Long-term demographics of Yosemite's songbirds: An analysis of data from the Monitoring Avian Productivity and Survivorship (MAPS) program in Yosemite National Park

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Above: Two target species (Nashville Warbler and Willow Flycatcher) of the MAPS program in Yosemite National Park that have experienced significant declines

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Summary

Landbirds are excellent indicators of environmental change in terrestrial ecosystems, because of their high body temperature, rapid metabolism, and high ecological position on most food webs. Application of standardized constant-effort mist netting and modern capture-recapture analytical techniques can provide information on population trends and demographic rates of many landbird species at a variety of spatial and temporal scales. In North America, constant-effort mist-netting stations operated during the breeding season typically follow protocols established by the Monitoring Avian Productivity and Survivorship (MAPS) program. MAPS stations were established in Yosemite National Park in 1990, and the park now hosts some of the longest-running MAPS stations in the country. Here we report monitoring results from the MAPS program in Yosemite, which has amassed the most extensive multi-species, demographic data set ever collected for Sierra Nevada birds. We analyzed Yosemite MAPS data through 2010, including >39,000 captures of 106 species, to assess community level changes through time in species composition at stations, estimate population trends, survival, and productivity of frequently captured target species, and identify possible environmental drivers of changes in bird community composition or species-specific demographic rates.

We used reverse-symmetry capture-recapture models to estimate time-constant population growth rate (λ) with reasonable precision for 38 species. Numbers of increasing and decreasing species were similar: 21 increasing species and 17 declining species. Six species (White-headed Woodpecker, Steller's Jay, Mountain Chickadee, American Robin, MacGillivray's Warbler, and Spotted Towhee) increased significantly and 6 species (Willow Flycatcher, Warbling Vireo, Nashville Warbler, Yellow Warbler, Dark-eyed Junco, and Brown-headed Cowbird) decreased significantly. We estimated time-constant adult apparent survival rate for the same 38 species for which we estimated population trend. Adult apparent survival rates ranged from a low of 0.237 for Golden-crowned Kinglet to a high of 0.876 for White-headed Woodpecker.

We used logit-linear models to model productivity as functions of year, mean May snow water content at Gin Flat East Meadow (used as an index for annual snow conditions at all the stations), and station. Twenty-five of 33 species with adequate data for productivity analyses showed evidence of an effect of May snow water content on productivity, with 23 of the 25 showing a negative relationship; productivity was higher in years that snow melted earlier.

Nonmetric multi-dimensional scaling (NMDS) ordinations on a year × species matrix for each station suggested that community composition has shifted at each of five MAPS stations over the course of the study. At Big Meadow, where the surrounding forest burned in a stand-replacing fire in 1990, community changes reflected a shift towards chaparral-associated species. At the other stations, where no such large-scale perturbations occurred during the study, communities also shifted substantially, changes that may attributable in part to climate change.

Implications of our results for management of park birds and habitats include:

1. Early post-fire habitats are valuable to numerous species of birds in the park. This is contrary to much public perception, wherein stand-replacing wildfire is viewed as “catastrophic”. Interpretive efforts conveying to visitors the value of wildfire to numerous

bird species could help bring public perception in line with current ecological understanding. Additionally, much remains unknown about avian response to wildfire in the Sierra Nevada; continued and enhanced research and monitoring efforts on birds' responses to fire in the park are warranted.

2. Several bird species that nest in montane meadows appear to be faring poorly in the park. The recent loss from the park of Willow Flycatcher as a breeding species (Siegel et al. 2008) may have been a harbinger of problems for other meadow-associated species, including Yellow Warbler. Efforts to restore, enhance, and sustain meadow habitats and their function – in particular efforts targeting restoration of meadow hydrology – may be among the most valuable things the park could do to protect vulnerable bird populations. Such efforts may become even more important if climate change leads to changes in the pattern and timing of spring runoff, and/or drier summer conditions in the future.

3. It is often assumed that the effects of climate change will be primarily or largely negative for wildlife, but early spring snowmelt in Yosemite may result in higher productivity for many bird species that nest in the montane zone. However, other effects of climate change, such as earlier summer drying of meadows, may be detrimental to some of the same bird species. Further study of the effects of annual weather variation and climate change on Sierra birds is warranted.

Introduction

Landbirds are excellent indicators of environmental change in terrestrial ecosystems, because of their high body temperature, rapid metabolism, and high ecological position on most food webs. Their abundance and diversity in virtually all terrestrial habitats, diurnal nature, discrete reproductive seasonality, and intermediate longevity facilitate the monitoring of their population and demographic parameters. An added benefit is that landbird monitoring is often particularly efficient, in the sense that many species can be monitored simultaneously with the same survey protocol, and costs are relatively low. Finally, landbirds hold high and growing public interest (Cordell et al. 1999; Cordell and Herbert 2002) and are perhaps the most visible faunal component of park ecosystems.

Application of standardized constant-effort mist netting and modern capture-recapture analytical techniques can provide information on population trends and demographic rates of many landbird species at a variety of spatial and temporal scales (DeSante et al. 2004, Robinson et al. 2009). In North America, constant-effort mist-netting stations operated during the breeding season typically follow protocols established by the Monitoring Avian Productivity and Survivorship (MAPS) program (DeSante and Kaschube 2009). Collaborators have contributed data from > 1000 stations to the program since its establishment in 1989. A core component of the MAPS program has been the long-term operation of stations in large protected areas, such as national parks, which can fulfill vital roles for birds, both as refuges for species dependent on late successional forest conditions, and as reference sites for assessing the effects of land use and land cover changes on populations (Silsbee and Peterson 1991). MAPS stations in national parks and other protected areas can provide insights into how land management practices on these areas may be affecting birds, as well as into the extent to which broad-scale factors (e.g., climate change) or factors operating outside of breeding areas (e.g., on overwintering areas of migratory species) may be driving population dynamics. Avian population monitoring in parks can be especially important because parks are among the few sites in the United States where population trends resulting from large-scale regional and global climate change patterns are less confounded by local changes in land-use practices (Simons et al. 1999, Siegel et al. 2011).

The MAPS program was established in Yosemite National Park in 1990, and Yosemite now hosts some of the longest-running MAPS stations in the country. Here we report monitoring results from the MAPS program in Yosemite, which has amassed the most extensive multi-species, demographic data set ever collected for Sierra Nevada birds. The purpose of this report is to analyze Yosemite MAPS data through 2010 to:

- estimate population trends, survival, and productivity of frequently captured target species,
- assess community level changes through time in species composition at stations, and
- identify possible environmental drivers of changes in bird community composition or species-specific demographic rates.

Methods

Study Areas and Field Methods

We established and operated five mist-netting stations in Yosemite National park between 1990 and 2010 spanning an elevation gradient of approximately 1100 m (Fig. 1). The lowest station, Big Meadow, was established in 1993 at 1311 m elevation in open dry meadow, riparian willow (*Salix* spp.), and mixed coniferous forest. The Hodgdon Meadow station was established in 1990 at 1408 m elevation, in, and near the edge of, wet montane meadow habitat including willow and dogwood (*Cornus* spp.) thickets and surrounded by mixed coniferous forest and California black oak (*Quercus kelloggii*) woodland. The Crane Flat station was established in 1993 at 1875 m elevation in a wet montane meadow with willow/aspen thickets and mixed coniferous forest. The Gin Flat East Meadow station was established in 1998 at 2073 m elevation. The White Wolf station was established in 1993 at 2402 m elevation in wet montane meadow and red fir (*Abies magnifica*)-lodgepole pine (*Pinus contorta*) forest habitats. Each mist-netting station consisted of a sampling area of about 20 ha.

Mist-netting operations at each station followed protocols established by the Monitoring Avian Productivity and Survivorship (MAPS) program (DeSante et al. 2004, DeSante and Kaschube 2009). Within the central 8 ha of each station, 10 or 14 (Hodgdon Meadow only) nets 12-m × 2.5-m, 30-mm mesh, 4-tier nylon mist nets were erected at fixed net sites, opened for approximately six morning hours (beginning at approximately local sunrise), and checked at approximately 30-60 min intervals on each day of station operation. Beginning in 1993, nets at each station were operated on a single day within each of 5-8 10-day periods between 21 May and 8 August (MAPS periods 3-10). At Hodgdon Meadow, seven of the 14 net sites were operated on one day with the remaining seven net sites operated on a second day. The maximum number of periods of operation at the highest station, White Wolf, was 7 due to later arrival of spring-like conditions. In addition, early periods were missed at the higher elevation stations (Crane Flat, Gin Flat East Meadow, and White Wolf) in years of heavy snowpack due to logistical difficulties of accessing sites and operating ground-level mist-nets with lingering snow, and later flooding. Occasionally nets were closed due to inclement weather, especially high capture rates, or for other logistical reasons. A complete summary of effort is provided in Appendix 1.

With few exceptions, all birds captured in mist nets were identified to species, age (young = 'hatching year'; adult = 'after hatching year'), and sex (based on Pyle 2007) and banded with United States Geological Survey - Biological Resources Division numbered aluminum leg bands if not already so marked. Band numbers of all recaptures were carefully recorded. We also collected ancillary data on skull pneumaticization, breeding condition, molt, fat, wing length, and subcutaneous fat deposition. All banding data were subjected to a rigorous verification process prior to analyses to ensure the validity and consistency of all band numbers and species, age, and sex determinations.

In addition to banding operations, we recorded observations on the breeding (i.e., summer residency) status (confirmed breeder, likely breeder, non-breeder) of each species seen, heard, or captured on each day of station operation using techniques similar to those employed in breeding bird atlas projects. We used these observations to classify each bird species captured in mist nets at each station into six groups: 1) *regular breeder* 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; 2) *usual breeder* if we had positive evidence of breeding or summer residency within the boundaries of the MAPS station during more than half (but not all) years that the station was operated; 3) *occasional breeder* if we had positive evidence of breeding or summer residency within the boundaries of the MAPS station in at least one year but fewer than half of the years the station was operated; 4) *transient* for species for which the station was within the known breeding range but that were never identified as a breeder or summer resident at the station; 5) *altitudinal disperser* if the species breeds only at lower elevations than that of the station but that disperse to higher elevations after breeding; 6) *migrant* if the station was not located within the overall breeding range of the species. The complete year-specific and cumulative breeding status list is presented as supplementary material in the file 'SYOSEN.dbf'.

Statistical Analyses

Population trend

We estimated population trend based on reverse-symmetry capture-recapture models (Pradel 1996) based on data from the four stations that operated for the entire 1993-2010 time period (i.e., all stations except GFEM). We aggregated data across all stations (i.e., assumed no spatial variation in population parameters or recapture probability among stations; changes in captures at station-scale explored as part of community ordinations [see methods, below]). We used the 'ϕ and λ' parameterization of this model in program MARK (White and Burnham 1999) and constrained both ϕ and λ to be time-constant (i.e., intercept-only models). For recapture probability, p, we considered both time-constant and year-specific models, although for most species data were insufficient to support year-specific p models. We report trend estimates as time-constant $\hat{\lambda}$'s model-averaged over the two p parameterizations; model weights were based on Aikaike's Information Criterion adjusted for small samples (AIC_c; Burnham and Anderson 2002). We do not report estimates of ϕ from these models here, as these estimates are biased low due to transient individuals (e.g., passage migrants, dispersing birds, and ‘floaters’ [sensu Brown 1969]) present in populations; see *Methods: Statistical analyses: Adult apparent survival rate*). Nevertheless, we assume that our trend estimates will still be unbiased as long as the negative bias in survival estimates is balanced by overestimation (positive bias) in the recruitment component of λ. We attempted to run models for all species classified as breeders, usual breeders, or occasional breeders (breeding status categories 1-3 defined in *Methods: Study areas and field methods*) at ≥ 1 station, and included only data from stations where a particular species was classified into one of the three breeding categories. Models were run in program MARK (White and Burnham 1999) using the R (R Development Core Team 2011) package RMark (Laake 2011).

Adult apparent survival rate

As in the population trend analysis, we estimated time-constant adult apparent survival rates, ϕ, using data from the four MAPS stations that operated from 1993-2010. For species with < 5 between-year recaptures or for which we never recorded a within-season recapture > 6 days from the date of initial capture (i.e., the date of banding), we report the survival-rate estimate obtained from the reverse-symmetry models described above. For all other species, we report estimates from modified Cormack-Jolly-Seber (CJS) models that account for transients in the population (Pradel et al. 1997, Hines et al. 2003). We used within-season capture histories from initial capture years (i.e., the year of banding) to designate individuals as members of one of two groups: 1) residents (birds captured more than once > 6 days apart) or 2) birds of unknown residency status (caught only once or caught more than once < 6 days apart). For the unknown group, we included an indicator variable in survival models to estimate first-year survival separately from subsequent intervals. This first-year survival rate estimate for the unknown group represents a mixture of the survival rate for resident birds, and the survival rate for non-residents, which is, by definition, zero. Survival rate estimates for the unknown group in subsequent intervals are assumed equal to the survival rate estimates for the resident group (i.e., those that make the transition are the residents of the unknown residency status group). We included this residency indicator in all models for species with sufficient data due to its strong support in previous survival analyses of MAPS data and to increase precision of resident adult survival estimates (Hines et al. 2003, DeSante and Kaschube 2009). As above, we considered parameterizations for capture probability (p) that varied by year and that were constrained to be constant across all years and present estimates as model-averaged values across the two models. As in the reverse-symmetry models, transient CJS models were run in program MARK via R using the RMark package.

Productivity

We assessed productivity for 33 bird species at the four stations that operated during the complete 1993-2010 period. We only considered species with > 50 captures (i.e., mean of ≥ 3 captures/year) and for which at least one individual was detected in each year of the study. We examined annual variation and temporal trend in productivity as well as a hypothesized relationship between productivity and May snow water content (swc). Spring snow pack varies greatly by year in Yosemite, and previous studies have suggested its importance in affecting bird behavior, productivity, and population dynamics (DeSante 1990, Siegel et al. 2007, Pereyra in press, Mathewson et al. in revision). We indexed spring snow pack in the park by averaging daily snow water content (swc) values collected during the month of May at the Gin Flat weather station (http://www.nps.gov/yose/naturescience/hydrology-data.htm). This value was highly variable among years (Fig. 2) and was judged *a priori* to be likely to affect breeding effort and reproductive success of birds in the park. Because the five MAPS stations are arrayed along a relatively broad elevational gradient, spanning from the lower montane zone to the Lodgepole Pine zone, snow conditions vary greatly across the stations at any given time. Nevertheless, since all stations are within relatively close geographic proximity to one another, we believe the Gin Flat weather data provides an appropriate index of conditions at the other stations – May swc at Gin Flat should be strongly correlated with May swc at the other stations on an annual basis, even if swc is consistently much lower at the lower-elevation stations, and much greater at the one substantially higher-elevation station.

We modeled productivity using Bernoulli models of the form:

$$Y_{ijt} \sim \mathrm{Bern}\,(p_{ijt}),$$

where p_{ijt} is our productivity index parameter, which represents the probability of a bird captured at station *i* on the *j*th day of the year in year *t* being a young (hatching year) bird, Y_{ijt}.

We used logit-linear models (glm function in R; R Development Core Team 2011) to model p_{ijt} as functions of year, snow water content (swc), and station (sta). For year effects, we considered models that hypothesized a logit-linear trend in productivity (denoted as T), as well as models that included year as a factor variable (denoted as t). We included linear and quadratic terms for day of year (doy and doy^2) in models to account for within-season variation in the timing of captures of young and adult birds. Continuous covariates were standardized to mean zero and unit variance to facilitate estimation and interpretation. We considered 20 candidate models, 10 of which assumed the logit-linear relationship between p_{ijt} and doy and the remaining 10 that assumed a quadratic (doy + doy^2) formulation for within-season variation in p_{ijt}. Our most general models (only well-supported for species with very large sample size) included sta + t factor variables in addition to the within-season doy covariates (full interaction models over-parameterized so not considered). The remaining eight parameterizations for station, year, and swc effects included: (1) t, (2) T, (3) swc, (4) sta, (5) sta + T, (6) sta + swc, (7) sta + T + sta:T, and (8) sta + swc + sta:swc.

We assessed support for candidate models using AIC$_c$ and AIC$_c$ model weights (Burnham and Anderson 2002). We present model-averaged estimates of regression coefficients for the trend (T) effects and for the swc effects based on the w_i from the complete candidate model set. We present model-averaged estimates of regression coefficients for the trend (T) effects and for the swc effects based on the w_i from the complete candidate model set. To provide an overview of temporal patterns in productivity for all species across stations, we present the productivity index as back-transformed model-averaged predictions from the logit-linear models that did not include station effects at mean values of doy during MAPS period 8 (July 10-19), which we denote as $\hat{p}_{.j=\bar{j}(\texttt{per8})t}$. We chose period 8 for predictions because captures of both age classes are common at that time. We approximated 95% confidence intervals for predictions with back-transformed estimates of model coefficients and standard errors on logit scale, assuming asymptotic normality. Although this productivity index ignores issues of detectability, it will accurately reflect temporal patterns and relationships with covariates as long as detectability differences between young and adult birds are consistent across years and values of covariates. Model comparisons and model-averaging of regression coefficient estimates and productivity index values for individual years and stations were performed using functions in the AICcmodavg package (Mazerolle 2011) in R (R Development Core Team 2011).

Community ordinations

To examine temporal variation in bird community composition, we conducted nonmetric multi-dimensional scaling (NMDS) ordinations on a year × species matrices for each station (Minchin 1987). Our response variable was the number of year-unique captures of adult birds × 100 net-hours^{-1} for species identified as breeding species in ≥ 1 year. We used Bray-Curtis distances as our dissimilarity measure (Bray and Curtis 1957). Capture rates were Wisconsin double standardized to improve the quality of ordinations for all stations except Gin Flat East Meadow.

We ran ordination analyses in R (R Core Development Team 2011) using the metaMDS function in the R package, vegan (Oksanen et al. 2011). This function automates finding of the best two-dimension NMDS solution by initializing analyses from up to 20 random starting points until convergent solutions are found. Here, convergent solutions were found for adults for Big Meadow, Gin Flat East Meadow, and White Wolf within 2-16 tries. For Hodgdon Meadow and Crane Flat convergent solutions were not found within 20 tries, and for those stations we report the solution with minimum stress. Solutions were rotated so that the largest variance of station-time scores was along the first NMDS axis and scaled such that one unit corresponded to halving of community similarity from replicate similarity. We present results as biplots of station-year and species scores along the two NMDS ordination axes. Species scores are weighted averages of site scores and were expanded such that species and station-time scores had equal variances. Relative positions of stations and species in ordination space provide a general view of variation in breeding bird community composition at the five mist-netting stations among years.

To examine trend in community composition, we used the envfit function in vegan to fit a year vector to the ordinations. The year vector can be defined as the direction of which the gradient of directional change in community composition between the beginning and end of the time series is strongest. We also fit a vector to ordinations that reflected an important aspect of annual climactic variation, spring snowpack. As for the productivity analyses described above (see *Methods: Statistical analyses: productivity)*, we indexed spring snow pack in the park by averaging daily snow water content (swc) values collected during the month of May at the Gin Flat weather station. We ran correlation analyses between adult capture rates and year to explore population trends for each species at the station scale. For species with significant ($\alpha = 0.10$) correlations, we scaled the size of species symbols on ordinations according to the magnitude of correlation coefficients and colored symbols according to the direction of the correlation (red = negative; blue = positive) to provide additional insight into shifts in populations and community composition over the study period.

Results

We recorded 39,234 captures of 106 species at the five Yosemite MAPS stations between 1993 and 2010. Of these, 28,032 records were captures of newly banded birds, 7,409 were recaptures (including within- and between-season recaptures), and 3,793 were birds captured and released unbanded. Of the unbanded birds, 1,548 (41% of the total unbanded) were hummingbirds and game birds, which are not typically banded as part of the MAPS protocol.

The most commonly captured species overall was Orange-crowned Warbler (4,539 year-specific captures of individuals), which is not a regular breeder at any of the stations but is a common altitudinal migrant. Other species with > 1,000 year-specific captures of individuals included Dark-eyed Junco (3,644 captures); Yellow-rumped Warbler (2,456 captures); MacGillivray's Warbler (1,854 captures), Lincoln's Sparrow (1,758 captures), Nashville Warbler (1,382 captures), Hermit Warbler (1,205 captures), Song Sparrow (1,127 captures), and Warbling Vireo (1,015 captures). Latin names and 4-letter codes of all bird species captured during this study are provided in Appendix 2.

The overall capture rate (summed across species) peaked at the middle-elevation station, Crane Flat (131.87 year-specific birds × 100 net-hours^{-1}), was intermediate at Gin Flat East Meadow (104.22 year-specific birds × 100 net-hours^{-1}) and Hodgdon Meadow (101.57 year-specific birds × 100 net-hours^{-1}), and was lowest at the lowest-elevation (Big Meadow at 67.15 year-specific birds × 100 net-hours^{-1}) and highest-elevation (White Wolf at 57.65 year-specific birds × 100 net-hours^{-1}) elevation stations. The number of species captured across years (observed species richness) was inversely related to elevation. The largest number of species banded was 75 at Big Meadow, followed by 64 at Hodgdon Meadow, 54 at Crane Flat, 53 at Gin Flat East Meadow, and 47 at White Wolf.

There was considerable variation in species composition among stations (see Appendix 2 for a complete summary of numbers of year-specific captures and capture rates for each species-station combination). Big Meadow had the largest number of unique species banded with 17. Among these were species associated with aquatic habitats, such as Belted Kingfisher and American Dipper; oak-woodland specialists, such as Acorn Woodpecker, Nuttall's Woodpecker, Oak Titmouse, and Ash-throated Flycatcher; species characteristic of dense brushy areas such as Wrentit, Western Scrub-Jay, Sage Sparrow, California Towhee and American Goldfinch; open habitats, such as Tree Swallow, Northern Rough-winged Swallow, Western Kingbird, and Savannah Sparrow; as well as disturbed-habitat generalists, such as European Starling and House Sparrow. Hodgdon Meadow had six unique banded species: Swainson's Thrush, American Redstart, Common Yellowthroat, Hooded Warbler, Rose-breasted Grosbeak, and Red-winged Blackbird. White Wolf had three unique banded species: Black-backed Woodpecker, Ruby-crowned Kinglet, and Pine Grosbeak. Gin Flat East Meadow had just one unique banded species, Sharp-shinned Hawk, while Crane Flat had no unique banded species.

Population Trend

We were able to estimate time-constant λ for the four MAPS stations with complete 1993-2010 effort (all except Gin Flat East Meadow) with reasonable precision (coefficient of variation < 20%) for 38 species (Table 3). Numbers of increasing and decreasing species were similar: 21 increasing species (6 significantly increasing at $P < 0.05$) and 17 declining species (6 significantly declining at $P < 0.05$). Significantly increasing species included: White-headed Woodpecker, Steller's Jay, Mountain Chickadee, American Robin, MacGillivray's Warbler, and Spotted Towhee. Significantly declining species included: Willow Flycatcher, Warbling Vireo, Nashville Warbler, Yellow Warbler, Dark-eyed Junco, and Brown-headed Cowbird.

Adult Apparent Survival Rate

We estimated time-constant adult apparent survival rate for the four long-running Yosemite MAPS stations for the same 38 species for which we estimated population trend (Table 4). Adult apparent survival rates ranged from a low of 0.237 for Golden-crowned Kinglet to a high of 0.876 for White-headed Woodpecker. For perspective, the adult survival rate for White-headed Woodpecker suggests, that a bird that reaches adulthood (1 yr post-hatching will, on average, live approximately 5 more years.

Productivity

Productivity, based on model-averaged (excluding models with station effects) estimates of $\hat{p}_{.j=\bar{j}(\mathrm{per8})t}$ from logit-linear regression models was highly variable among years for most species (Fig. 3), and all species included annually varying covariates (swc, t, or T) among the best-supported models (based on AICc < 2 points of best model; Appendix 3). Sixteen of these species included models allowing for annual variation in productivity (t models) among the best-supported models (Appendix 3). Year-specific estimates of $\hat{p}_{.j=\bar{j}(\mathrm{per8})t}$ and their precision were, however, difficult to estimate for species and years with few captures or where point estimates were very close to boundary values of 0 or 1. For some species for which the only well-supported models allowing for annual variation were those with logit-linear trend (T) effects or snow water content (swc) effects (e.g., Western Wood-Pewee, Cassin's Vireo, Mountain Chickadee, Chipping Sparrow, Lazuli Bunting, and Pine Siskin), the range of annual variation in productivity was very small. Best models for all such species also included station (sta) effects, and annual estimates for these species may have been obscured to some extent by aggregating data across stations. Indeed, twenty-three species of the 33 species analyzed showed evidence of spatial (among-station) variation in productivity (Appendix 3), although such differences could reflect differences in age-specific capture probabilities among stations. Little annual variation for some species may have reflected different responses by stations to covariate effects (e.g., there was strong support for swc × station interaction for Cassin's Vireo, Pine Siskin). In others, effect sizes may have been small (at least when data aggregated across stations). There was substantial variation in patterns of productivity among species. However, productivity for many species was relatively high in 1997 (primarily species that showed a strong negative relationship with swc; see below and Table 5), and most species had relatively low productivity in 2010, years associated with low and high snow pack, respectively.

Twenty-five of the 33 species analyzed showed evidence of an effect of May snow water content (swc) on productivity (Table 5; Fig. 4). Model selection based on AIC_c suggested the importance of the snow water content variable, swc, for 16 species (models with swc selected as best model or swc models with $\Delta\ AIC_c < 2$ points of best model; Table 5, Appendix 3). Twenty-three of the 25 species showing evidence of an swc effect on productivity had negative relationships between swc and productivity, and these relationships were significant (95% confidence intervals from model-averaged regression coefficients not containing 0) for 17 species (Table 5). Just two species, Hermit Thrush and Yellow Warbler, had model-averaged regression coefficients for swc that were positive (both significant). For Hermit Thrush, models with swc effects were among the best supported models, however, the effect size was small and confidence intervals for productivity index estimates overlapped broadly. For Yellow Warbler, models with annual variation were much better supported than models with swc effects, and model-averaged productivity index estimates did not show a strong pattern in relation to swc (Appendix 3; Fig. 4).

Twelve species showed evidence of trend in productivity (Table 6). Five of these species had models with trend (T) effects selected as among the most parsimonious models considered (Table 5, Appendix 3); and three of these species had statistically significant trend effects (model-averaged 95% confidence intervals on regression coefficients for T that did not overlap zero). The remaining seven species had statistically significant model-averaged trend effects, but models including trend effects were not among the top (based on AIC_c) models considered. Of the total 12 species, three showed evidence of negative trend in productivity (Western Wood-pewee, Cassin's Vireo, and MacGillivray's Warbler), although this trend was only significant for one species, MacGillivray's Warbler. The remaining nine species all had significantly increasing trends in productivity.

For each species, population growth rates, trends in productivity indices, and time-constant estimates of adult apparent survival are summarized in Table 7. For comparative purposes, we also provide estimates of adult apparent survival for the Northwest MAPS region (which covers the Pacific Northwest as well as the Sierra Nevada) during the period 1992-2006 (Michel et al. 2011). Interesting, for all six of the species with significantly increasing populations at the Yosemite MAPS stations, survival probabilities at Yosemite are substantially higher than across the region at large (Table 7). For species that are declining or apparently stable at the Yosemite MAPS stations, in the majority of cases survival estimates are quite similar to the corresponding regional survival estimates (Table 7). It is also interesting that there is no evidence of a declining productivity trend at Yosemite in any of the six species with significantly declining populations (Table 7), though for some species (e.g., Willow Flycatcher) this may reflect a paucity of data rather than truly stable productivity rate.

Community Ordinations

Ordinations suggested that community composition has shifted at each of the five MAPS stations over the course of the study (Fig. 5). Year was highly significantly correlated with ordinations in each case (Table 1), indicating substantial directional change in bird communities at each station over the time span of the study. Based on correlations of species adult capture rates with year, declines were more common at the lower elevation stations. Numbers of negative correlations for breeding species at the five stations were: 37 (14 with $P < 0.10$) at BIME, 28 (9 with $P < 0.10$) at HODG, 16 (5 with $P < 0.10$) at CRFL, 15 (2 with $P < 0.10$) at GFEM, and 18 (2 with $P < 0.10$) at White Wolf (Table 2). Numbers of positive correlations for breeding species at the five stations were: 25 (9 with $P < 0.10$) at BIME, 25 (9 with $P < 0.10$) at HODG, 31 (8 with $P < 0.10$) at CRFL, 32 (8 with $P < 0.10$) at GFEM, and 16 (6 with $P < 0.10$) at White Wolf (Table 2). Year was strongly correlated with the ordination for each station ($0.001 \leq P \leq 0.007$). Snow water content was strongly correlated with the ordination at the highest station, White Wolf (WHWO).

Discussion

Declining Species

Our modeling of data from Yosemite's MAPS stations reveals pervasive, significant declines among six species: Willow Flycatcher, Warbling Vireo, Nashville Warbler, Yellow Warbler, Dark-eyed Junco, and Brown-headed Cowbird. Three of these, Willow Flycatcher, Warbling Vireo and Yellow Warbler are strongly to completely tied to meadow or riparian habitat for nesting and foraging. Willow Flycatcher, the most strictly meadow-dependent of the three and a California endangered species, has not only declined in Yosemite during the study period, but was shown in another study to have been completely lost from the park as a breeding species during the timeframe of this study (Siegel et al. 2008). Severe regional declines in Willow Flycatcher populations have generally been attributed to cattle grazing and other anthropogenic factors that degraded meadow habitats over the past century (Green et al. 2003). Cain et al. (2003) provided compelling evidence that late-season persistence of surface water in meadows is critical for protecting Willow Flycatcher (and Yellow Warbler) nests from predation by small mammals, thus providing a potential mechanism by which anthropogenic meadow alteration has diminished populations of meadow-dependent birds. However, Siegel et al. (2008) suggested that the loss of the species from even relatively pristine-seeming meadows in Yosemite indicates other factors, such as problems on the wintering grounds or migratory routes, that may also have contributed to declines.

Yellow Warbler is also a species of conservation concern throughout California, and is classified by the state as a California bird species of special concern (Shuford and Gardali 2008). Elsewhere in the Sierra, Yellow Warblers have likely benefited from meadow and riparian restoration, as well as Brown-headed Cowbird trapping programs that were implemented to benefit Southwestern Willow Flycatcher recovery (Heath 2008). Interestingly, Brown-headed Cowbird is another species that has declined significantly at Yosemite's MAPS stations, likely suggesting that it has not been a major factor in recent declines of other meadow-nesting species at the stations. The apparent decline in Brown-headed Cowbird numbers, coupled with the strong evidence of declines for three strongly meadow-associated species, suggests that carefully targeted meadow restoration projects could be important for safeguarding some of the park's vulnerable bird populations. Individual meadows throughout Yosemite have been altered by historical grazing, road construction, or other activities, and restoration of hydrologic processes at such sites, perhaps along with active restoration of riparian deciduous vegetation, would likely benefit riparian and meadow-dwelling bird species.

Community-level Changes: Post-fire Succession

Community-level changes are apparent to varying degrees at each of the individual MAPS stations. At the Big Meadow station, where stand replacing fires drastically altered the surrounding forest in 1990 and again in 2009, the main driver of the observed changes has likely been the changes in the post-fire plant community around the station. The importance of fire in shaping ecosystem structure and composition can hardly be overstated (Bowman et al. 2009). This is particularly true in fire-prone environments such as the Sierra Nevada (van Wagtendonk and Fites-Kaufman 2006). Responses of individual bird species to fire are highly variable – depending not only on the natural history of the individual species, but also on the severity of the fire and the characteristics of the post-fire habitat.

At Big Meadow, dense chaparral developed around the perimeter of the meadow in the years after the 1990 fire, largely replacing Sierra Mixed Conifer forest. Consequently, chaparral-associated species appear to have increased substantially, including Bushtit, Wrentit, Spotted Towhee, and Green-tailed Towhee (Fig. 5, Table 2). The chaparral includes a substantial oak (*Quercus* spp.) component, which may explain why species associated with oak woodland or mixed oak-conifer forest, such as Ash-throated Flycatcher, Oak Titmouse, Nashville Warbler, and Black-throated Gray Warbler have also increased at the station (Fig. 5, Table 2), although we note that Nashville Warbler has actually decreased when data from all stations are pooled. Hairy and Downy Woodpecker capture rates decreased over the study period, perhaps reflecting the declining foraging value of post-fire snags over time.

Community-level Changes: Climate Change

Unlike the Big Meadow station, which has undergone dramatic ecological changes during the study timeframe, no obvious perturbation has occurred at the other stations. Rather, the community-level changes observed at those stations may at least in part be attributable to climate change. The scientific consensus predicts most plant and animal species will shift their ranges poleward and upward in elevation in order to follow their climatic niches (Parmesan 2006). For bird species this shift is likely to be in response to vegetation shifts upslope and poleward. Mountain-dwelling birds have already responded to climate change around the world by shifting ranges upslope (Pounds et al. 1999, Root et al. 2003, Root et al. 2005). In Yosemite, this suggests that in aggregate, bird species currently found in lower elevations may occur more often at higher elevations while species currently limited to the alpine regions of the park may lose most or all suitable habitat and perhaps cease to occur within the park. Recent evidence from Yosemite indicates that distributions of many Sierra birds have already begun to change (Tingley et al. 2009), and in the coming decades increased temperature, decreased snowpack, altered fire regimes, and shifting plant communities will likely accelerate such changes and may restructure entire bird assemblages (Stralberg et al. 2009).

Species that are most likely to be affected negatively by climate change are those limited to the highest elevations in mountainous regions (Loarie et al. 2009) such as the Sierra Nevada. Such alpine-obligate species are most vulnerable because they lack higher altitude habitats to which they can disperse. However, the highest-elevation MAPS station in Yosemite is White Wolf at 2402 m above sea level, which is not high enough to monitor the park's largely alpine-restricted species: White-tailed Ptarmigan (introduced), Horned Lark, American Pipit, and Gray-crowned Rosy-Finch. Although demography of high-elevation species at Yosemite is not monitored by the existing configuration of MAPS stations, population trends of those species are being monitored by by the SIEN Network's long-term bird monitoring program (Siegel et al. 2010) which was launched in 2011.

Nevertheless, changes in distribution of montane (rather than alpine) species in Yosemite are likely to occur. The park's (and the overall Sierra Nevada's) relatively steep elevation gradients may allow species to track optimal temperatures by dispersing relatively small distances upslope. In less topographically diverse areas (e.g., the San Joaquin Valley), a northward migration along a gradual elevation gradient would require dispersal of a much greater distance to track shifting average temperatures (Loarie et al. 2009). In mountainous regions where upslope range shifts are more feasible, turnover in community composition at any given location may be comparatively rapid (Lawler et al. 2009). Extensive baseline data on birds' elevation ranges within the parks has only been recently gathered (Siegel et al. 2011), and monitoring efforts that would be able to detect changes in those distributions have only recently been initiated (Siegel et al. 2010).

Data from Yosemite's MAPS stations provide only limited inference about changes in individual species' absolute elevation ranges because they describe only five locations in the park.

Nevertheless the data provide valuable information about apparent community-level changes at those locations. At the Hodgdon Meadow station, the bird community appears to have shifted away from species that are most strongly associated with riparian or meadow habitats, such as Willow Flycatcher, Warbling Vireo, Yellow Warbler, and Lincoln's Sparrow (Fig. 5, Table 2). Also notable is the highly significant decline of Dusky Flycatcher at the station (Table 2). Declines in meadow-associated species are not evident at the next two highest stations, Crane Flat and Gin Flat East Meadow (Fig. 5). Indeed, MacGillivray's Warbler has significantly increased at both stations (Table 2). Also notable at Gin Flat East Meadow is the significant increase exhibited by Pacific-slope Flycatcher (Table 2) – the station near the upper reaches of the elevation zone where the species has historically been found (Siegel et al. 2011). The bird community at White Wolf, the highest-elevation station, seems to have changed the least during the study period (Table 2).

Effect of Spring Snowpack on Productivity

In exploring the effects of annual weather variation on avian population dynamics, we focused on May snow water content because the timing of spring snowmelt, at least at the higher stations, varies dramatically from year to year, and years with late melting and/or late snowstorms likely challenge many species' ability to nest successfully (DeSante 1990, Morton 2002, Pereyra 2011, Mathewson et al. in review). Remarkably, 25 of the 33 species analyzed showed evidence of an effect of May snow water content on productivity, with 23 of them exhibiting lower productivity in years with more snow on the ground in May (Table 5, Fig. 5). Climate models generally predict earlier snowmelt in the Sierra Nevada in the future, at least in the montane zone (Cayan 1996, Howat and Tulaczyk 2005, Maurer et al. 2007). Our results suggest this could positively affect populations of many montane bird species by increasing their average annual productivity. Of course, effects of climate change are likely to be numerous and complex – as one example, earlier snowmelt is likely to lead to drier mid-summer meadow conditions, which might have negative consequences for nesting meadow birds. It is unclear how such effects might weigh against one another.

Management Implications

1. Early post-fire habitats are valuable to numerous species of birds in the park. This is contrary to much public perception, wherein stand-replacing wildfire is viewed as 'catastrophic'. Interpretive efforts conveying to visitors the value of wildfire to numerous bird species could help bring public perception in line with current ecological understanding. Additionally, much remains unknown about avian response to wildfire in the Sierra Nevada; continued and enhanced research and monitoring efforts on birds' responses to fire in the park are warranted.

2. Several bird species that nest in montane meadows appear not to be faring well in the park. The recent loss from the park of Willow Flycatcher as a breeding species may have been a harbinger of problems for other meadow-associated species, including Yellow Warbler. Efforts to restore, enhance, and sustain meadow habitats – in particular efforts targeting restoration of meadow hydrology – may be among the most valuable things the park could do to protect vulnerable bird populations. Such efforts may become even more important if climate change leads to drier summer conditions in the future.

3. It is often assumed that the effects of climate change will be primarily or largely negative for wildlife, but early spring snowmelt in Yosemite may result in higher productivity for many bird species that nest in the montane zone. However, other effects of climate change, such as earlier, more pronounced mid-summer drying of meadows, may be detrimental to some of the same bird species. Further study of the effects of annual weather variation and climate change on Sierra birds is warranted.

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Table 1. Squared correlation coefficients and p-values from randomization tests for correlations of year and May snow water content (SWC) with non-metric multidimensional scaling (NMDS) ordinations of adult capture rates at the five Monitoring Avian Productivity and Survivorship (MAPS) stations in Yosemite National Park 1993-2010.

	Year		SWC	
Station	r^2	P	r^2	P
Big Meadow (BIME)	0.691	0.001	0.091	0.503
Hodgdon Meadow (HODG)	0.742	0.001	0.095	0.453
Crane Flat (CRFL)	0.627	0.001	0.150	0.306
Gin Flat East Meadow (GFEM)	0.861	0.001	0.313	0.154
White Wolf (WHWO)	0.506	0.007	0.237	0.133

Table 2. Correlations between the capture rate of adult birds (birds × 100 net-hours^{-1}) and year for breeding species at five MAPS stations operated in Yosemite National Park 1993-2010.

Species	Big Meadow (BIME)		Hodgdon Meadow (HODG)		Crane Flat (CRFL)		Gin Flat East Meadow (GFEM)		White Wolf (WHWO)	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Belted Kingfisher	-0.351	0.154	—	—	—	—	—	—	—	—
Acorn Woodpecker	0.163	0.519	—	—	—	—	—	—	—	—
Williamson's Sapsucker	—	—	—	—	—	—	0.400	0.176	-0.053	0.835
Red-breasted Sapsucker	0.473	0.047	0.274	0.270	0.486	0.041	0.405	0.170	0.077	0.760
Downy Woodpecker	-0.527	0.025	-0.130	0.608	—	—	—	—	—	—
Hairy Woodpecker	-0.601	0.008	0.285	0.251	0.133	0.599	0.530	0.062	0.465	0.052
White-headed Woodpecker	-0.099	0.695	0.302	0.223	0.637	0.004	-0.009	0.976	—	—
Black-backed Woodpecker	—	—	—	—	—	—	—	—	0.351	0.154
Northern Flicker	-0.201	0.423	-0.180	0.474	0.009	0.973	0.147	0.632	0.435	0.071
Olive-sided Flycatcher	-0.375	0.125	0.301	0.225	—	—	-0.154	0.615	—	—
Western Wood-Pewee	0.180	0.476	0.467	0.051	0.411	0.090	0.600	0.030	-0.407	0.094
Willow Flycatcher	-0.035	0.889	-0.653	0.003	-0.212	0.399	—	—	—	—
Hammond's Flycatcher	-0.152	0.547	-0.464	0.052	0.310	0.210	0.082	0.791	—	—

Table 2, continued.

Species	Big Meadow (BIME)		Hodgdon Meadow (HODG)		Crane Flat (CRFL)		Gin Flat East Meadow (GFEM)		White Wolf (WHWO)	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Dusky Flycatcher	-0.340	0.167	-0.897	0.000	-0.433	0.073	0.724	0.005	0.314	0.205
Pacific-slope Flycatcher	-0.045	0.859	-0.008	0.975	0.316	0.202	0.669	0.012	0.400	0.100
Black Phoebe	-0.449	0.062	-0.064	0.801	0.308	0.214	0.077	0.802	—	—
Ash-throated Flycatcher	0.609	0.007	—	—	—	—	—	—	—	—
Cassin's Vireo	0.380	0.120	-0.238	0.342	0.242	0.333	0.261	0.389	—	—
Warbling Vireo	-0.414	0.088	-0.745	0.000	0.128	0.613	0.214	0.483	-0.258	0.302
Steller's Jay	0.071	0.779	0.580	0.012	0.345	0.161	0.429	0.143	0.324	0.189
Western Scrub-Jay	0.391	0.109	—	—	—	—	—	—	—	—
Northern Rough-winged Swallow	0.022	0.932	—	—	—	—	—	—	—	—
Mountain Chickadee	0.002	0.993	0.706	0.001	0.372	0.128	-0.109	0.722	0.202	0.421
Chestnut-backed Chickadee	—	—	-0.322	0.193	—	—	—	—	—	—
Oak Titmouse	0.481	0.043	—	—	—	—	—	—	—	—
Bushtit	0.488	0.040	-0.339	0.169	—	—	—	—	—	—

Table 2, continued.

Species	Big Meadow (BIME)		Hodgdon Meadow (HODG)		Crane Flat (CRFL)		Gin Flat East Meadow (GFEM)		White Wolf (WHWO)	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Red-breasted Nuthatch	0.397	0.102	0.639	0.004	0.063	0.805	0.172	0.574	0.440	0.068
White-breasted Nuthatch	0.096	0.706	—	—	—	—	-0.001	0.997	—	—
Brown Creeper	-0.428	0.076	0.408	0.092	0.001	0.998	0.073	0.813	0.420	0.083
Bewick's Wren	0.179	0.477	—	—	—	—	0.231	0.447	—	—
House Wren	-0.371	0.130	0.048	0.848	-0.335	0.174	0.286	0.344	-0.184	0.466
Pacific Wren	-0.182	0.470	0.174	0.489	0.183	0.468	—	—	—	—
American Dipper	0.023	0.927	—	—	—	—	—	—	—	—
Golden-crowned Kinglet	—	—	-0.041	0.873	-0.533	0.023	-0.518	0.070	-0.132	0.600
Ruby-crowned Kinglet	—	—	—	—	—	—	—	—	-0.656	0.003
Western Bluebird	-0.493	0.038	—	—	—	—	0.231	0.447	—	—
Townsend's Solitaire	—	—	0.023	0.927	0.477	0.045	0.259	0.394	—	—
Swainson's Thrush	—	—	0.028	0.912	—	—	—	—	—	—
Hermit Thrush	0.250	0.317	-0.201	0.424	-0.163	0.519	-0.403	0.172	0.315	0.203

Table 2, continued.

Species	Big Meadow (BIME)		Hodgdon Meadow (HODG)		Crane Flat (CRFL)		Gin Flat East Meadow (GFEM)		White Wolf (WHWO)	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
American Robin	-0.520	0.027	0.598	0.009	0.682	0.002	-0.079	0.797	0.391	0.109
Wrentit	0.813	0.000	—	—	—	—	—	—	—	—
European Starling	0.397	0.102	—	—	—	—	—	—	—	—
Nashville Warbler	0.681	0.002	-0.572	0.013	-0.175	0.486	0.108	0.725	-0.224	0.372
Yellow Warbler	0.202	0.421	-0.657	0.003	-0.341	0.166	—	—	—	—
Yellow-rumped Warbler	-0.033	0.897	0.697	0.001	0.004	0.987	-0.589	0.034	-0.058	0.820
Black-throated Gray Warbler	0.417	0.085	0.207	0.411	0.164	0.517	—	—	—	—
Hermit Warbler	-0.304	0.220	-0.126	0.619	-0.538	0.021	0.240	0.429	-0.065	0.796
MacGillivray's Warbler	-0.309	0.213	0.674	0.002	0.812	0.000	0.600	0.030	—	—
Wilson's Warbler	-0.612	0.007	-0.276	0.267	-0.247	0.322	0.377	0.204	—	—
Western Tanager	-0.029	0.910	0.242	0.334	0.156	0.536	-0.405	0.170	0.225	0.369
Green-tailed Towhee	0.502	0.034	0.210	0.402	0.444	0.065	0.590	0.034	—	—
Spotted Towhee	0.699	0.001	0.712	0.001	0.142	0.574	—	—	—	—

Table 2, continued.

Species	Big Meadow (BIME)		Hodgdon Meadow (HODG)		Crane Flat (CRFL)		Gin Flat East Meadow (GFEM)		White Wolf (WHWO)	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Chipping Sparrow	-0.774	0.000	-0.702	0.001	0.030	0.907	-0.453	0.120	0.188	0.455
Fox Sparrow	-0.023	0.927	0.023	0.927	0.235	0.348	0.612	0.026	—	—
Song Sparrow	-0.714	0.001	0.383	0.116	0.352	0.152	—	—	-0.141	0.577
Lincoln's Sparrow	-0.234	0.351	-0.627	0.005	0.414	0.088	0.609	0.027	0.534	0.022
Dark-eyed Junco	-0.783	0.000	-0.282	0.257	-0.596	0.009	-0.202	0.508	0.370	0.130
Black-headed Grosbeak	-0.376	0.124	-0.053	0.833	0.316	0.202	0.266	0.379	-0.070	0.784
Lazuli Bunting	-0.535	0.022	-0.325	0.189	-0.016	0.949	0.314	0.296	—	—
Red-winged Blackbird	—	—	0.232	0.353	—	—	—	—	—	—
Brewer's Blackbird	-0.614	0.007	0.166	0.510	0.304	0.220	0.309	0.305	-0.390	0.109
Brown-headed Cowbird	-0.330	0.181	0.222	0.376	-0.117	0.644	-0.154	0.615	—	—
Bullock's Oriole	-0.134	0.597	—	—	—	—	0.231	0.447	—	—
Pine Grosbeak	—	—	—	—	—	—	—	—	-0.251	0.315
Purple Finch	0.245	0.327	-0.684	0.002	-0.567	0.014	-0.433	0.140	-0.147	0.560

Table 2, continued.

Species	Big Meadow (BIME)		Hodgdon Meadow (HODG)		Crane Flat (CRFL)		Gin Flat East Meadow (GFEM)		White Wolf (WHWO)	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Cassin's Finch	-0.061	0.809	-0.251	0.315	0.142	0.573	-0.106	0.730	-0.293	0.238
House Finch	—	—	—	—	-0.351	0.154	—	—	—	—
Red Crossbill	-0.023	0.927	-0.023	0.927	—	—	—	—	-0.351	0.154
Pine Siskin	-0.307	0.216	-0.010	0.970	-0.235	0.349	0.216	0.477	-0.334	0.176
Lesser Goldfinch	-0.428	0.077	-0.196	0.435	-0.182	0.469	0.348	0.243	—	—
Lawrence's Goldfinch	0.187	0.457	—	—	0.257	0.303	-0.154	0.615	—	—
Evening Grosbeak	-0.297	0.231	-0.397	0.102	—	—	0.077	0.802	-0.351	0.154

Table 3. Estimated rate of population change ($\hat{\lambda}$), standard errors ($\hat{SE}$), and 95% confidence intervals for 38 bird species from time-constrained Pradel reverse-symmetry model applied to 1993-2010 capture-recapture data from four MAPS stations in Yosemite National Park.

Species name	No. ind.[a]	No. rec.[b]	$\hat{\lambda}$	$\hat{SE}$	Lower 95%	Upper 95%
Significantly increasing						
White-headed Woodpecker	38	6	1.066	0.033	1.004	1.131
Steller's Jay	38	2	1.096	0.036	1.028	1.169
Mountain Chickadee	184	24	1.045	0.017	1.012	1.078
American Robin	234	41	1.040	0.013	1.014	1.065
MacGillivray's Warbler	785	280	1.022	0.007	1.008	1.035
Spotted Towhee	104	22	1.078	0.038	1.006	1.155
Significantly declining						
Willow Flycatcher	64	6	0.819	0.06	0.709	0.945
Warbling Vireo	699	74	0.970	0.007	0.956	0.984
Nashville Warbler	261	5	0.671	0.117	0.477	0.943
Yellow Warbler	144	39	0.949	0.015	0.920	0.980
Dark-eyed Junco	1163	326	0.970	0.010	0.950	0.990
Brown-headed Cowbird	11	3	0.797	0.092	0.635	0.999
Non-significant trend						
Williamson's Sapsucker	45	7	0.985	0.028	0.933	1.041
Red-breasted Sapsucker	171	30	1.027	0.016	0.997	1.059
Hairy Woodpecker	37	5	0.978	0.031	0.920	1.039
Northern Flicker	44	5	0.989	0.028	0.935	1.047
Western Wood-Pewee	171	27	1.017	0.016	0.986	1.050
Hammond's Flycatcher	83	4	0.983	0.022	0.942	1.027
Dusky Flycatcher	398	73	0.956	0.026	0.905	1.009
Black Phoebe	58	9	0.953	0.024	0.906	1.001
Cassin's Vireo	135	7	1.001	0.017	0.969	1.034
Bushtit	66	8	0.842	0.114	0.646	1.096

Table 3, continued.

Species name	No. ind.[a]	No. rec.[b]	$\hat{\lambda}$	$\hat{SE}$	Lower 95%	Upper 95%
Red-breasted Nuthatch	120	7	0.940	0.092	0.776	1.139
Brown Creeper	133	10	1.029	0.021	0.990	1.070
Golden-crowned Kinglet	211	9	0.963	0.078	0.821	1.130
Hermit Thrush	108	10	0.989	0.018	0.954	1.026
Yellow-rumped Warbler	720	53	1.036	0.034	0.972	1.104
Hermit Warbler	448	24	1.007	0.046	0.920	1.101
Western Tanager	198	10	0.952	0.097	0.780	1.161
Chipping Sparrow	204	27	0.971	0.036	0.904	1.043
Song Sparrow	399	131	1.003	0.009	0.984	1.021
Lincoln's Sparrow	575	185	0.995	0.010	0.975	1.014
Black-headed Grosbeak	337	52	0.990	0.024	0.944	1.039
Lazuli Bunting	482	29	1.002	0.039	0.929	1.081
Red-winged Blackbird	61	6	1.036	0.026	0.986	1.088
Pine Grosbeak	38	4	0.942	0.030	0.884	1.004
Purple Finch	392	14	0.990	0.061	0.878	1.117
Cassin's Finch	173	4	1.090	0.198	0.763	1.556

[a] Number of adult individuals banded across all years.

[b] Number of between-year recaptures recorded for banded adults.

Table 4. Estimates of time-constrained (i.e., constant among years) adult apparent survival rates ($\hat{\phi}$), standard errors ($\hat{SE}$), and 95% confidence intervals for 38 bird species captured at four MAPS stations in Yosemite National Park 1993-2010. For species with < 5 between-year recaptures or for which no individual was captured multiple times ≥ 6 d apart in the initial year of capture, we show estimates from the Cormack-Jolly-Seber (CJS) formulation of the Pradel (1996) reverse-symmetry model. For the remaining species, estimates are from a CJS model that accounts for transients in the population. In both cases, estimates were model-averaged across two models for recapture probability, p one that allowed p, to vary among years; the other constraining p to be constant among years.

Species name	No. ind.[a]	No. rec.[b]	No. pr. Res.[c]	$\hat{\phi}$	$\hat{SE}$	Lower 95%	Upper 95%
Williamson's Sapsucker	45	7	7	0.576	0.138	0.310	0.804
Red-breasted Sapsucker	171	30	20	0.470	0.075	0.331	0.615
Hairy Woodpecker	37	5	2	0.542	0.167	0.240	0.816
White-head. Woodpecker	38	6	1	0.876	0.112	0.483	0.982
Northern Flicker	44	5	0	0.456	0.162	0.189	0.750
Western Wood-Pewee	171	27	24	0.640	0.067	0.502	0.759
Willow Flycatcher	64	6	1	0.620	0.154	0.312	0.854
Hammond's Flycatcher	83	4	5	0.298	0.189	0.067	0.714
Dusky Flycatcher	398	73	72	0.421	0.044	0.338	0.510
Black Phoebe	58	9	4	0.395	0.139	0.173	0.670
Cassin's Vireo	135	7	7	0.442	0.153	0.190	0.729
Warbling Vireo	699	74	111	0.498	0.043	0.415	0.581
Steller's Jay	38	2	1	0.844	0.203	0.208	0.991
Mountain Chickadee	184	24	23	0.493	0.084	0.336	0.652
Bushtit	66	8	3	0.361	0.149	0.137	0.667
Red-breasted Nuthatch	120	7	7	0.382	0.161	0.140	0.702
Brown Creeper	133	10	12	0.302	0.119	0.125	0.566
Golden-crowned Kinglet	211	9	20	0.237	0.104	0.091	0.491
Hermit Thrush	108	10	8	0.483	0.127	0.256	0.717
American Robin	234	41	21	0.579	0.060	0.458	0.691
Nashville Warbler	261	5	16	0.320	0.166	0.095	0.678

Table 4, continued.

Species name	No. ind.[a]	No. rec.[b]	No. pr. Res.[c]	$\hat{\phi}$	$\hat{SE}$	Lower 95%	Upper 95%
Yellow Warbler	144	39	35	0.610	0.054	0.500	0.710
Yellow-rumped Warbler	720	53	34	0.404	0.055	0.302	0.516
Hermit Warbler	448	24	16	0.593	0.072	0.448	0.724
MacGillivray's Warbler	785	280	222	0.550	0.023	0.504	0.594
Western Tanager	198	10	2	0.517	0.147	0.252	0.772
Spotted Towhee	104	22	10	0.504	0.092	0.330	0.677
Chipping Sparrow	204	27	25	0.485	0.072	0.349	0.624
Song Sparrow	399	131	124	0.478	0.034	0.412	0.544
Lincoln's Sparrow	575	185	200	0.480	0.028	0.427	0.534
Dark-eyed Junco	1163	326	307	0.482	0.021	0.441	0.524
Black-headed Grosbeak	337	52	19	0.653	0.050	0.550	0.743
Lazuli Bunting	482	29	35	0.681	0.056	0.562	0.780
Red-winged Blackbird	61	6	3	0.438	0.172	0.166	0.754
Brown-headed Cowbird	11	3	0	0.545	0.144	0.277	0.790
Pine Grosbeak	38	4	1	0.317	0.191	0.076	0.723
Purple Finch	392	14	9	0.378	0.106	0.200	0.596
Cassin's Finch	173	4	1	0.836	0.213	0.194	0.991

[a] Number of adult individuals banded across all years.

[b] Number of between-year recaptures recorded for banded adults.

[c] Number of 'predetermined residents' (individuals captured more than once ≥ 6 d apart in initial capture year).

Table 5. Species for which there was support for productivity at four MAPS stations in Yosemite National Park 1993-2010 varying in relation to mean daily May snow water content, swc (cm; measured at the Gin Flat weather station). Support was assessed based on (1) whether models in candidate model sets containing swc were selected as 'best' models (lowest AICc) or had ΔAIC_c values within 2 points of the best model (see Appendix 3 for detail) or (2) had model-averaged regression coefficients for swc (expressed here as $\hat{\beta}$) with confidence intervals that did not contain zero.

Species	ΔAIC_c < 2	$\hat{\beta}$	SE	Lower 95%	Upper 95%
Red-breasted Sapsucker	X	-0.379	0.156	-0.685	-0.072
Hairy Woodpecker	X	-1.136	0.408	-1.936	-0.336
Northern Flicker	X	-0.698	0.547	-1.771	0.374
Western Wood-Pewee	X	-0.108	0.212	-0.524	0.308
Hammond's Flycatcher	X	-0.521	0.272	-1.053	0.011
Dusky Flycatcher		-0.543	0.150	-0.837	-0.248
Cassin's Vireo	X	-0.076	0.175	-0.419	0.266
Warbling Vireo	X	-0.478	0.112	-0.697	-0.258
Mountain Chickadee	X	-0.28	0.147	-0.567	0.008
Brown Creeper	X	-0.473	0.130	-0.728	-0.218
Golden-crowned Kinglet		-0.503	0.094	-0.687	-0.319
Hermit Thrush	X	0.475	0.231	0.022	0.929
American Robin	X	-0.466	0.213	-0.883	-0.050
Yellow Warbler		0.312	0.144	0.029	0.595
Yellow-rumped Warbler		-0.418	0.067	-0.549	-0.287
Hermit Warbler	X	-0.513	0.090	-0.690	-0.336
MacGillivray's Warbler		-0.369	0.074	-0.514	-0.224
Western Tanager	X	-0.486	0.192	-0.862	-0.110
Song Sparrow		-0.363	0.064	-0.488	-0.239
Lincoln's Sparrow		-0.234	0.060	-0.351	-0.117
Dark-eyed Junco		-0.315	0.040	-0.393	-0.238
Purple Finch		-0.272	0.102	-0.473	-0.072

Table 5, continued.

Species	ΔAIC_c < 2	$\hat{\beta}$	SE	Lower 95%	Upper 95%
Cassin's Finch	X	-0.802	0.324	-1.436	-0.168
Pine Siskin	X	-0.099	0.232	-0.554	0.357
Lesser Goldfinch	X	-0.437	0.159	-0.748	-0.125

Table 6. Species for which there was support for trend in productivity based on data from four MAPS stations in Yosemite National Park 1993-2010. Support was assessed based on (1) whether models in candidate model sets containing trend (T) were selected as 'best' models (lowest AICc) or had ΔAICc values within 2 points of the best model (see Appendix 3 for detail) or (2) had model-averaged regression coefficients for T (expressed here as $\hat{\beta}$) with confidence intervals did not contain zero.

Species	ΔAIC_c < 2	$\hat{\beta}$	SE	Lower 95%	Upper 95%
Western Wood-Pewee	X	-0.17	0.213	-0.587	0.248
Hammond's Flycatcher	X	0.628	0.288	0.064	1.191
Dusky Flycatcher		0.453	0.131	0.196	0.71
Cassin's Vireo	X	-0.12	0.179	-0.471	0.231
Bushtit	X	-0.165	0.189	-0.535	0.204
Red-breasted Nuthatch		0.432	0.146	0.145	0.719
Pacific Wren	X	-0.457	0.377	-1.195	0.282
Yellow Warbler		0.408	0.141	0.131	0.686
Hermit Warbler		0.238	0.095	0.051	0.425
MacGillivray's Warbler		-0.168	0.072	-0.309	-0.026
Spotted Towhee	X	0.209	0.26	-0.3	0.718
Chipping Sparrow	X	0.516	0.238	0.049	0.983
Black-headed Grosbeak		0.576	0.134	0.312	0.839
Lazuli Bunting	X	0.185	0.087	0.015	0.356
Purple Finch		0.363	0.113	0.142	0.584

Table 7. Summary demographics of species that underwent significant population increases, decreases, or that exhibited no trend at Yosemite MAPS stations between 1993 and 2010. Regional indices indicate corresponding values from the MAPS Northwest Region for the years 1992-2006 (obtained from Michel et al. [2011]).

Species name	$\hat{\lambda}$ ($\hat{SE}$)	Trend in Yosemite Productivity Index[1]	Yosemite Adult Survival Probability $\hat{\phi}$ ($\hat{SE}$)	Regional Adult Survival Probability $\hat{\phi}$ ($\hat{SE}$)
Significantly increasing				
White-headed Woodpecker	1.066 (0.033)	no trend	0.876 (0.112)	0.601 (0.310)
Steller's Jay	1.096 (0.036)	no trend	0.844 (0.203)	0.681 (0.073)
Mountain Chickadee	1.045 (0.017)	no trend	0.493 (0.084)	0.407 (0.031)
American Robin	1.040 (0.013)	no trend	0.579 (0.060)	0.518 (0.013)
MacGillivray's Warbler	1.022 (0.007)	declining	0.550 (0.023)	0.491 (0.008)
Spotted Towhee	1.078 0.038)	increasing[2]	0.504 (0.092)	0.488 (0.021)
Significantly declining				
Willow Flycatcher	0.819 (0.060)	no trend	0.620 (0.154)	0.510 (0.022)
Warbling Vireo	0.970 (0.007)	no trend	0.498 (0.043)	0.508 (0.013)
Nashville Warbler	0.671 (0.117)	no trend	0.320 (0.166)	0.325 (0.048)
Yellow Warbler	0.949 (0.015)	increasing	0.610 (0.054)	0.564 (0.009)
Dark-eyed Junco	0.970 (0.010)	no trend	0.482 (0.021)	0.460 (0.009)
Brown-headed Cowbird	0.797 (0.092)	no trend	0.545 (0.144)	0.452 (0.025)

Table 7, continued.

Species name	$\hat{\lambda}$ ($\hat{SE}$)	Trend in Yosemite Productivity Index[1]	Yosemite Survival Probability $\hat{\phi}$ ($\hat{SE}$)	Regional Survival Probability $\hat{\phi}$ ($\hat{SE}$)
No significant trend				
Williamson's Sapsucker	0.985 (0.028)	no trend	0.576 (0.138)	0.499 (0.111)
Red-breasted Sapsucker	1.027 (0.016)	no trend	0.470 (0.075)	0.440 (0.027)
Hairy Woodpecker	0.978 (0.031)	no trend	0.542 (0.167)	0.603 (0.048)
Northern Flicker	0.989 (0.028)	no trend	0.876 (0.112)	0.364 (0.143)
Western Wood-Pewee	1.017 (0.016)	decreasing[2]	0.640 (0.067)	0.529 (0.024)
Hammond's Flycatcher	0.983 (0.022)	increasing	0.298 (0.189)	0.467 (0.024)
Dusky Flycatcher	0.956 (0.026)	increasing	0.421 (0.044)	0.494 (0.018)
Black Phoebe	0.953 (0.024)	no trend	0.395 (0.139)	0.706 (0.105)
Cassin's Vireo	1.001 (0.017)	decreasing[2]	0.442 (0.153)	0.547 (0.054)
Bushtit	0.842 (0.114)	decreasing[2]	0.361 (0.149)	0.335 (0.095)
Red-breasted Nuthatch	0.940 (0.092)	increasing	0.382 (0.161)	0.356 (0.068)
Brown Creeper	1.029 (0.021)	no trend	0.302 (0.119)	0.376 (0.047)
Golden-crowned Kinglet	0.963 (0.078)	no trend	0.237 (0.104)	0.084 (0.050)
Hermit Thrush	0.989 (0.018)	no trend	0.483 (0.127)	0.443 (0.028)
Yellow-rumped Warbler	1.036 (0.034)	no trend	0.404 (0.055)	0.456 (0.020)
Hermit Warbler	1.007 (0.046)	increasing	0.593 (0.072)	0.649 (0.047)
Western Tanager	0.952 (0.097)	no trend	0.517 (0.147)	0.495 (0.036)

Table 7, continued.

Species name	$\hat{\lambda}$ ($\hat{SE}$)	Trend in Yosemite Productivity Index[1]	Yosemite Survival Probability $\hat{\phi}$ ($\hat{SE}$)	Regional Survival Probability $\hat{\phi}$ ($\hat{SE}$)
Chipping Sparrow	0.971 (0.036)	increasing	0.485 (0.072)	0.457 (0.038)
Song Sparrow	1.003 (0.009)	no trend	0.478 (0.034)	0.473 (0.007)
Lincoln's Sparrow	0.995 (0.010)	no trend	0.480 (0.028)	0.438 (0.012)
Black-headed Grosbeak	0.990 (0.024)	increasing	0.653 (0.050)	0.571 (0.017)
Lazuli Bunting	1.002 (0.039)	increasing	0.681 (0.056)	0.523 (0.029)
Red-winged Blackbird	1.036 (0.026)	no trend	0.438 (0.172)	0.679 (0.036)
Pine Grosbeak	0.942 (0.030)	no trend	0.317 (0.191)	0.384 (0.202)
Purple Finch	0.990 (0.061)	increasing	0.378 (0.106)	0.471 (0.021)
Cassin's Finch	1.090 (0.198)	no trend	0.836 (0.213)	0.550 (0.100)

[1]For some species, an assessment of 'no trend' may indicate there is truly no temporal trend in productivity; for others it may merely signify that there were inadequate numbers of captures for confidently assessing the trend.
[2]Assessment based on models in candidate model sets containing trend having been selected as 'best' models (lowest AICc) or had ΔAICc values within 2 points of the best model, even though the confidence interval for $\hat{\beta}$) contained zero.

Figure 1. Locations of the five Monitoring Avian Productivity and Survivorship (MAPS) stations in Yosemite National Park.

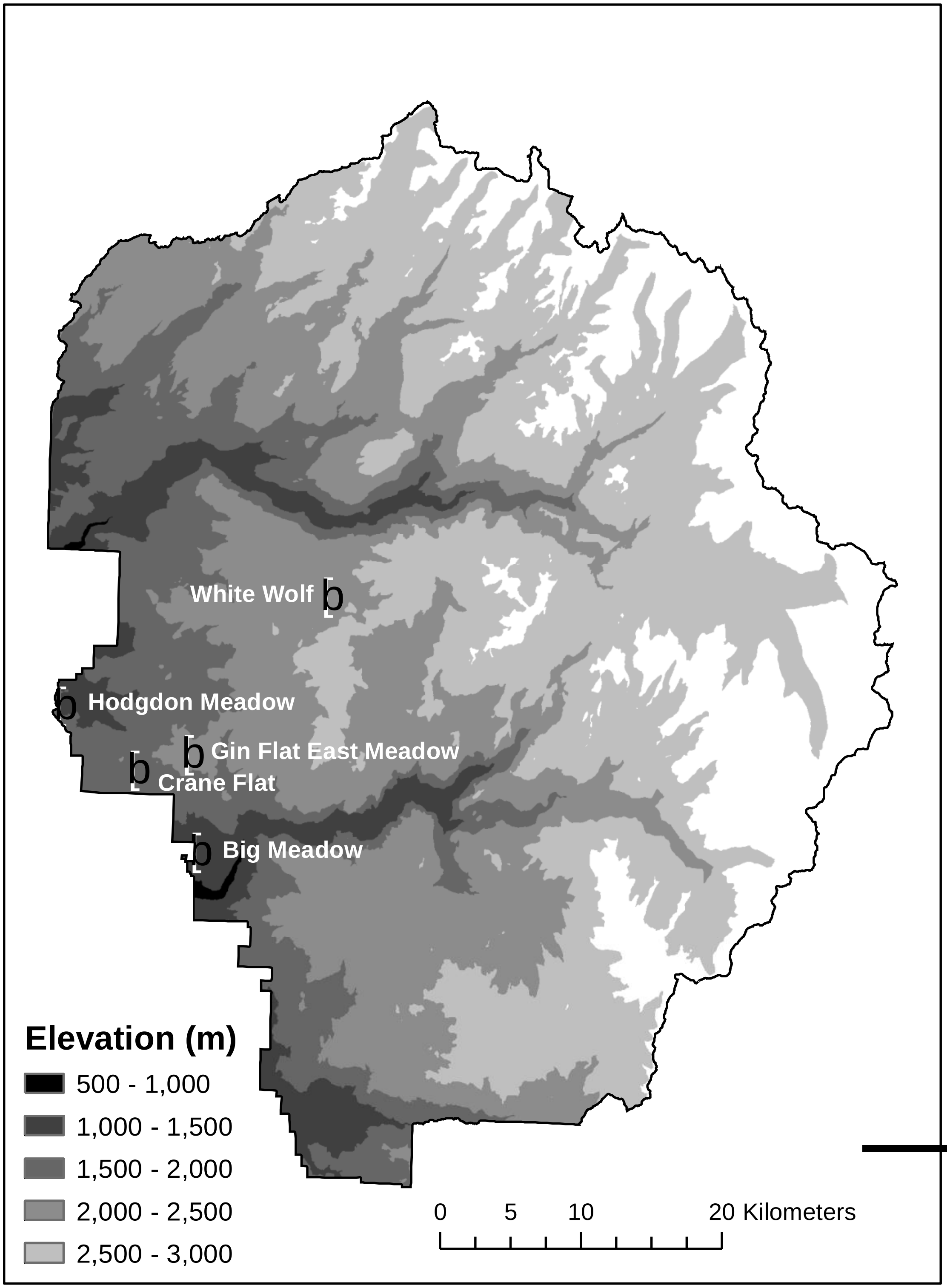


Figure 2. Temporal variation in mean May daily snow water content (cm) measured at the Gin Flat weather station.

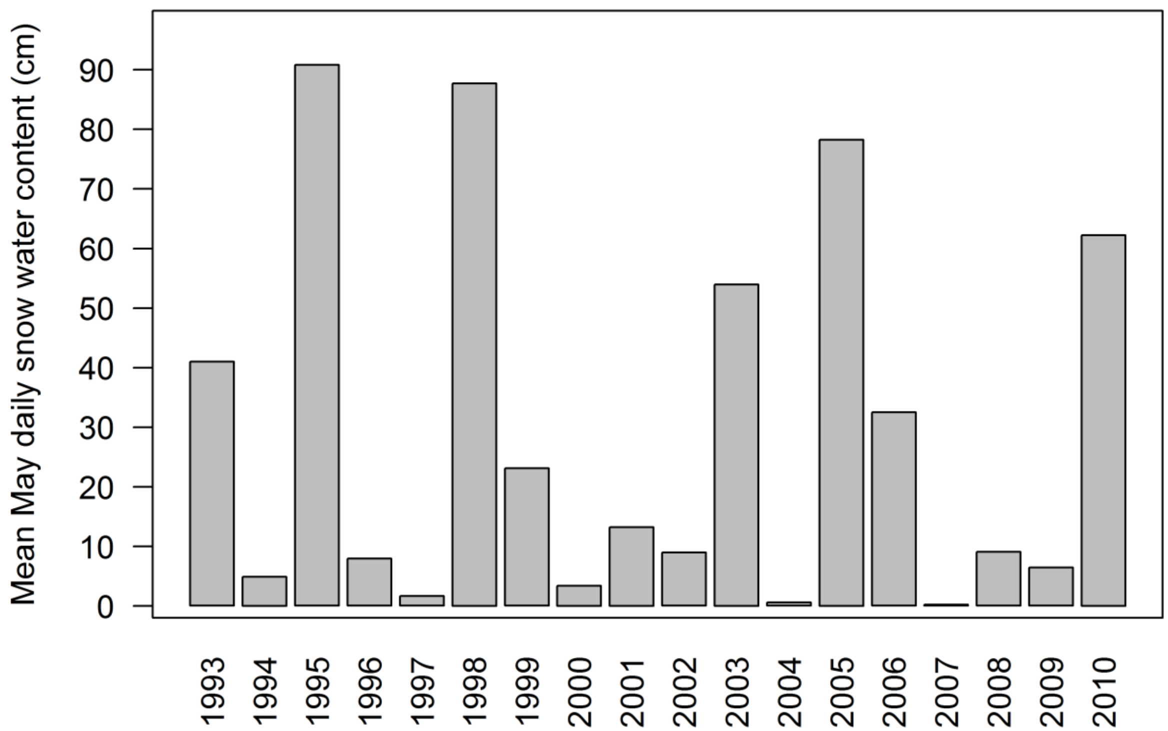


Figure 3. Annual productivity index estimates, for 33 bird species from four Monitoring Avian Productivity and Survivorship (MAPS) stations in Yosemite National Park 1993-2010. Estimates represent the probability of a captured bird being a young (hatching year) bird in MAPS period 8 (10-19 July), $\hat{p}_{.j=\bar{j}(\mathtt{per8})t}$; they are model-averaged predictions from logit-linear regression models that aggregated data across stations (i.e., models allowing station-level variation were not included in the model set used for model-averaging).

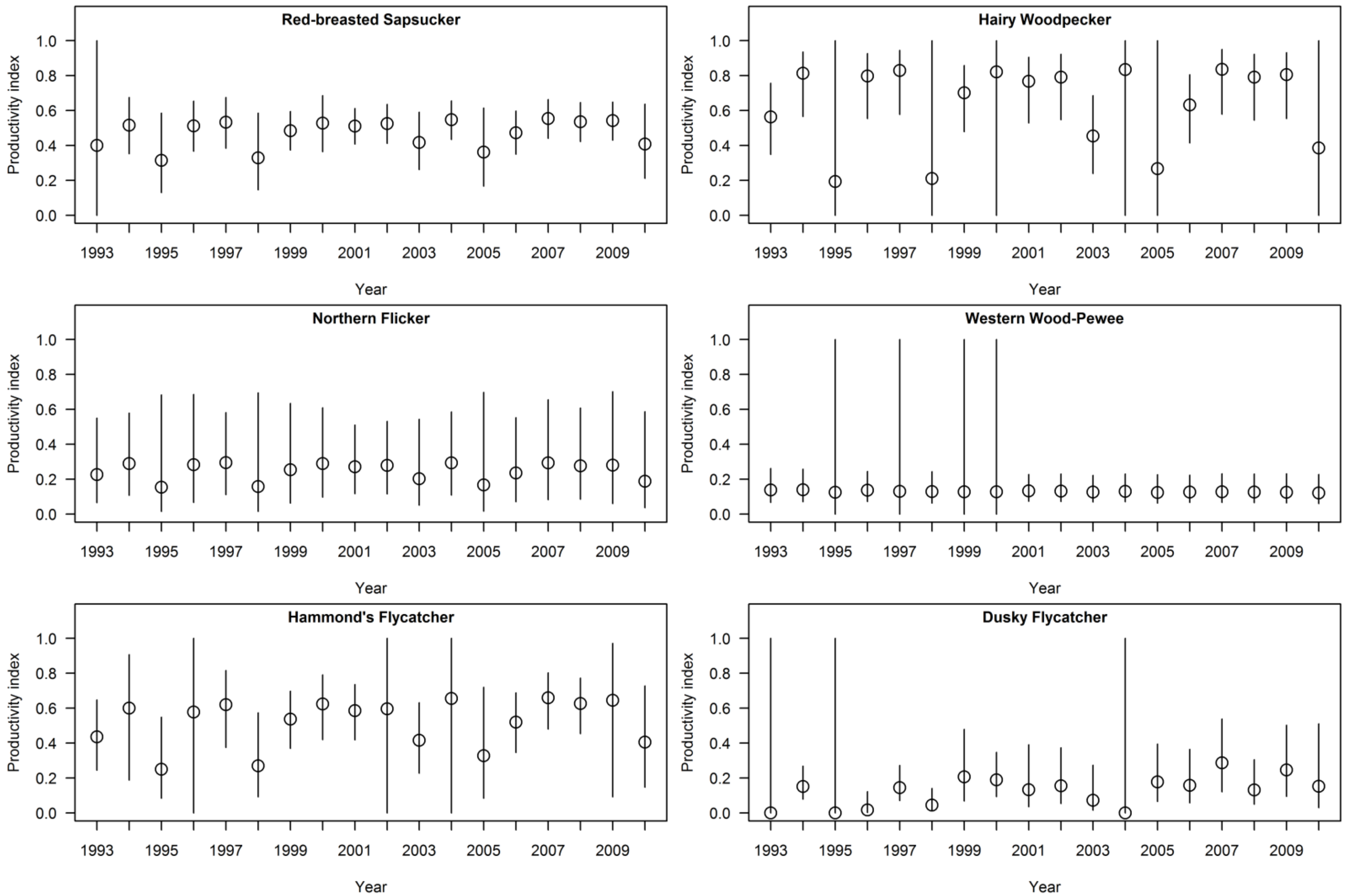


Figure 3, continued.

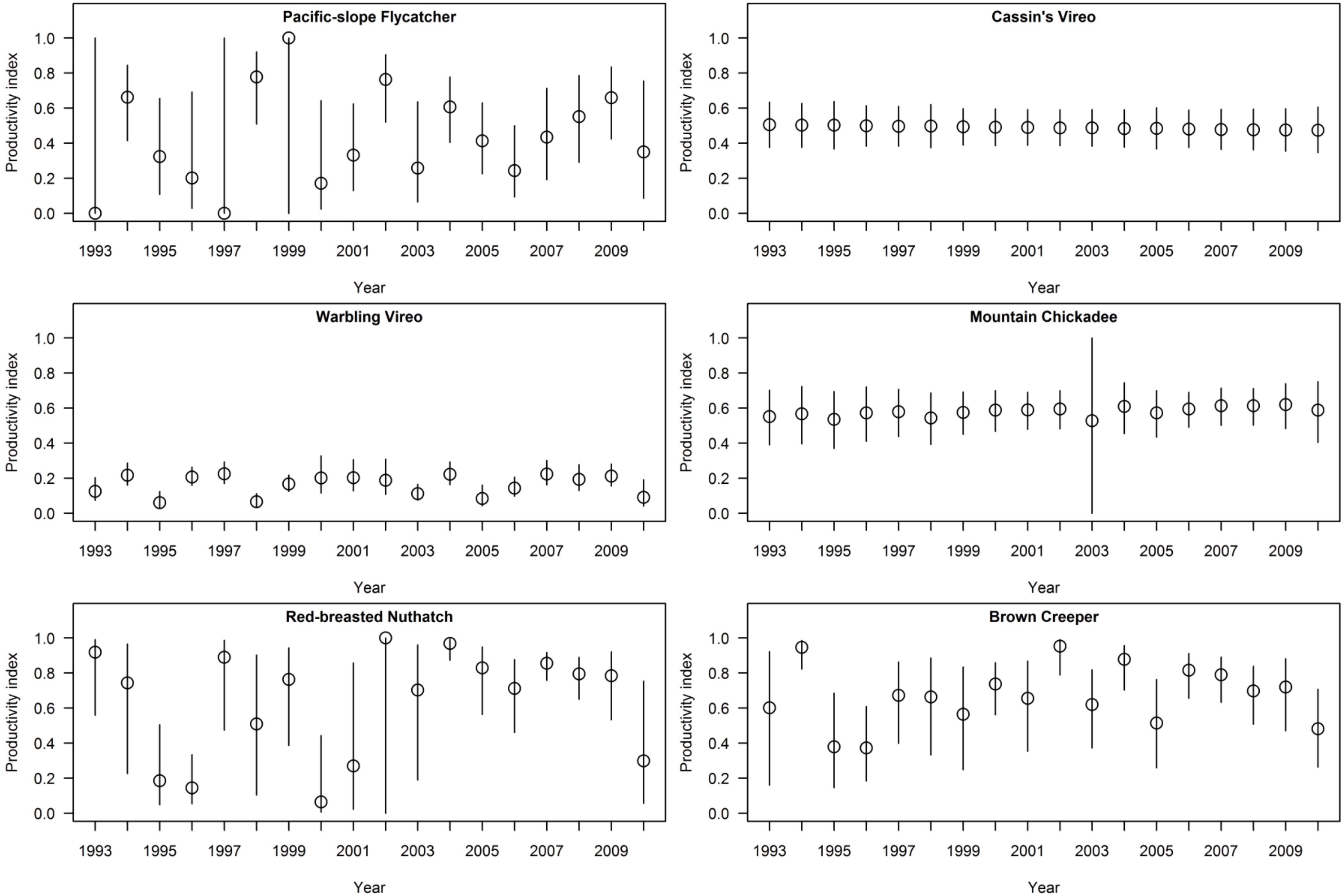


Figure 3, continued.

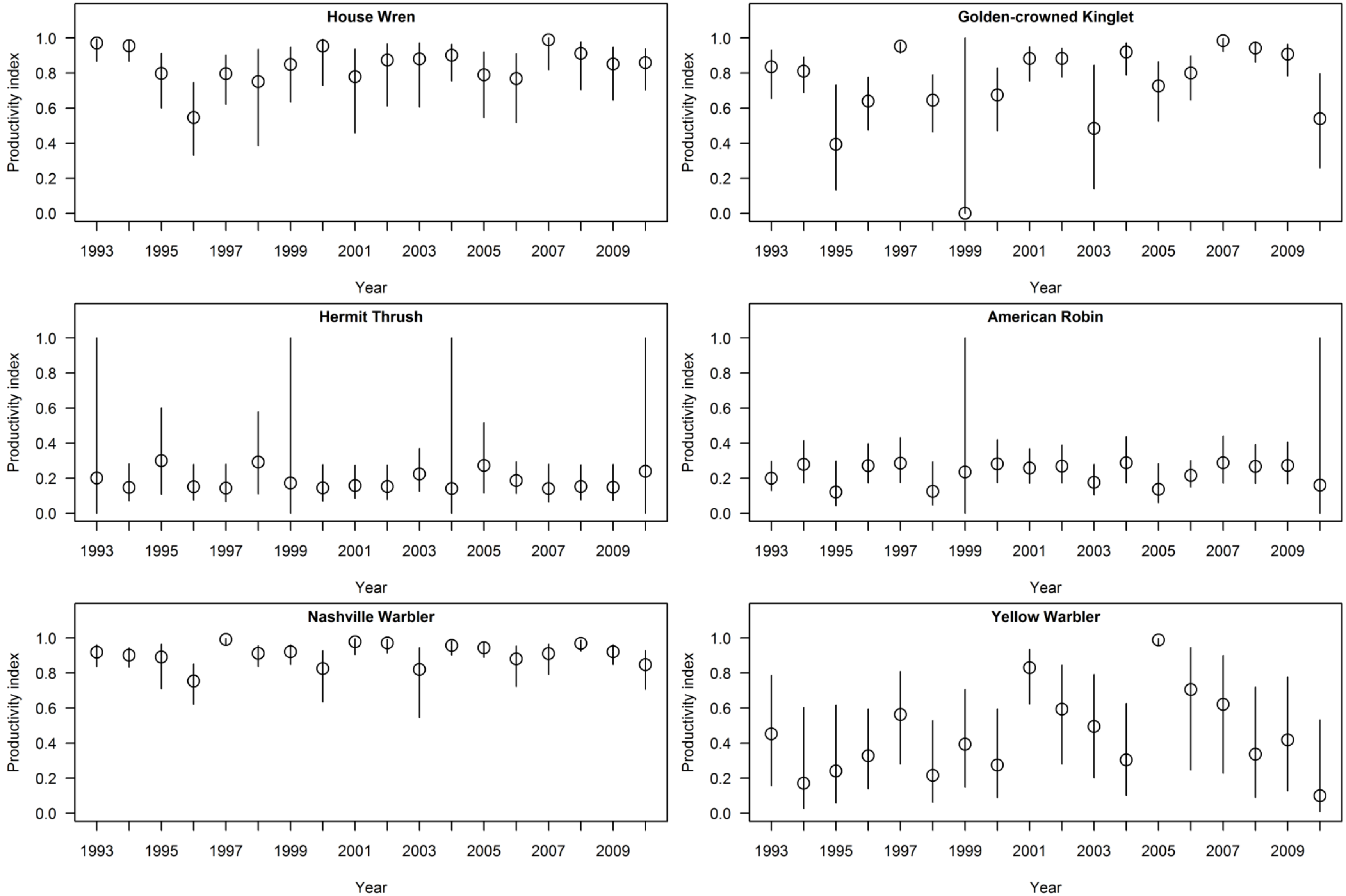
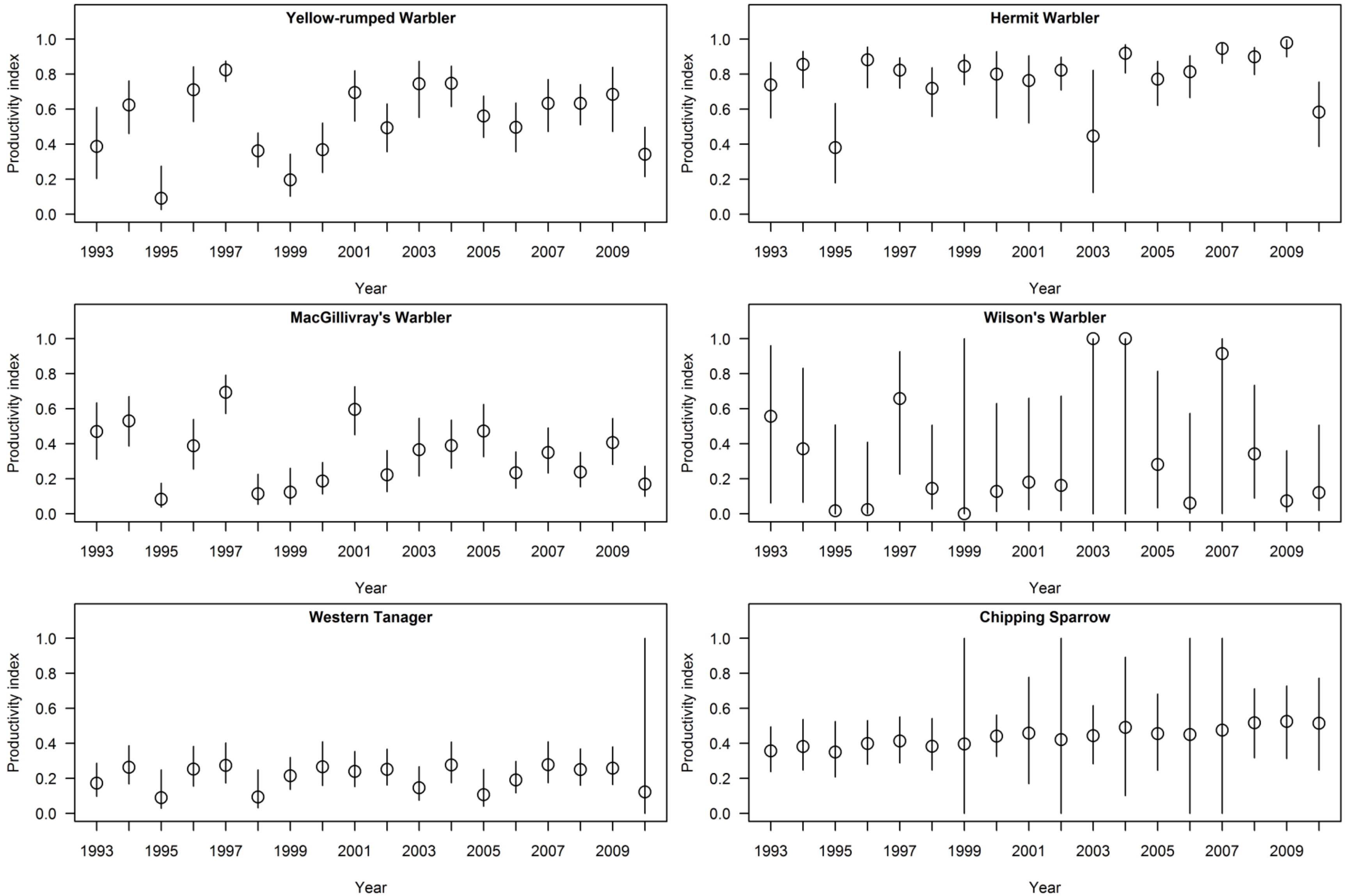


Figure 3, continued.



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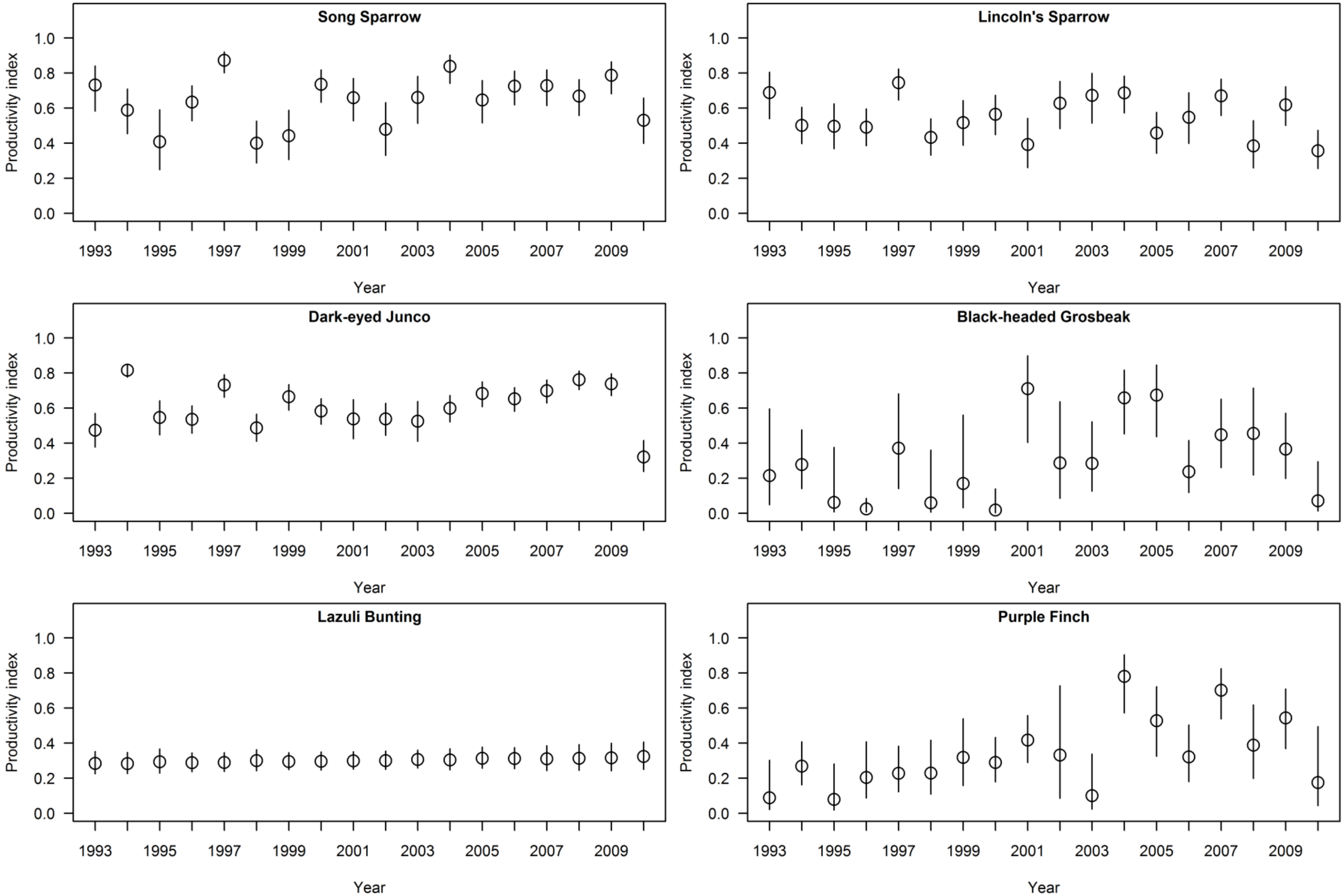


Figure 3, continued.

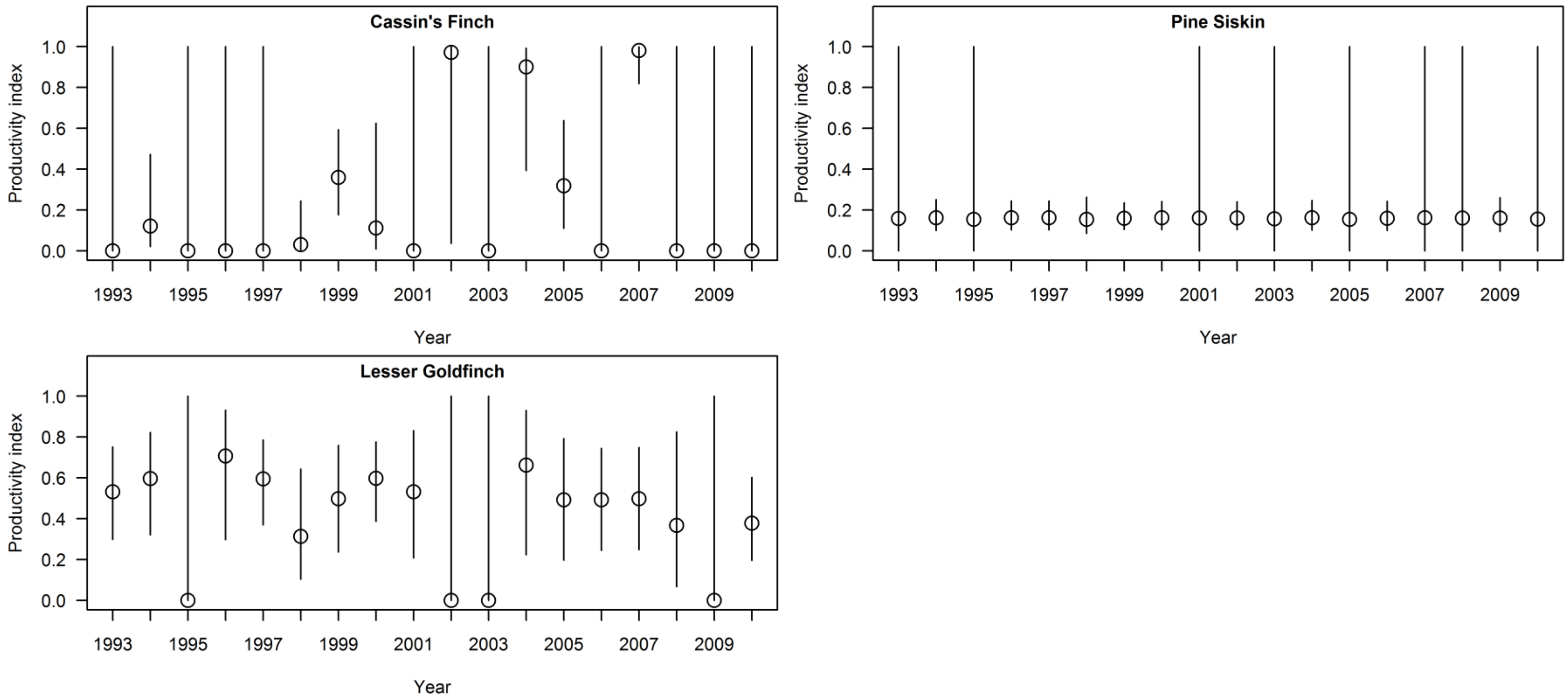


Figure 4. Annual productivity index estimates for 25 bird species (see Table 5) in relation to mean May daily snow water content (cm) measured at the Gin Flat weather station. Estimates represent the probability of a captured bird being a young (hatching year) bird in MAPS period 8 (10-19 July), $\hat{p}_{.j=\bar{j}(\mathtt{per8})t}$; they are model-averaged predictions from logit-linear regression models that aggregated data across stations (i.e., models allowing station-level variation were not included in the model set used for model-averaging).

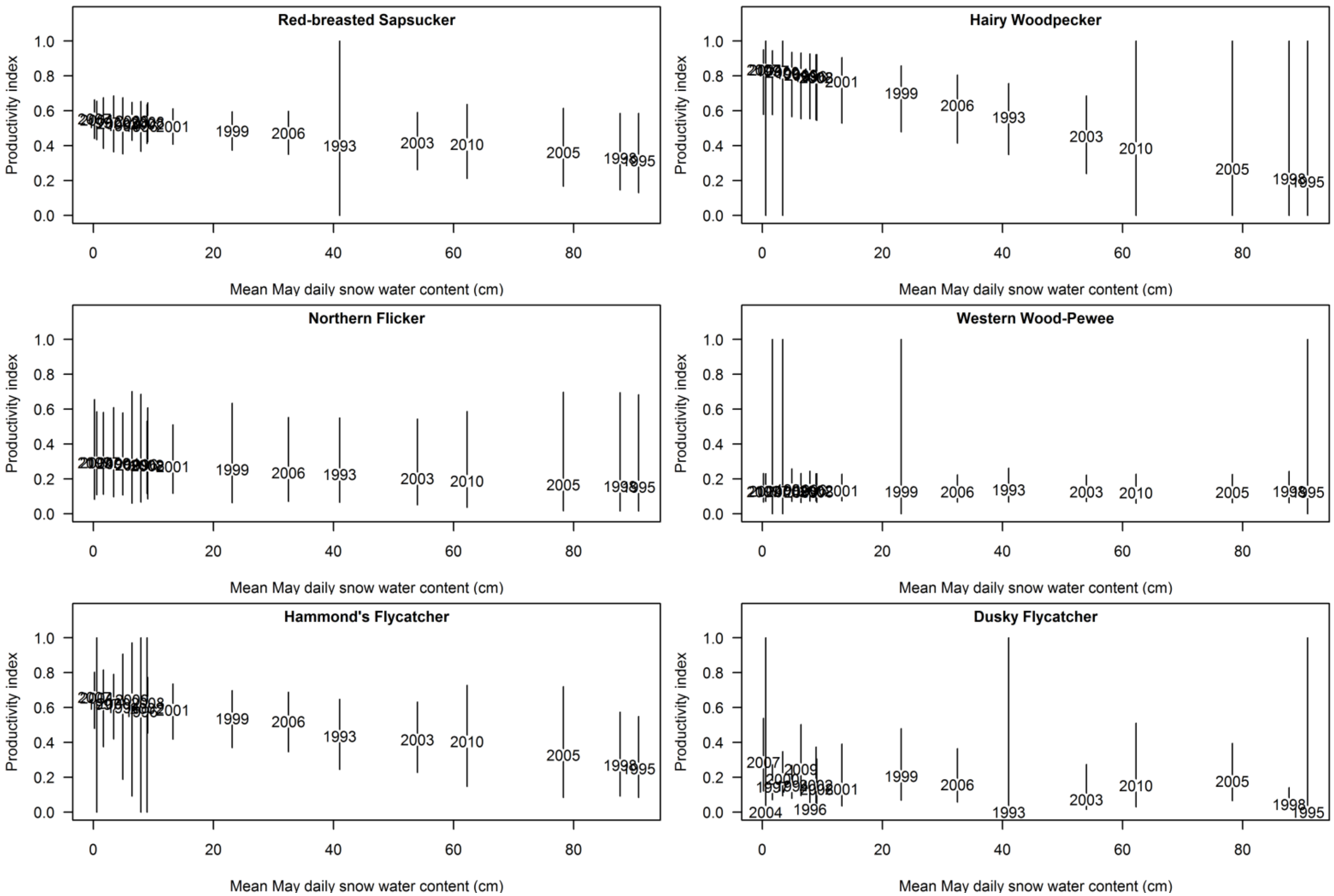


Figure 4, continued.

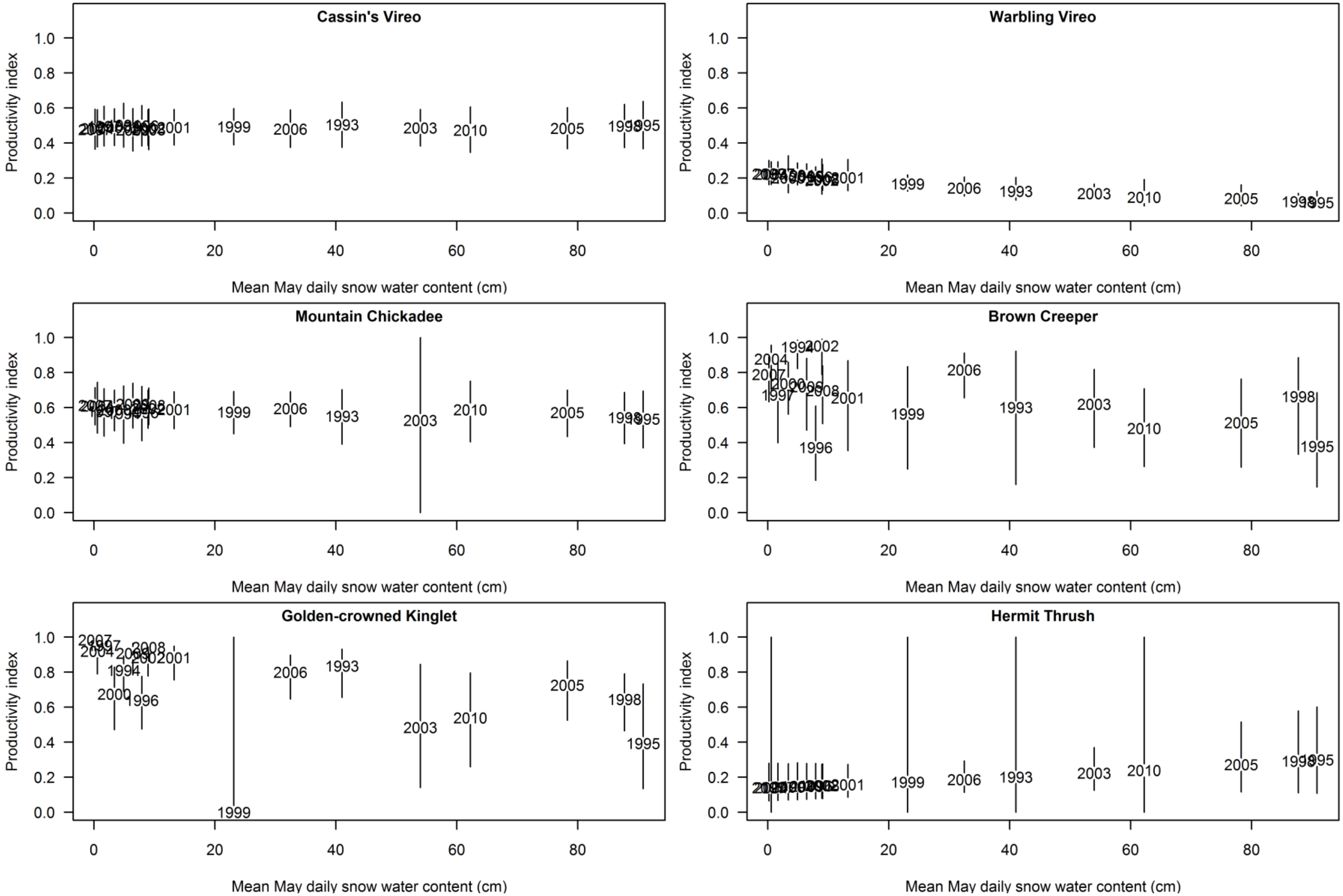


Figure 4, continued.

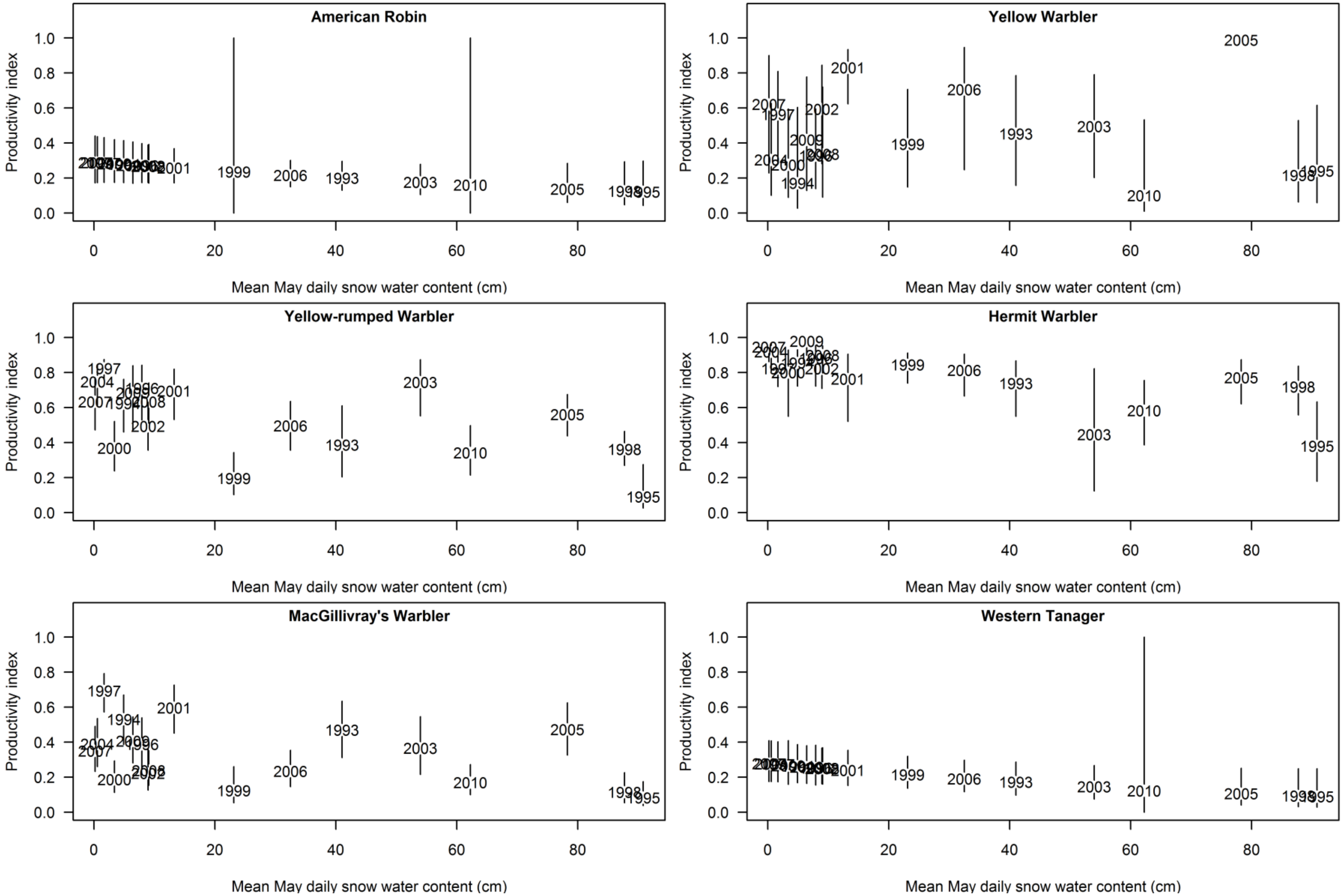


Figure 4, continued.

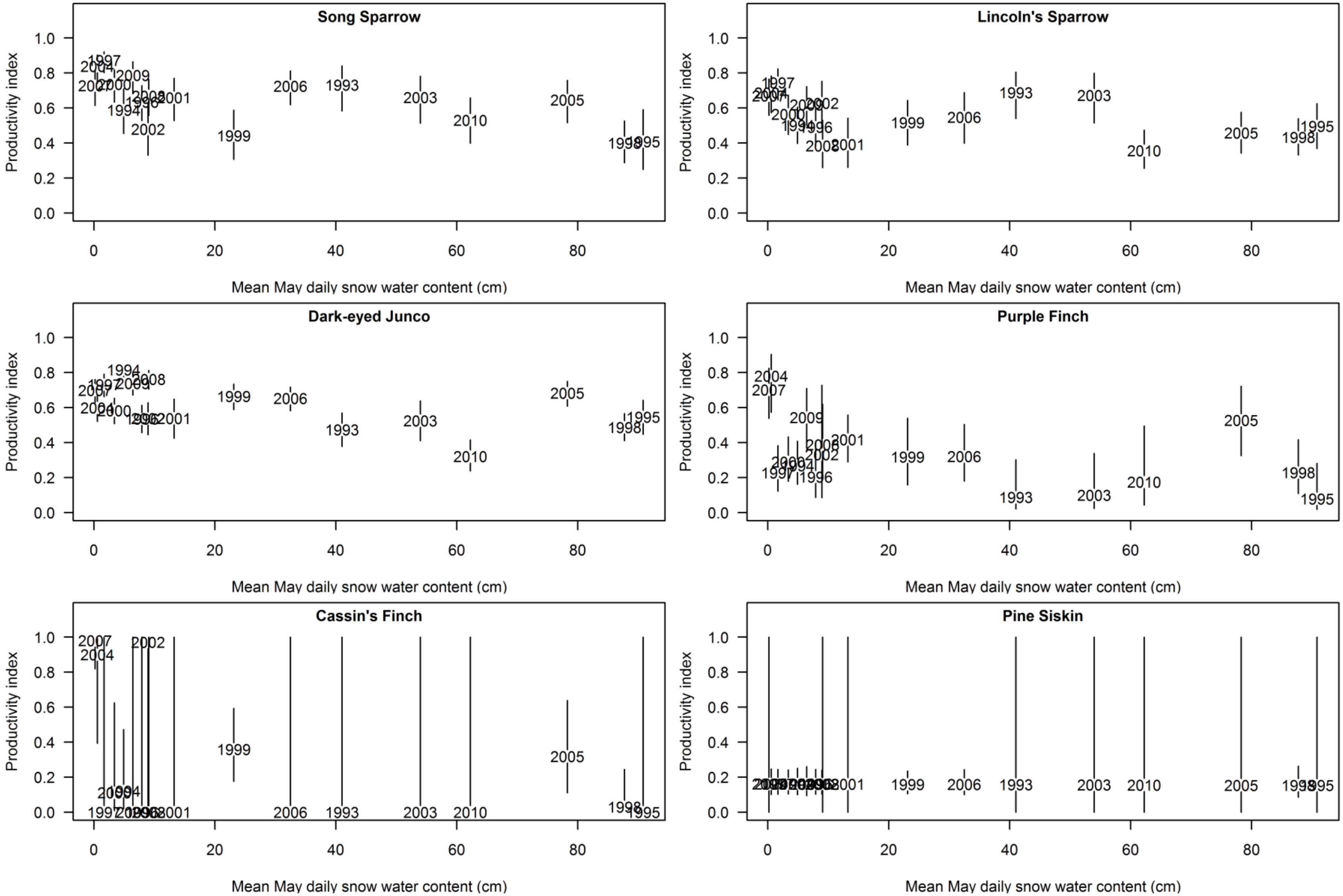


Figure 4, continued.

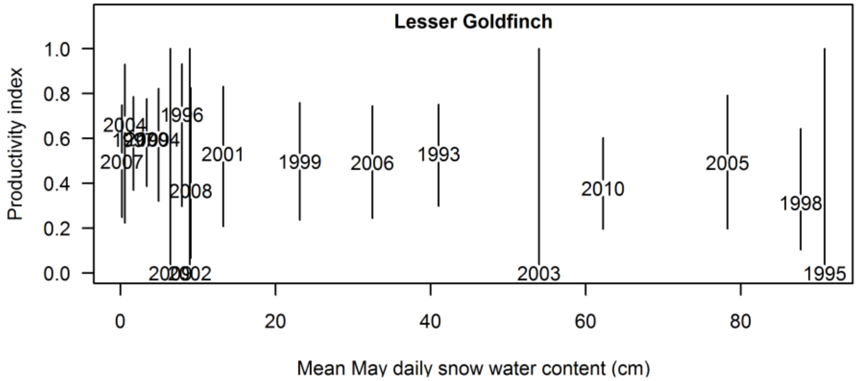
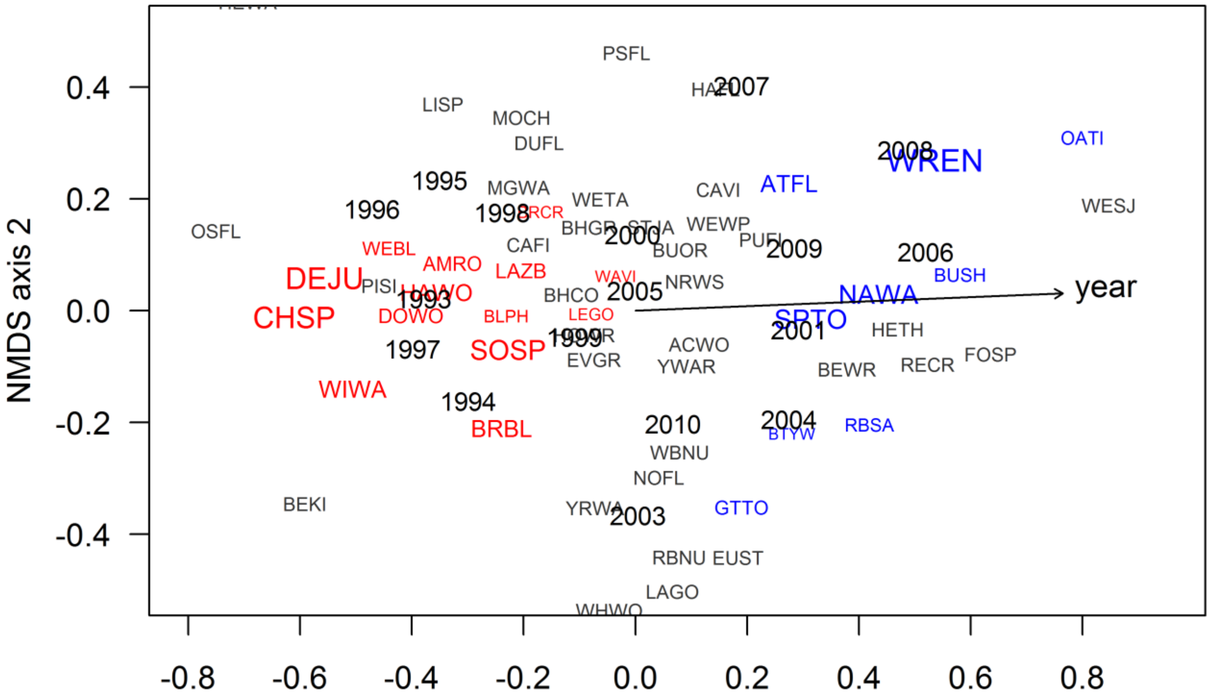


Figure 5 (begins on following page). Non-linear multi-dimensional scaling (NMDS) biplots showing temporal changes in species composition for adult birds at each Monitoring Avian Productivity and Survivorship (MAPS) station in Yosemite National Park from 1993-2010. Scores are based on capture rates of adult breeding birds at the station in ≥ 1 year (see Methods for detail). Species scores are weighted averages of site scores and were expanded such that species and station-time scores had equal variances. They are represented by four-letter species codes (see Appendix 2 for definitions). Gray species codes indicate species with capture rates that were not strongly correlated with year; red codes indicate species that were negatively correlated with year ($P < 0.10$), while blue codes are species that were positively correlated with year ($P < 0.10$). The size of blue and red species codes are scaled to reflect the magnitude of correlation (i.e. stronger correlation is indicated by larger font). Arrow vectors on each plot show the direction and strength of the year (and for White Wolf, snow water content) gradients

Big Meadow (BIME)



Hodgdon Meadow (HODG)

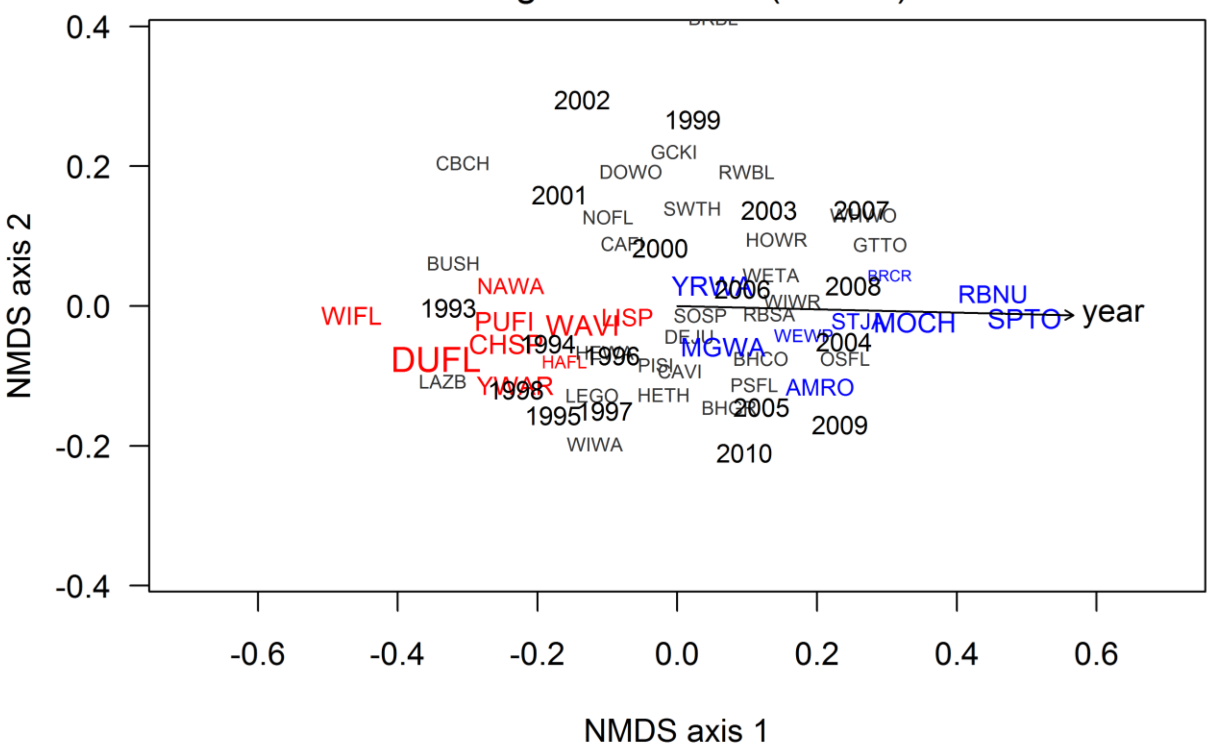


Figure 5, continued.

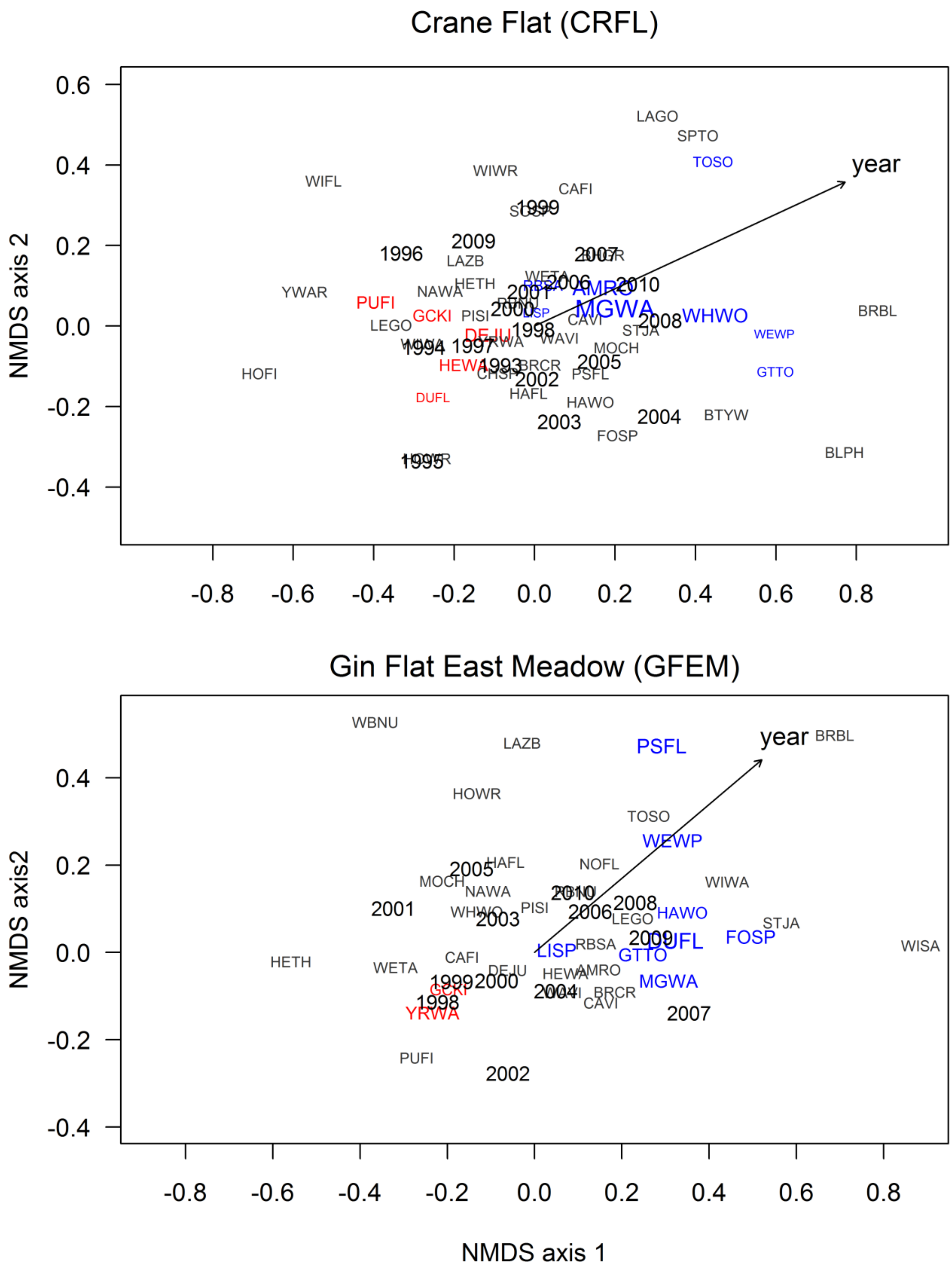
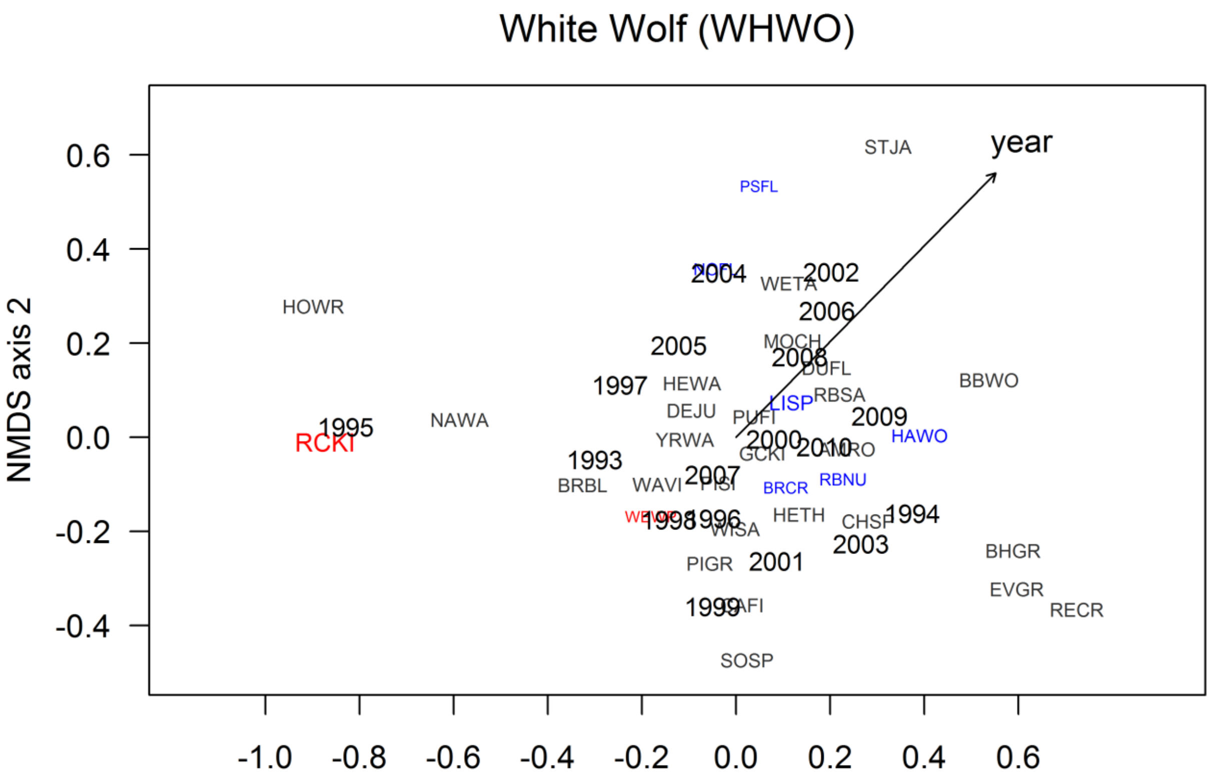


Figure 5, continued.



Appendix 1. Summary of mist-netting effort (net-hours) from 1993-2010 at the 5 Yosemite MAPS stations for each of the eight MAPS 10-day banding periods.

	MAPS period								
t	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Big Meadow (BIME)									
1993	59.50	48.00	50.00	44.00	54.00	50.00	52.00	45.50	403.00
1994	55.00	54.33	58.33	60.00	60.00	60.00	54.83	53.50	456.00
1995	58.33	54.00	45.00	60.83	60.67	59.17	59.33	52.83	450.17
1996	61.00	30.00	60.00	60.00	44.00	43.33	43.67	33.00	375.00
1997	57.17	60.00	51.67	56.33	60.00	51.83	60.00	61.67	458.67
1998	48.83	60.00	56.67	58.00	60.00	60.00	60.00	60.00	463.50
1999	60.00	60.00	46.67	53.33	45.00	34.33	34.50	0.00	333.83
2000	60.00	59.33	48.00	46.00	60.00	60.00	60.00	44.67	438.00
2001	57.00	60.00	58.33	60.00	56.00	60.00	60.00	60.00	471.33
2002	59.17	60.00	58.33	60.00	30.00	54.67	51.17	53.33	426.67
2003	60.00	58.33	53.33	58.33	59.33	38.83	43.67	33.33	405.17
2004	51.50	57.00	56.17	60.00	50.00	50.67	40.00	30.00	395.33
2005	60.00	58.67	60.00	56.67	54.67	50.00	44.67	43.33	428.00
2006	42.33	52.00	60.00	49.83	56.67	54.00	30.00	47.33	392.17
2007	60.00	63.33	60.00	56.67	42.67	32.67	55.50	41.50	412.33
2008	34.50	44.00	50.00	60.00	54.50	55.17	40.17	35.33	373.67
2009	54.00	49.33	54.33	52.00	53.33	51.17	52.50	46.67	413.33
2010	40.67	44.50	56.50	60.00	58.17	46.83	47.50	49.50	403.67
Hodgdon Meadow (HODG)									
1993	84.00	84.00	84.00	84.00	84.00	84.00	79.00	78.00	661.00
1994	84.00	71.17	79.00	81.67	79.67	70.33	68.00	76.83	610.67
1995	81.33	82.83	78.00	83.17	82.33	81.33	84.00	76.00	649.00
1996	83.17	84.00	84.00	75.33	83.17	82.33	74.17	69.83	636.00
1997	78.17	78.00	71.17	69.67	71.17	84.00	78.67	59.50	590.33
1998	90.00	75.67	82.83	82.83	84.00	82.67	83.33	82.83	664.17
1999	84.00	84.00	84.00	84.00	73.33	76.00	64.33	76.17	625.83
2000	79.33	84.00	78.67	84.00	80.33	82.83	84.00	77.33	650.50
2001	83.33	83.17	84.00	81.33	75.33	84.00	84.00	84.00	659.17
2002	84.00	78.17	80.50	84.00	84.00	74.67	82.67	73.50	641.50
2003	79.00	75.00	69.00	72.33	63.50	67.50	54.67	79.33	560.33
2004	60.83	75.83	79.33	80.67	74.67	72.17	72.00	78.50	594.00
2005	83.33	84.00	83.33	81.67	84.00	82.67	77.00	78.67	654.67
2006	78.17	82.67	82.00	84.00	84.00	83.33	70.67	75.33	640.17
2007	83.33	83.33	76.67	77.00	74.83	76.00	80.00	64.67	615.83
2008	63.67	74.67	81.67	75.67	84.00	70.00	76.33	69.33	595.33
2009	77.67	84.00	67.33	75.17	73.33	78.00	73.00	77.00	605.50
2010	46.00	83.17	77.00	82.50	84.00	82.17	77.33	80.00	612.17

Crane Flat (CRFL)

1993	60.00	56.50	46.50	52.00	54.00	60.00	48.00	48.00	425.00
1994	60.00	60.00	61.67	60.00	57.00	39.00	51.33	41.67	430.67
1995	0.00	0.00	46.17	58.33	48.33	59.00	36.67	46.33	294.83
1996	53.33	60.00	60.00	50.83	49.67	60.00	42.00	38.00	413.83
1997	59.17	60.00	60.00	60.00	42.67	57.67	60.00	58.17	457.67
1998	48.00	60.00	60.00	60.00	0.00	58.33	60.00	24.00	370.33
1999	60.00	39.83	60.00	53.33	54.00	60.00	60.00	60.00	447.17
2000	60.00	55.00	60.00	60.00	60.00	60.00	58.33	60.00	473.33
2001	60.00	58.33	60.00	60.00	54.00	60.00	59.33	60.00	471.67
2002	59.33	60.00	58.33	60.00	60.00	57.33	38.00	60.00	453.00
2003	60.00	60.00	56.67	60.00	59.33	54.00	49.83	60.00	459.83
2004	35.17	59.50	63.33	58.00	55.33	59.33	53.83	54.33	438.83
2005	59.33	60.00	60.00	60.00	49.33	51.33	57.33	60.00	457.33
2006	40.50	58.67	60.00	59.33	51.33	38.67	40.00	58.00	406.50
2007	53.33	60.00	60.00	58.00	49.33	58.00	55.50	49.67	443.83
2008	32.17	56.00	60.00	60.00	56.67	59.33	55.00	49.83	429.00
2009	54.67	43.17	53.00	47.50	55.50	54.00	53.17	55.00	416.00
2010	46.83	53.33	58.83	54.50	60.00	53.83	57.50	58.50	443.33

Gin Flat East Meadow (GFEM)

1998	0.00	0.00	60.00	60.00	60.00	58.33	60.00	60.00	358.33
1999	0.00	45.00	60.00	55.00	55.33	59.50	40.83	51.67	367.33
2000	0.00	60.00	60.00	59.33	60.00	58.33	60.00	60.00	417.67
2001	0.00	58.33	54.50	60.00	35.00	60.00	55.67	60.00	383.50
2002	0.00	52.83	60.00	58.67	50.00	52.67	51.33	46.00	371.50
2003	0.00	60.00	60.00	50.00	53.33	33.33	53.83	60.00	370.50
2004	0.00	60.00	61.67	60.00	60.00	53.33	60.00	60.00	415.00
2005	0.00	49.67	59.33	54.67	58.67	56.67	42.00	59.33	380.33

White Wolf (WHWO)

1993	0.00	0.00	60.00	60.00	54.00	51.00	49.50	58.17	332.67
1994	0.00	55.00	46.67	60.00	59.17	59.17	59.83	60.00	399.83
1995	0.00	0.00	0.00	36.00	33.83	61.67	54.00	60.00	245.50
1996	0.00	0.00	60.00	48.00	54.00	52.00	60.00	33.67	307.67
1997	0.00	45.00	60.00	42.17	60.00	46.67	55.00	45.00	353.83
1998	0.00	0.00	37.50	42.50	49.50	52.50	54.00	54.00	290.00
1999	0.00	0.00	42.00	40.00	59.50	40.00	39.00	46.67	267.17
2000	0.00	60.00	60.00	60.00	51.67	60.00	60.00	60.00	411.67
2001	0.00	43.50	45.00	43.50	46.67	46.67	51.67	46.67	323.67
2002	0.00	46.67	50.00	54.00	60.00	53.33	38.33	50.83	353.17
2003	0.00	40.00	51.67	41.67	50.00	44.67	30.00	47.67	305.67
2004	0.00	49.00	53.33	56.67	58.33	53.33	53.33	40.00	364.00
2005	0.00	45.50	59.00	58.00	60.00	54.00	49.67	60.00	386.17
2006	0.00	54.00	59.33	60.00	60.00	60.00	60.00	60.00	413.33
2007	0.00	52.67	53.33	43.33	46.67	60.00	60.00	60.00	376.00

2008	0.00	50.00	56.67	31.33	60.00	54.00	55.00	60.00	367.00
2009	0.00	54.17	48.00	56.67	58.00	60.00	59.00	53.00	388.83
2010	0.00	0.00	44.83	58.33	60.00	60.00	45.00	48.33	316.50

Appendix 2. Numbers of year-specific individual birds captured (N) and capture rates (BNH; birds*100 net-hours^{-1}) at the five Yosemite MAPS stations for 92 species banded between 1993 and 2010. Also included are four-letter species codes used in Figure 2.

			Station									
			Big Meadow (BIME)		Hodgdon Meadow (HODG)		Crane Flat (CRFL)		Gin Flat Meadow East (GFEM)		White Wolf (WHWO)	
Common name	Scientific name	Species code	N	BNH	N	BNH	N	BNH	N	BNH	N	BNH
Sharp-shinned Hawk	*Accipiter striatus*	SSHA	0	0.000	0	0.000	0	0.000	1	0.020	0	0.000
Belted Kingfisher	*Megaceryle alcyon*	BEKI	1	0.013	0	0.000	0	0.000	0	0.000	0	0.000
Acorn Woodpecker	*Melanerpes formicivorus*	ACWO	12	0.160	0	0.000	0	0.000	0	0.000	0	0.000
Williamson's Sapsucker	*Sphyrapicus thyroideus*	WISA	0	0.000	0	0.000	0	0.000	8	0.164	69	1.112
Red-breasted Sapsucker	*Sphyrapicus ruber*	RBSA	34	0.453	241	2.139	71	0.918	88	1.800	11	0.177
Nuttall's Woodpecker	*Picoides nuttallii*	NUWO	1	0.013	0	0.000	0	0.000	0	0.000	0	0.000
Downy Woodpecker	*Picoides pubescens*	DOWO	32	0.427	16	0.142	0	0.000	0	0.000	0	0.000
Hairy Woodpecker	*Picoides villosus*	HAWO	32	0.427	13	0.115	15	0.194	11	0.225	9	0.145
White-headed Woodpecker	*Picoides albolarvatus*	WHWO	10	0.133	25	0.222	27	0.349	15	0.307	0	0.000
Black-backed Woodpecker	*Picoides arcticus*	BBWO	0	0.000	0	0.000	0	0.000	0	0.000	1	0.016
Northern Flicker	*Colaptes auratus*	RSFL	26	0.347	23	0.204	6	0.078	5	0.102	7	0.113
Olive-sided Flycatcher	*Contopus cooperi*	OSFL	3	0.040	16	0.142	0	0.000	2	0.041	0	0.000
Western Wood-Pewee	*Contopus sordidulus*	WEWP	125	1.667	119	1.056	3	0.039	29	0.593	15	0.242
Willow Flycatcher	*Empidonax traillii*	WIFL	12	0.160	33	0.293	6	0.078	0	0.000	0	0.000

Hammond's Flycatcher	*Empidonax hammondii*	HAFL	4	0.053	50	0.444	87	1.125	103	2.106	29	0.468
Gray Flycatcher	*Empidonax wrightii*	GRFL	1	0.013	2	0.018	1	0.013	0	0.000	1	0.016
Dusky Flycatcher	*Empidonax oberholseri*	DUFL	19	0.253	339	3.009	299	3.867	96	1.963	41	0.661
Pacific-slope Flycatcher	*Empidonax difficilis*	PSFL	13	0.173	174	1.544	79	1.022	28	0.573	11	0.177
Black Phoebe	*Sayornis nigricans*	BLPH	175	2.333	14	0.124	3	0.039	4	0.082	0	0.000
Ash-throated Flycatcher	*Myiarchus cinerascens*	ATFL	6	0.080	0	0.000	0	0.000	0	0.000	0	0.000
Western Kingbird	*Tyrannus verticalis*	WEKI	2	0.027	0	0.000	0	0.000	0	0.000	0	0.000
Cassin's Vireo	*Vireo cassinii*	CAVI	28	0.373	147	1.305	49	0.634	11	0.225	5	0.081
Hutton's Vireo	*Vireo huttoni*	HUVI	0	0.000	2	0.018	1	0.013	0	0.000	0	0.000
Warbling Vireo	*Vireo gilvus*	WAVI	140	1.867	711	6.311	338	4.371	21	0.429	29	0.468
Steller's Jay	*Cyanocitta stelleri*	STJA	4	0.053	36	0.320	2	0.026	11	0.225	3	0.048
Western Scrub-Jay	*Aphelocoma californica*	WESJ	4	0.053	0	0.000	0	0.000	0	0.000	0	0.000
Tree Swallow	*Tachycineta bicolor*	TRES	1	0.013	0	0.000	0	0.000	0	0.000	0	0.000
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	NRWS	6	0.080	0	0.000	0	0.000	0	0.000	0	0.000
Mountain Chickadee	*Poecile gambeli*	MOCH	5	0.067	75	0.666	174	2.250	176	3.599	116	1.870
Chestnut-backed Chickadee	*Poecile rufescens*	CBCH	0	0.000	18	0.160	1	0.013	0	0.000	1	0.016
Oak Titmouse	*Baeolophus inornatus*	OATI	11	0.147	0	0.000	0	0.000	0	0.000	0	0.000
Bushtit	*Psaltriparus minimus*	BUSH	145	1.933	54	0.479	0	0.000	0	0.000	0	0.000
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	1	0.013	110	0.976	215	2.781	91	1.861	26	0.419
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	12	0.160	1	0.009	2	0.026	4	0.082	0	0.000
Brown Creeper	*Certhia americana*	BRCR	58	0.773	84	0.746	153	1.979	85	1.738	140	2.257
Bewick's Wren	*Thryomanes bewickii*	BEWR	41	0.547	0	0.000	0	0.000	1	0.020	0	0.000

House Wren	*Troglodytes aedon*	HOWR	164	2.187	104	0.923	165	2.134	44	0.900	39	0.629
Pacific Wren	*Troglodytes pacificus*	PAWR	4	0.053	32	0.284	14	0.181	0	0.000	1	0.016
American Dipper	*Cinclus mexicanus*	AMDI	1	0.013	0	0.000	0	0.000	0	0.000	0	0.000
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	0	0.000	86	0.763	495	6.402	304	6.217	82	1.322
Ruby-crowned Kinglet	*Regulus calendula*	RCKI	0	0.000	0	0.000	0	0.000	0	0.000	7	0.113
Western Bluebird	*Sialia mexicana*	WEBL	29	0.387	0	0.000	0	0.000	4	0.082	0	0.000
Townsend's Solitaire	*Myadestes townsendi*	TOSO	1	0.013	7	0.062	2	0.026	10	0.205	0	0.000
Swainson's Thrush	*Catharus ustulatus*	SWTH	0	0.000	9	0.080	0	0.000	0	0.000	0	0.000
Hermit Thrush	*Catharus guttatus*	HETH	4	0.053	45	0.399	70	0.905	2	0.041	30	0.484
American Robin	*Turdus migratorius*	AMRO	57	0.760	121	1.074	68	0.879	72	1.472	101	1.628
Wrentit	*Chamaea fasciata*	WREN	137	1.827	0	0.000	0	0.000	0	0.000	0	0.000
European Starling	*Sturnus vulgaris*	EUST	4	0.053	0	0.000	0	0.000	0	0.000	0	0.000
Orange-crowned Warbler	*Vermivora celata*	OCWA	737	9.827	2050	18.196	1471	19.024	345	7.055	374	6.030
Nashville Warbler	*Vermivora ruficapilla*	NAWA	167	2.227	336	2.982	472	6.104	218	4.458	264	4.256
Yellow Warbler	*Dendroica petechia*	YWAR	214	2.853	157	1.394	25	0.323	0	0.000	2	0.032
Yellow-rumped Warbler	*Dendroica coronata*	AUWA	15	0.200	172	1.527	693	8.963	1154	23.600	522	8.416
Black-throated Gray Warbler	*Dendroica nigrescens*	BTYW	16	0.213	34	0.302	21	0.272	6	0.123	1	0.016
Townsend's Warbler	*Dendroica townsendi*	TOWA	0	0.000	1	0.009	11	0.142	14	0.286	2	0.032
Hermit Warbler	*Dendroica occidentalis*	HEWA	1	0.013	344	3.053	574	7.424	166	3.395	144	2.322
American Redstart	*Setophaga ruticilla*	AMRE	0	0.000	4	0.036	0	0.000	0	0.000	0	0.000
MacGillivray's Warbler	*Oporornis tolmiei*	MGWA	232	3.093	1688	14.983	602	7.786	150	3.068	9	0.145
Common Yellowthroat	*Geothlypis trichas*	COYE	0	0.000	2	0.018	0	0.000	0	0.000	0	0.000

Hooded Warbler	*Wilsonia citrina*	HOWA	0	0.000	1	0.009	0	0.000	0	0.000	0	0.000
Wilson's Warbler	*Wilsonia pusilla*	WIWA	17	0.227	106	0.941	78	1.009	24	0.491	18	0.290
Western Tanager	*Piranga ludoviciana*	WETA	50	0.667	171	1.518	65	0.841	118	2.413	12	0.193
Green-tailed Towhee	*Pipilo chlorurus*	GTTO	4	0.053	2	0.018	7	0.091	16	0.327	0	0.000
Spotted Towhee	*Pipilo maculatus*	SPTO	146	1.947	51	0.453	3	0.039	1	0.020	0	0.000
California Towhee	*Pipilo crissalis*	CALT	3	0.040	0	0.000	0	0.000	0	0.000	0	0.000
Chipping Sparrow	*Spizella passerina*	CHSP	138	1.840	77	0.683	102	1.319	8	0.164	19	0.306
Sage Sparrow	*Amphispiza belli*	SAGS	1	0.013	0	0.000	0	0.000	0	0.000	0	0.000
Savannah Sparrow	*Passerculus sandwichensis*	SAVS	4	0.053	0	0.000	0	0.000	0	0.000	0	0.000
Fox Sparrow	*Passerella iliaca*	FOSP	3	0.040	1	0.009	5	0.065	38	0.777	1	0.016
Song Sparrow	*Melospiza melodia*	SOSP	154	2.053	1225	10.873	192	2.483	18	0.368	4	0.064
Lincoln's Sparrow	*Melospiza lincolnii*	LISP	35	0.467	739	6.559	1262	16.321	603	12.332	169	2.725
Dark-eyed Junco	*Junco hyemalis*	ORJU	61	0.813	811	7.199	1906	24.650	709	14.499	1008	16.251
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	0	0.000	2	0.018	0	0.000	0	0.000	0	0.000
Black-headed Grosbeak	*Pheucticus melanocephalus*	BHGR	297	3.960	308	2.734	18	0.233	17	0.348	4	0.064
Lazuli Bunting	*Passerina amoena*	LAZB	636	8.480	14	0.124	136	1.759	5	0.102	2	0.032
Indigo Bunting	*Passerina cyanea*	INBU	0	0.000	1	0.009	2	0.026	0	0.000	0	0.000
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL	0	0.000	76	0.675	0	0.000	0	0.000	0	0.000
Brewer's Blackbird	*Euphagus cyanocephalus*	BRBL	33	0.440	15	0.133	2	0.026	6	0.123	7	0.113
Brown-headed Cowbird	*Molothrus ater*	BHCO	11	0.147	6	0.053	1	0.013	1	0.020	0	0.000
Bullock's Oriole	*Icterus bullockii*	BUOR	35	0.467	0	0.000	0	0.000	1	0.020	0	0.000
Pine Grosbeak	*Pinicola enucleator*	PIGR	0	0.000	0	0.000	0	0.000	0	0.000	45	0.725

Purple Finch	*Carpodacus purpureus*	PUFI	318	4.240	220	1.953	97	1.254	10	0.205	8	0.129
Cassin's Finch	*Carpodacus cassinii*	CAFI	22	0.293	40	0.355	30	0.388	25	0.511	111	1.790
House Finch	*Carpodacus mexicanus*	HOFI	0	0.000	3	0.027	1	0.013	0	0.000	0	0.000
Red Crossbill	*Loxia curvirostra*	RECR	3	0.040	11	0.098	0	0.000	0	0.000	1	0.016
Pine Siskin	*Carduelis pinus*	PISI	10	0.133	52	0.462	62	0.802	162	3.313	72	1.161
Lesser Goldfinch	*Carduelis psaltria*	LEGO	234	3.120	15	0.133	11	0.142	52	1.063	0	0.000
Lawrence's Goldfinch	*Carduelis lawrencei*	LAGO	45	0.600	0	0.000	1	0.013	2	0.041	0	0.000
American Goldfinch	*Carduelis tristis*	AMGO	2	0.027	0	0.000	0	0.000	0	0.000	0	0.000
Evening Grosbeak	*Coccothraustes vespertinus*	EVGR	22	0.293	1	0.009	0	0.000	1	0.020	3	0.048
House Sparrow	*Passer domesticus*	HOSP	1	0.013	0	0.000	0	0.000	0	0.000	0	0.000

Appendix 3. Model selection results for productivity models for the 34 bird species captured at four MAPS stations in Yosemite National Park 1993-2010 (see *Methods: Statistical analyses: Productivity* for detail). Models comprising ≥ 95% support are shown for each species. Note: models with * denote inclusion of each individual term + 2-way interactions (e.g., swc*sta = swc + sta + swc×sta).

Model	No. parameters	AIC_c	ΔAIC_c	Model likelihood	Model weight (w_i)	$\sum w_i$
Red-breasted Sapsucker (*Sphyrapicus ruber*)						
swc*sta + doy + doy^2	10	286.433	0.000	1.000	0.272	0.272
swc + doy + doy^2	4	286.462	0.029	0.986	0.268	0.540
swc + sta + doy + doy^2	7	287.687	1.255	0.534	0.145	0.686
T + doy + doy^2	4	289.404	2.972	0.226	0.062	0.747
swc + sta + doy	6	289.611	3.178	0.204	0.056	0.803
swc + doy	3	289.734	3.302	0.192	0.052	0.855
doy + doy^2	3	290.122	3.690	0.158	0.043	0.898
swc*sta + doy	9	291.248	4.816	0.090	0.024	0.923
T* sta + doy + doy^2	10	291.650	5.217	0.074	0.020	0.943
T + sta + doy + doy^2	7	291.937	5.505	0.064	0.017	0.960
Hairy Woodpecker (*Picoides villosus*)						
swc + doy + doy^2	4	64.811	0.000	1.000	0.389	0.389
swc + doy	3	65.268	0.457	0.796	0.310	0.699
swc + sta + doy + doy^2	7	66.941	2.129	0.345	0.134	0.833
swc + sta + doy	6	68.175	3.364	0.186	0.072	0.906
swc*sta + doy + doy^2	10	69.263	4.452	0.108	0.042	0.948
swc*sta + doy	9	70.329	5.518	0.063	0.025	0.972
Northern Flicker (*Colaptes auratus*)						
swc*sta + doy + doy^2	10	24.681	0.000	1.000	0.922	0.922
swc*sta + doy	9	29.880	5.199	0.074	0.069	0.991
Western Wood-Pewee (*Contopus sordidulus*)						
doy	2	155.822	0.000	1.000	0.237	0.237

doy + doy^2	3	156.071	0.249	0.883	0.210	0.447
T + doy	3	157.281	1.459	0.482	0.114	0.562
T + doy + doy^2	4	157.458	1.636	0.441	0.105	0.666
swc + doy	3	157.623	1.801	0.406	0.097	0.763
swc + doy + doy^2	4	157.856	2.034	0.362	0.086	0.849
swc*sta + doy + doy^2	10	158.727	2.905	0.234	0.056	0.904
swc*sta + doy	9	158.976	3.154	0.207	0.049	0.953
<u>Hammond's Flycatcher (*Empidonax hammondii*)</u>						
T + sta + doy + doy^2	7	105.528	0.000	1.000	0.441	0.441
swc + sta + doy + doy^2	7	106.791	1.263	0.532	0.235	0.676
sta + doy + doy^2	6	108.463	2.935	0.231	0.102	0.778
T + sta + doy	6	109.520	3.992	0.136	0.060	0.838
T* sta + doy + doy^2	10	109.734	4.206	0.122	0.054	0.892
swc + sta + doy	6	110.524	4.996	0.082	0.036	0.928
swc*sta + doy + doy^2	10	110.567	5.039	0.081	0.036	0.964
<u>Dusky Flycatcher (*Empidonax oberholseri*)</u>						
t + doy	19	365.708	0.000	1.000	0.618	0.618
t + doy + doy^2	20	367.419	1.711	0.425	0.263	0.881
t + sta + doy	22	370.379	4.671	0.097	0.060	0.940
t + sta + doy + doy^2	23	371.996	6.288	0.043	0.027	0.967
<u>Pacific-slope Flycatcher (Empidonax difficilis)</u>						
t + sta + doy + doy^2	23	310.480	0.000	1.000	0.852	0.852
t + sta + doy	22	314.263	3.782	0.151	0.129	0.981
<u>Cassin's Vireo (*Vireo cassinii*)</u>						
sta + doy + doy^2	6	230.043	0.000	1.000	0.203	0.203
swc*sta + doy + doy^2	10	230.166	0.122	0.941	0.191	0.393
sta + doy	5	230.882	0.838	0.658	0.133	0.526
T + sta + doy + doy^2	7	231.736	1.692	0.429	0.087	0.613
swc + sta + doy + doy^2	7	231.932	1.889	0.389	0.079	0.692
T + sta + doy	6	232.608	2.565	0.277	0.056	0.748
swc + sta + doy	6	232.747	2.704	0.259	0.052	0.801
T* sta + doy + doy^2	10	233.023	2.979	0.225	0.046	0.846

T*sta + doy	9	233.130	3.086	0.214	0.043	0.890
swc*sta + doy	9	233.147	3.104	0.212	0.043	0.933
doy + doy^2	3	234.229	4.185	0.123	0.025	0.958
Warbling Vireo (*Vireo gilvus*)						
swc*sta + doy	9	707.994	0.000	1.000	0.642	0.642
swc*sta + doy + doy^2	10	710.029	2.035	0.361	0.232	0.874
swc + sta + doy	6	712.088	4.094	0.129	0.083	0.957
Mountain Chickadee (*Poecile gambeli*)						
swc + sta + doy + doy^2	7	291.754	0.000	1.000	0.519	0.519
sta + doy + doy^2	6	293.401	1.647	0.439	0.228	0.747
T + sta + doy + doy^2	7	294.232	2.478	0.290	0.150	0.897
swc*sta + doy + doy^2	10	297.961	6.207	0.045	0.023	0.920
swc + sta + doy	6	298.045	6.291	0.043	0.022	0.943
T* sta + doy + doy^2	10	298.301	6.547	0.038	0.020	0.962
Red-breasted Nuthatch (*Sitta canadensis*)						
t + doy	19	321.913	0.000	1.000	0.509	0.509
t + doy + doy^2	20	323.022	1.108	0.575	0.292	0.802
t + sta + doy	22	324.751	2.838	0.242	0.123	0.925
t + sta + doy + doy^2	23	325.736	3.823	0.148	0.075	1.000
Brown Creeper (*Certhia americana*)						
swc + sta + doy + doy^2	7	402.547	0.000	1.000	0.530	0.530
swc + sta + doy	6	403.752	1.205	0.547	0.290	0.821
t + sta + doy	22	407.315	4.768	0.092	0.049	0.870
t + sta + doy + doy^2	23	407.318	4.771	0.092	0.049	0.918
swc*sta + doy + doy^2	10	407.492	4.945	0.084	0.045	0.963
House Wren (*Troglodytes aedon*)						
t + sta + doy + doy^2	23	367.272	0.000	1.000	0.990	0.990
Doy	2	56.026	0.000	1.000	0.363	0.363
T + doy	3	56.759	0.733	0.693	0.251	0.614
doy + doy^2	3	58.295	2.269	0.322	0.117	0.730
swc + doy	3	58.296	2.270	0.321	0.117	0.847

T + doy + doy^2	4	59.143	3.118	0.210	0.076	0.923
swc + doy + doy^2	4	60.669	4.643	0.098	0.036	0.959
Golden-crowned Kinglet (*Regulus satrapa*)						
t + sta + doy + doy^2	22	595.301	0.000	1.000	1.000	1.000
Hermit Thrush (*Catharus guttatus*)						
swc*sta + doy	9	113.239	0.000	1.000	0.285	0.285
swc + doy	3	113.920	0.681	0.711	0.203	0.488
swc + sta + doy	6	115.170	1.931	0.381	0.109	0.597
swc*sta + doy + doy^2	10	115.483	2.244	0.326	0.093	0.690
Doy	2	115.937	2.698	0.260	0.074	0.764
swc + doy + doy^2	4	116.031	2.792	0.248	0.071	0.834
swc + sta + doy + doy^2	7	116.937	3.698	0.157	0.045	0.879
sta + doy	5	117.702	4.463	0.107	0.031	0.910
T + doy	3	118.011	4.772	0.092	0.026	0.936
doy + doy^2	3	118.014	4.775	0.092	0.026	0.962
American Robin (*Turdus migratorius*)						
swc + doy	3	167.007	0.000	1.000	0.470	0.470
swc + doy + doy^2	4	168.941	1.934	0.380	0.179	0.649
swc + sta + doy	6	170.295	3.288	0.193	0.091	0.740
Doy	2	170.425	3.418	0.181	0.085	0.825
T + doy	3	172.374	5.368	0.068	0.032	0.857
swc + sta + doy + doy^2	7	172.382	5.375	0.068	0.032	0.889
doy + doy^2	3	172.386	5.379	0.068	0.032	0.921
sta + doy	5	172.469	5.462	0.065	0.031	0.952
Nashville Warbler (*Oreothlypis ruficapilla*)						
t + sta + doy + doy^2	23	722.600	0.000	1.000	0.850	0.850
T* sta + doy + doy^2	10	726.115	3.514	0.173	0.147	0.997
Yellow Warbler (*Dendroica petechia*)						
t + doy	19	281.111	0.000	1.000	0.683	0.683
t + doy + doy^2	20	283.352	2.241	0.326	0.223	0.906
t + sta + doy	22	285.635	4.524	0.104	0.071	0.977

Yellow-rumped Warbler (*Dendroica coronata*)						
t + sta + doy + doy^2	23	1208.926	0.000	1.000	0.997	0.997
Hermit Warbler (*Dendroica occidentalis*)						
swc*sta + doy + doy^2	9	733.937	0.000	1.000	0.466	0.466
t + doy + doy^2	20	734.201	0.265	0.876	0.408	0.874
t + sta + doy + doy^2	23	737.085	3.149	0.207	0.097	0.971
MacGillivray's Warbler (*Oporornis tolmiei*)						
t + sta + doy + doy^2	23	1215.107	0.000	1.000	0.946	0.946
t + sta + doy	22	1221.381	6.274	0.043	0.041	0.987
Wilson's Warbler (*Wilsonia pusilla*)						
t + sta + doy	22	129.882	0.000	1.000	0.483	0.483
t + doy	19	131.366	1.485	0.476	0.230	0.712
t + sta + doy + doy^2	23	132.407	2.526	0.283	0.137	0.849
t + doy + doy^2	20	133.713	3.831	0.147	0.071	0.920
swc + doy + doy^2	4	137.257	7.375	0.025	0.012	0.932
swc + sta + doy + doy^2	7	137.601	7.720	0.021	0.010	0.942
swc + sta + doy	6	137.761	7.880	0.019	0.009	0.952
Western Tanager (*Piranga ludoviciana*)						
swc + doy + doy^2	4	225.376	0.000	1.000	0.354	0.354
swc + doy	3	225.874	0.498	0.780	0.276	0.629
swc + sta + doy	6	227.449	2.073	0.355	0.125	0.755
swc + sta + doy + doy^2	7	228.175	2.800	0.247	0.087	0.842
doy + doy^2	3	230.848	5.473	0.065	0.023	0.865
sta + doy	5	231.072	5.696	0.058	0.020	0.885
swc*sta + doy	9	231.091	5.715	0.057	0.020	0.906
doy	2	231.200	5.825	0.054	0.019	0.925
swc*sta + doy + doy^2	10	231.944	6.568	0.037	0.013	0.938
sta + doy + doy^2	6	231.949	6.573	0.037	0.013	0.951
Chipping Sparrow (*Spizella passerina*)						
T + sta + doy + doy^2	7	215.200	0.000	1.000	0.394	0.394
T + doy + doy^2	4	215.713	0.513	0.774	0.305	0.698

swc + doy + doy^2	4	217.784	2.585	0.275	0.108	0.807
doy + doy^2	3	218.305	3.105	0.212	0.083	0.890
T* sta + doy + doy^2	10	219.122	3.922	0.141	0.055	0.945
swc + sta + doy + doy^2	7	221.494	6.295	0.043	0.017	0.962
<u>Song Sparrow (*Melospiza melodia*)</u>						
t + doy + doy^2	20	1508.572	0.000	1.000	0.829	0.829
t + sta + doy + doy^2	23	1511.725	3.153	0.207	0.171	1.000
<u>Lincoln's Sparrow (*Melospiza lincolnii*)</u>						
t + sta + doy + doy^2	23	1680.406	0.000	1.000	0.999	0.999
<u>Dark-eyed Junco (*Junco hyemalis*)</u>						
t + sta + doy + doy^2	23	3701.299	0.000	1.000	1.000	1.000
<u>Black-headed Grosbeak (*Pheucticus melanocephalus*)</u>						
t + sta + doy	22	400.328	0.000	1.000	0.409	0.409
t + doy	19	400.977	0.650	0.723	0.295	0.704
t + sta + doy + doy^2	23	402.108	1.781	0.411	0.168	0.872
t + doy + doy^2	20	402.647	2.320	0.314	0.128	1.000
<u>Lazuli Bunting (*Passerina amoena*)</u>						
T + sta + doy + doy^2	7	800.672	0.000	1.000	0.604	0.604
sta + doy + doy^2	6	803.133	2.461	0.292	0.177	0.781
T + sta + doy	6	804.997	4.325	0.115	0.070	0.851
swc + sta + doy + doy^2	7	805.121	4.449	0.108	0.065	0.916
T* sta + doy + doy^2	10	805.953	5.281	0.071	0.043	0.959
<u>Purple Finch (*Carpodacus purpureus*)</u>						
t + sta + doy	22	635.228	0.000	1.000	0.583	0.583
t + sta + doy + doy^2	23	636.877	1.649	0.438	0.255	0.838
T*sta + doy	9	639.988	4.760	0.093	0.054	0.892
T + sta + doy	6	640.875	5.648	0.059	0.035	0.927
T* sta + doy + doy^2	10	641.464	6.237	0.044	0.026	0.953
<u>Cassin's Finch (*Carpodacus cassinii*)</u>						
swc + sta + doy	6	98.522	0.000	1.000	0.382	0.382

swc + sta + doy + doy^2	7	100.394	1.872	0.392	0.150	0.532
t + sta + doy	22	100.815	2.294	0.318	0.121	0.653
swc*sta + doy	9	101.424	2.902	0.234	0.090	0.743
T*sta + doy	9	101.491	2.970	0.227	0.087	0.829
T* sta + doy + doy^2	10	102.753	4.232	0.121	0.046	0.875
swc*sta + doy + doy^2	10	103.320	4.799	0.091	0.035	0.910
t + sta + doy + doy^2	23	103.351	4.830	0.089	0.034	0.944
sta + doy	5	103.984	5.463	0.065	0.025	0.969
Pine Siskin (*Spinus pinus*)						
swc*sta + doy	9	131.595	0.000	1.000	0.578	0.578
swc*sta + doy + doy^2	10	133.027	1.432	0.489	0.282	0.860
sta + doy	5	136.435	4.840	0.089	0.051	0.912
swc + sta + doy	6	138.382	6.787	0.034	0.019	0.931
T + sta + doy	6	138.546	6.952	0.031	0.018	0.949
sta + doy + doy^2	6	138.550	6.955	0.031	0.018	0.967
Lesser Goldfinch (*Spinus psaltria*)						
swc + sta + doy + doy^2	6	263.839	0.000	1.000	0.420	0.420
swc*sta + doy + doy^2	8	265.971	2.132	0.344	0.145	0.565
t + doy + doy^2	20	266.223	2.385	0.304	0.128	0.693
t + sta + doy + doy^2	22	266.262	2.423	0.298	0.125	0.818
swc + doy + doy^2	4	266.978	3.139	0.208	0.087	0.905
swc + sta + doy	5	269.174	5.335	0.069	0.029	0.934
sta + doy + doy^2	5	270.313	6.475	0.039	0.017	0.951