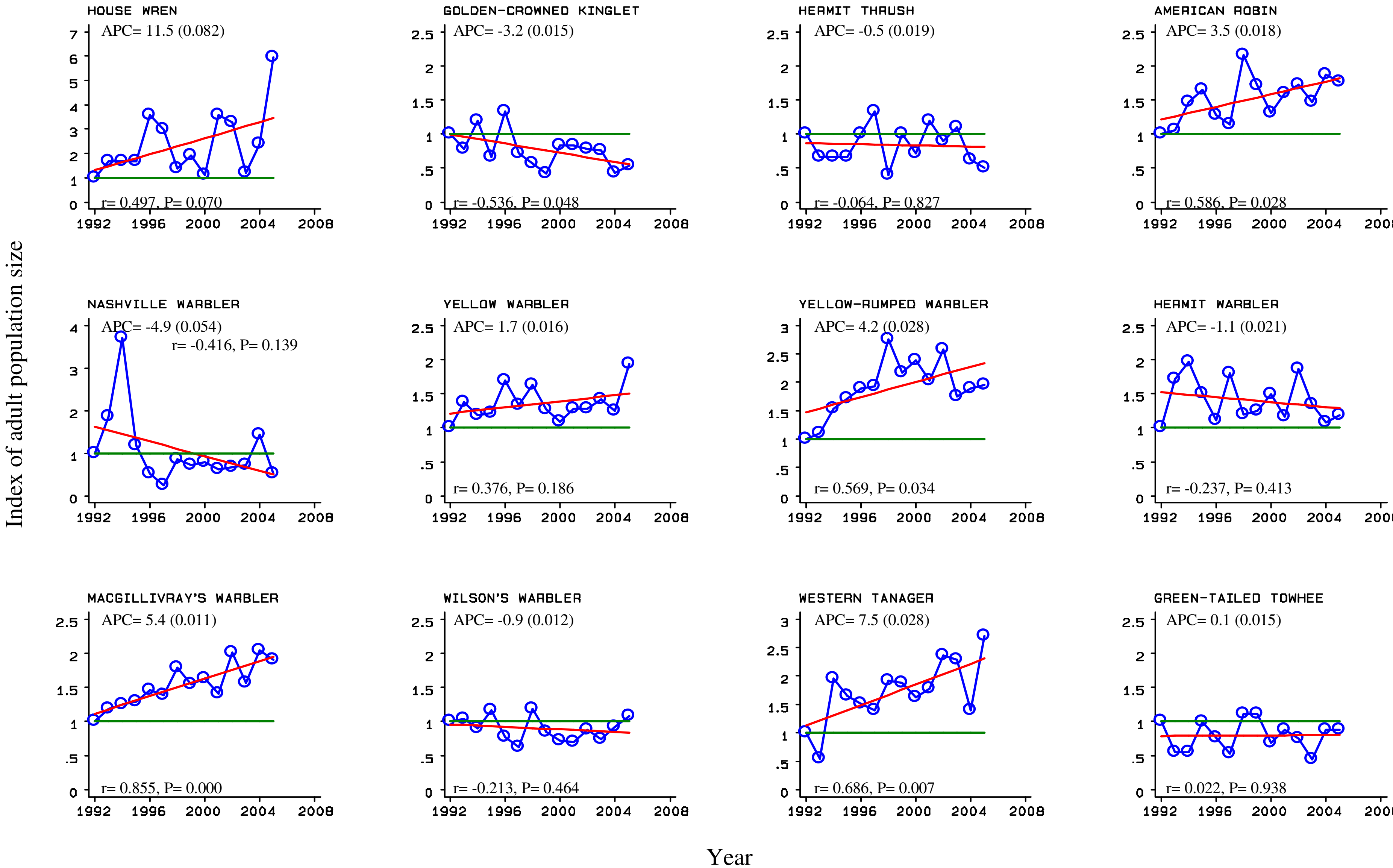


Figure 2. (cont.) Population trends for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The index of population size was arbitrarily defined as 1.0 in 1992. Indices for subsequent years were determined from constant-effort between-year changes in the number of adult birds captured from stations where the species was a regular or usual breeder and summer resident. The annual percentage change in the index of adult population size was used as the measure of the population trend (*APC*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

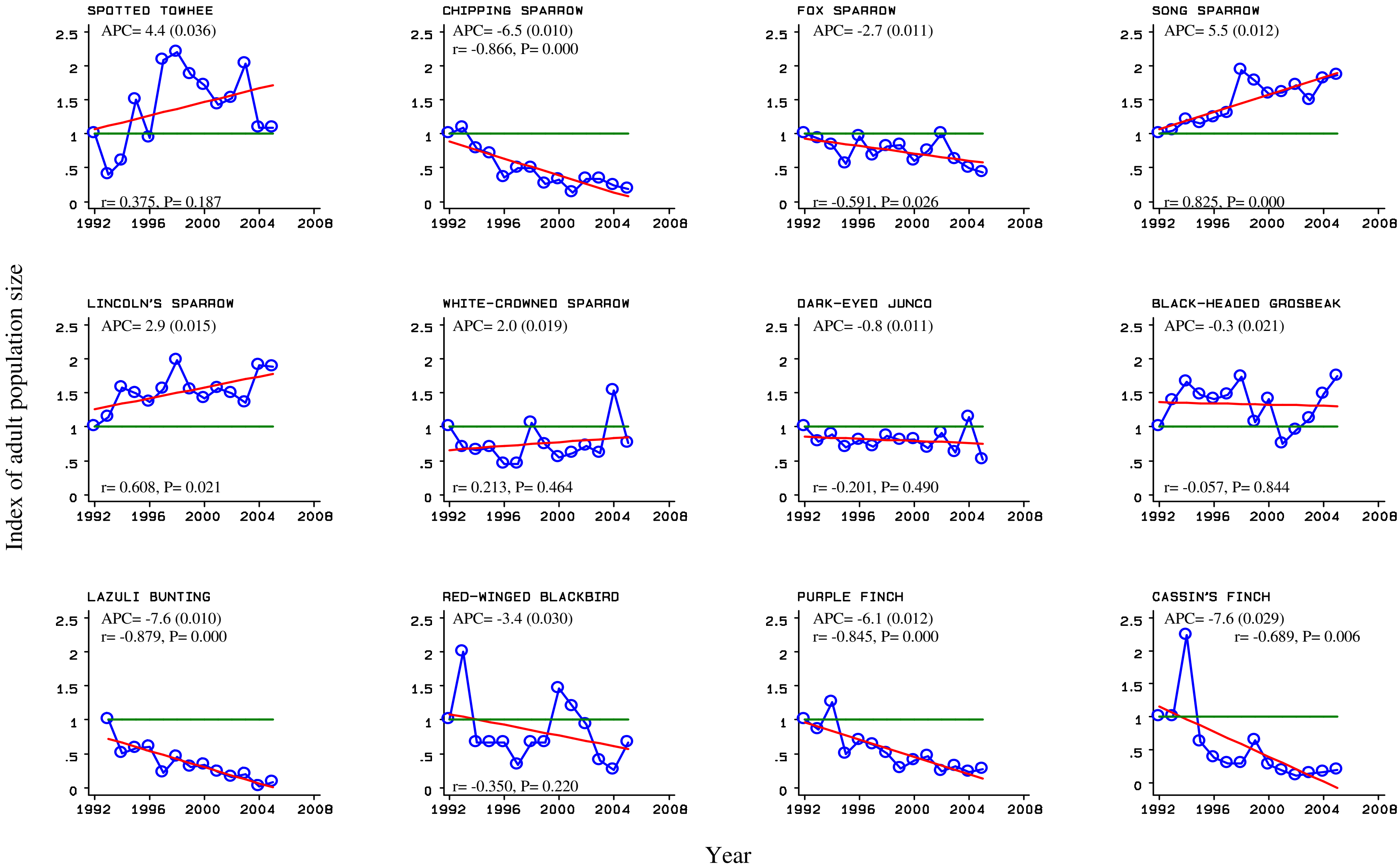


Figure 2. (cont.) Population trends for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The index of population size was arbitrarily defined as 1.0 in 1992. Indices for subsequent years were determined from constant-effort between-year changes in the number of adult birds captured from stations where the species was a regular or usual breeder and summer resident. The annual percentage change in the index of adult population size was used as the measure of the population trend (*APC*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

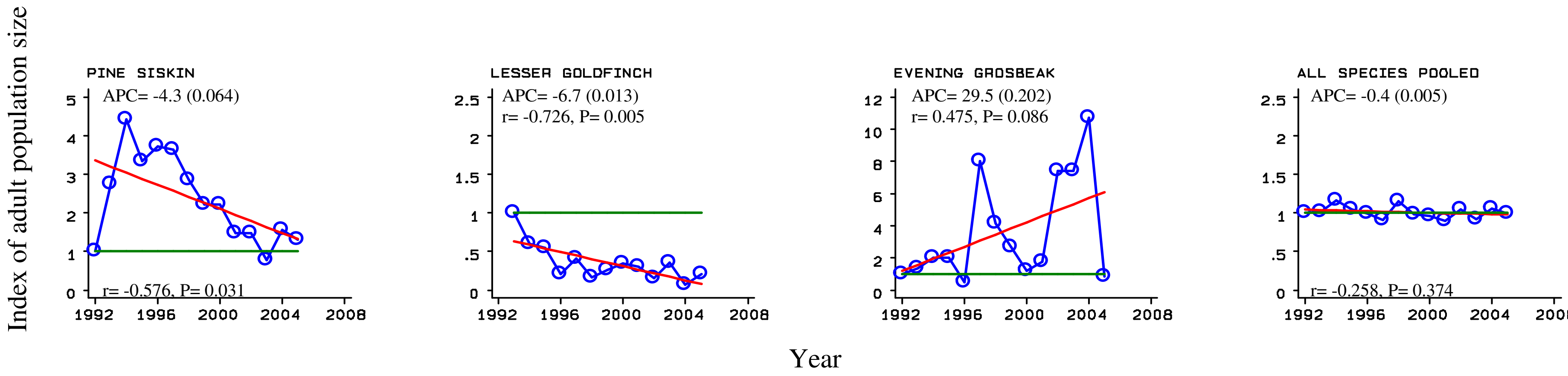


Figure 2. (cont.) Population trends for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The index of population size was arbitrarily defined as 1.0 in 1992. Indices for subsequent years were determined from constant-effort between-year changes in the number of adult birds captured from stations where the species was a regular or usual breeder and summer resident. The annual percentage change in the index of adult population size was used as the measure of the population trend (*APC*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

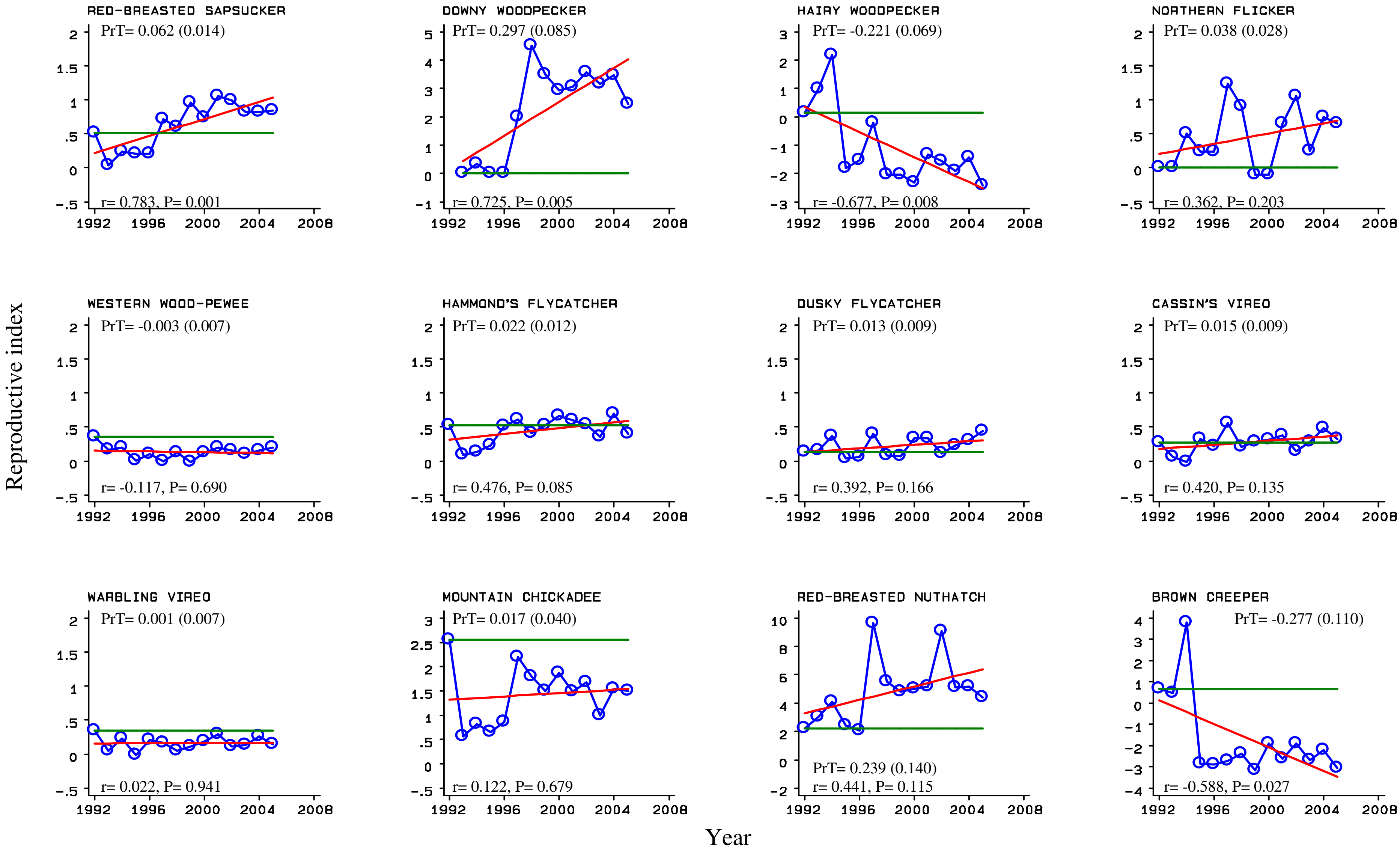


Figure 3. Trend in productivity for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The productivity index was defined as the actual productivity value in 1992. Indices for subsequent years were determined from constant-effort between-year changes in proportion of young in the catch from stations where the species was a regular or usual breeder and summer resident. The slope of the regression line for annual change in the index of productivity was used as the measure of the productivity trend (*PrT*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

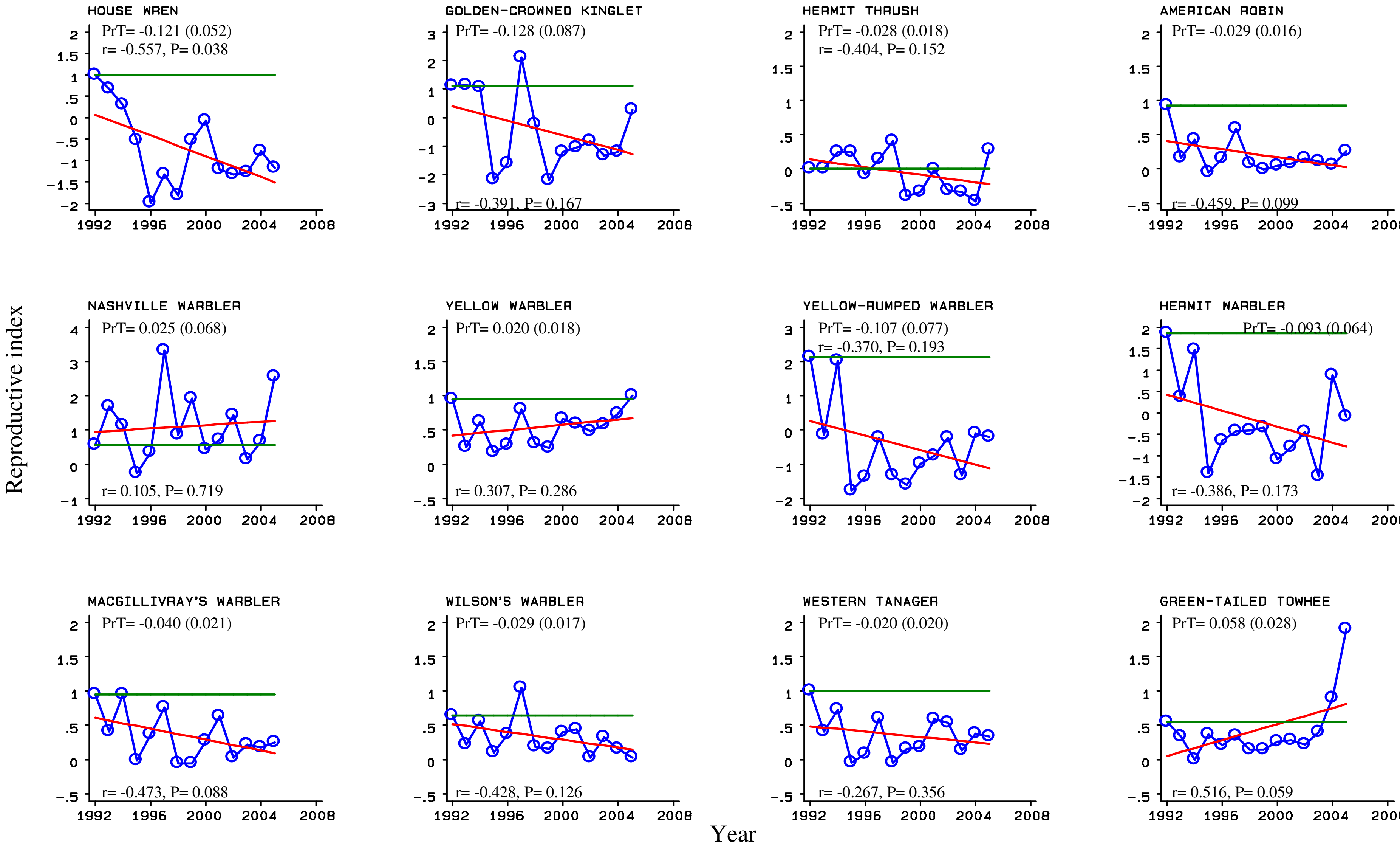


Figure 3. (cont.) Trend in productivity for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The productivity index was defined as the actual productivity value in 1992. Indices for subsequent years were determined from constant-effort between-year changes in proportion of young in the catch from stations where the species was a regular or usual breeder and summer resident. The slope of the regression line for annual change in the index of productivity was used as the measure of the productivity trend (*PrT*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

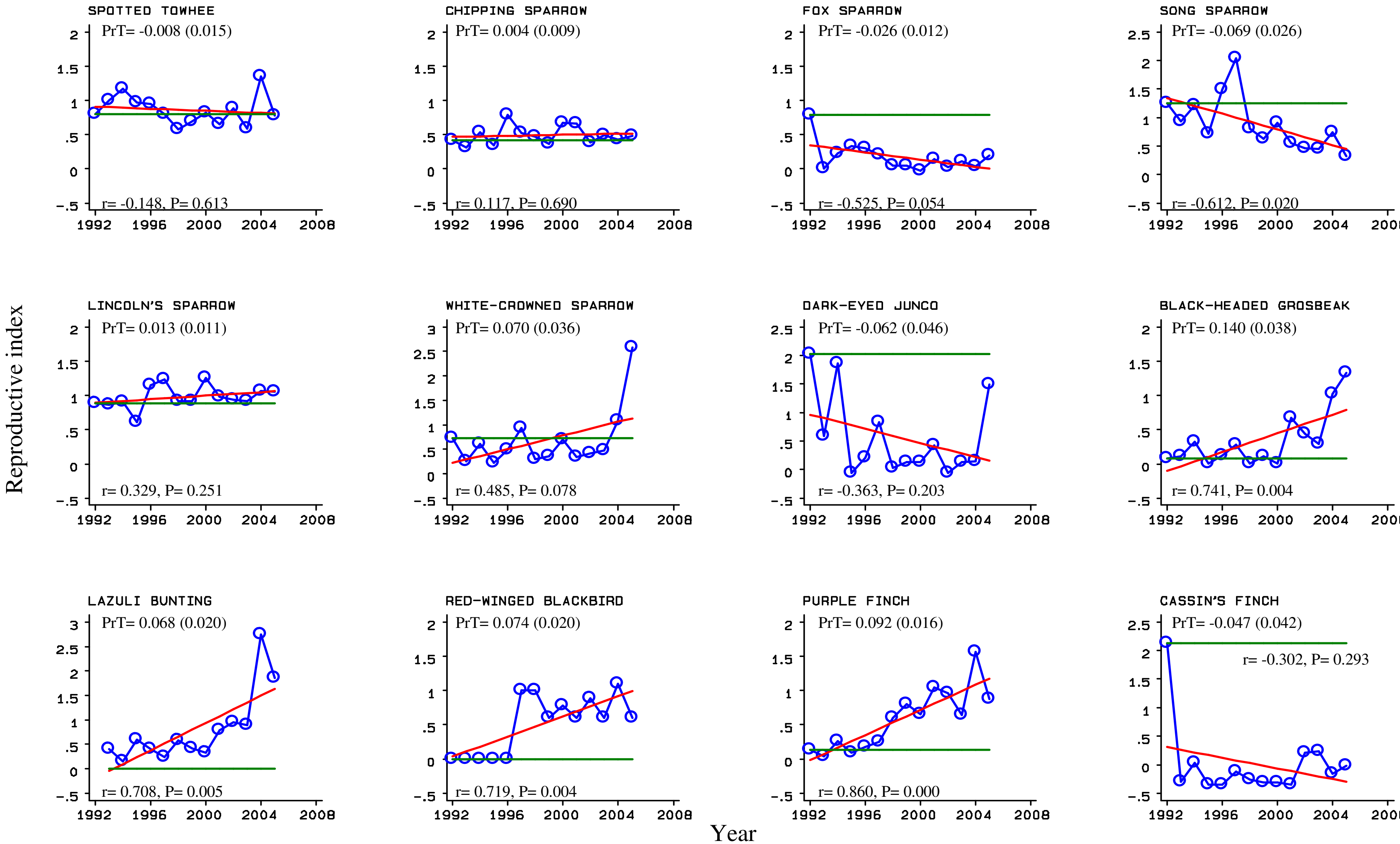


Figure 3. (cont.) Trend in productivity for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The productivity index was defined as the actual productivity value in 1992. Indices for subsequent years were determined from constant-effort between-year changes in proportion of young in the catch from stations where the species was a regular or usual breeder and summer resident. The slope of the regression line for annual change in the index of productivity was used as the measure of the productivity trend (*PrT*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

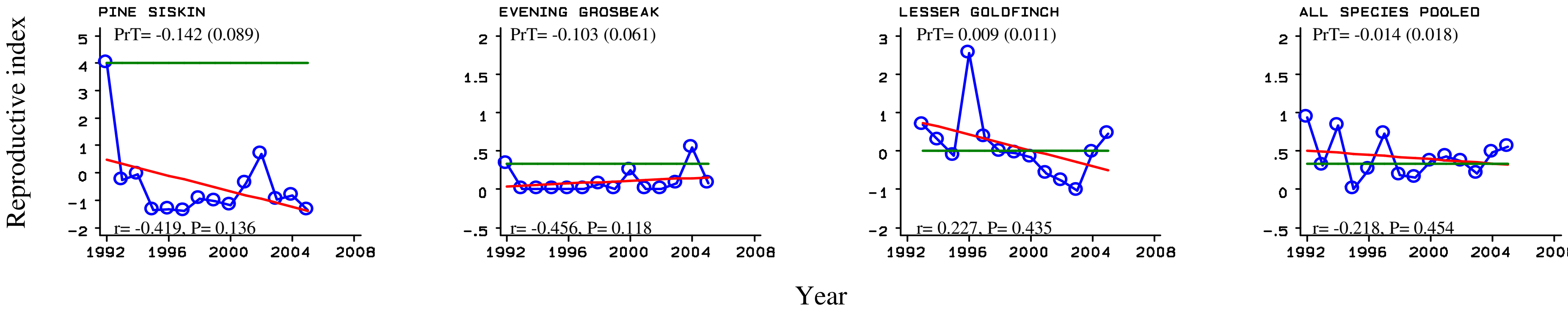


Figure 3. (cont.) Trend in productivity for 39 species and all species pooled in the Sierra Nevada Bird Conservation Region over the 14 years 1992-2005. The productivity index was defined as the actual productivity value in 1992. Indices for subsequent years were determined from constant-effort between-year changes in proportion of young in the catch from stations where the species was a regular or usual breeder and summer resident. The slope of the regression line for annual change in the index of productivity was used as the measure of the productivity trend (*PrT*), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.