Riparian Bird Population Monitoring in Utah, 1992-2001[1]

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Abstract

We report statewide linear and non-linear trends in density from 1992 to 2001 for six common bird species in the riparian areas of Utah. The six species examined here represent over 24 percent of all observations in the period. Four of the six species showed linear declines (Black-headed Grosbeak [*Pheucticus melanocephalus*], American Goldfinch [*Carduelis tristis*], American Robin [*Turdus migratorius*], and Broad-tailed Hummingbird [*Selasphorus platycercus*]) over this period, but the decline in only one species—the Broad-tailed Hummingbird—was considered significant here (F = 19.45, P = 0.002). Yellow Warbler (*Dendroica petechia*) numbers showed the only other significant linear trend, increasing significantly since 1992 (F = 15.30, P = 0.004); Song Sparrow (*Melospiza melodia*) numbers showed a non-significant increase. A parallel analysis, using Generalized Linear Models to identify non-linear patterns in population trends, showed two apparently consistent patterns of population change with synchronous timing of significant trend inflection points. The evaluation of these non-linear patterns, if they persist as additional analyses are competed, will be important to future assessments of Utah's avian conservation needs.

Keywords American Goldfinch, American Robin, Black-headed Grosbeak, Broad-tailed Hummingbird, distance sampling, Generalized Additive Model, monitoring, population, riparian, Song Sparrow, trend, Utah, Yellow Warbler.

Introduction

At the beginning of this study in 1992, little was known about Utah's riparian bird populations beyond a general sense of their importance. Their breeding status, distribution, densities, population trends, or use of habitat components in Utah were either not well documented or largely unknown. Further, Breeding Bird Survey (BBS) data suggested that long-term large-scale declines in bird populations had occurred, and were occurring, over large portions of North America (Robbins et al. 1989). Some declines were regional in scope; others were most notable in suites of species such as neotropical migratory birds (NTMB). But BBS data from our region were largely equivocal.

There are two major reasons why the BBS was not well suited to monitoring riparian bird populations in Utah. First, the state's relatively sparse human population and large area has hamstrung the volunteer-staffed BBS. This has hindered the completion of many rural routes in Utah, resulting in spatially and temporally spotty coverage. Second, the BBS is a road-based survey without an explicit habitat component. Breeding Bird Survey routes do, however, have an implicit habitat component due to the non-random positioning of roads and hence the BBS survey routes themselves. In Utah's largely roadless landscape, the potential bias introduced by this implicit habitat component is magnified. We have found that over 75 percent of all Utah's bird species breed or forage in riparian habitat and are considered 'riparian dependent' in Utah (Howe 1992, Parrish et al. 2002, but see Rich 2002). Riparian areas comprise less than 0.4 percent of the state's area (Edwards et al. 1995, Parrish et al. 2002), and BBS routes seldom are seldom adjacent to riparian habitat. As a result, Utah's most important habitat type for birds is largely unsampled by BBS routes. In 1992 we began the monitoring program to fill the gaps in basic knowledge of riparian bird densities and give habitat-specific population trends. This paper presents initial statewide trend results for six species discussed at the 2002 Partners in Flight meeting at Asilomar, California.

Methods

Field Methods

Thirty-two sites were randomly established in riparian habitat statewide in 1992 (*fig. 1*). Potential study sites (i.e., riparian habitat along non-ephemeral rivers and streams on publicly accessible land) within each of four randomly selected 1:24,000 scale map grid cells within each 1:100,000 scale map grid cells covering the state were enumerated, ordered using a random numbers table, and field checked for suitability (e.g., suffi-

[1]A version of this paper was presented at the **Third International Partners in Flight Conference, March 20-24, 2002, Asilomar Conference Grounds, California.**

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cient vegetative coverage). The first suitable site was then accepted. Study design and sampling method, i.e., point count methods, followed Ralph et al. (1995). Point to observation distances were also measured (Howe 1993) to allow the data to be analyzed as point transects, a form of distance sampling (Buckland et al. 2001). Ten sampling points per site were systematically established from a random start, points were placed a minimum of 150 m apart. Sites were surveyed twice each breeding season. Count duration at each point was 8 min, and surveys were conducted between 15 min before sunrise and 10:00. Distance (estimated to the nearest meter) to each bird seen or heard was recorded along with the species, flock size, age/gender, and means of detection (i.e., seen, heard, or both).

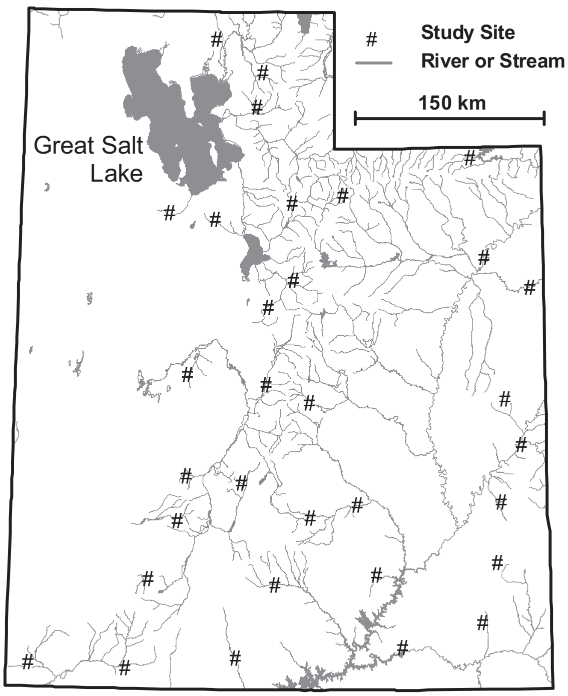

Figure 1— Locations of the 32 baseline riparian study sites in Utah, 1992-2001.

Analysis Methods

We present data for six species here: Black-headed Grosbeak (*Pheucticus melanocephalus*) and Song Sparrow (*Melospiza melodia*) illustrate the riparian dependent species, American Goldfinch (*Carduelis tristis*) and American Robin (*Turdus migratorius*) illustrate the riparian independent species, and Yellow Warbler (*Dendroica petechia*) and Broad-tailed Hummingbird (*Selasphorus platycercus*) are discussed as special cases, though both are considered riparian dependent species in Utah. Classification as to riparian dependence in Utah followed Howe (1992, but see Rich 2002).

Both visual and audible observations of non-juvenile, non-flyover birds were used for this analysis; all analyses were by species. Survey data were analyzed for estimated annual statewide densities (detections/ha) using DISTANCE v3.5 (Thomas et al. 1998), with distance sampling analyses following Buckland et al. (2001). Selection of annual detection functions were guided by Akaike's Information Criterion (Akaike 1973, Burnham and Anderson 1998), χ^2 model fit statistics, and visual inspection of detection probability and probability density plots (Buckland et al. 2001).

For simplicity's sake, we defined linear population trend as the mean annual change in density, for the 1992-2001 period, measured using simple linear regression (Allen 1983, Allen et al. 1983, Neter et al. 1996, Zar 1999). Trends in estimated density for each species were expressed as a percentage of the mean of density for all years, in order to express the trend as a relative percentage for each species. This approach was taken, as opposed to a route-regression analysis (Geissler and Noon 1981, Geissler and Sauer 1990, Sauer and Geissler 1990) as sample sizes were generally inadequate to reliably estimate density at each site in each year. To investigate patterns of population change, we used a Generalized Linear Modeling (GAM), nonlinear non-parametric trend estimation method (detailed in Fewster et al. 2000) for the open-source statistical package 'R' (Wood 2001, Wood and Augustin 2002, R Development CoreTeam 2003, Wood 2003). Generalized Linear Models are a non-parametric form of the log-linear Poisson regression model and generalized linear models that incorporate a smooting function (Hastie and Tibshirani 1990, Fewster et al. 2000). This approach avoids parametric assumptions, offers an inferential context in which to compare non-linear patterns of variation, and identifies significant inflection points in the smoothed non-linear estimated trend. Smoothing is used to reduce the influence of short-term variation (e.g., caused by weather or measurement error), revealing underlying longer-term patterns of population change. The non-parametric smooth curve fitted in our models is based on a smoothing spline (Wahba 1990, Wood 2000) where the degree of smoothing is specified by the number of degrees of freedom (df). Here we have used a df of 3, or approximately 0.3 times the number of years in our time series (Fewster et al. 2000). This allows examination of intermediate patterns of non-linear population change without the noise of temporally local change or the strict assumption of linear (or even curvilinear) change over the whole period. Once a smooth curve has been fit (a process described in detail by Fewster et al. 2000), an annual abundance index curve can be calculated as:

$$I(t) = \frac{\text{total predicted density for year } t}{\text{total predicted density for year } 1} = \frac{\exp(\hat{s}(t))}{\exp(\hat{s}(1))}. \quad (1)$$

The index *I(t)* measures the relative change in estimated smoothed density, $\exp(\hat{s}(t))$, relative to an arbitrary reference year, $\exp(\hat{s}(1))$ as a smooth function of time. Here we used 1992, the first year of our study, as our reference year as a smooth function of time. It also allows the identification of significant inflection points in population trajectories by testing the second derivative of the trend curve *I(t)* at time *t*. Where the second derivative is positive, the trajectory is turning upward; where negative, the trajectory is turning downward. The magnitude of the second derivative can also be tested for a significant difference from zero (i.e., from a steady rate of change, or a roughly linear trend). Significant inflection points indicate years in which the estimated population trend changes substantially. Thus the method provides a level playing field on which to identify patterns of non-linear change between species. Confidence limits on the indices are estimated here by 399 bootstrapped resamples (Manley 1997, Fewster et al. 2000).

Results

Over 100,000 observations of over 200 species of birds have been collected in the 1992-2001 period. Over 75 percent of recorded observations have been of riparian dependent species. The number of sites with data for a given species in any given year ranged from 9 to 31, with a mean of 21 sites per species per year used for the analysis. Statewide mean densities (birds/ha ± se) for the 1992-2001 period were: Black-headed Grosbeak 0.288 ± 0.361, Song Sparrow 0.499 ± 0.007, American Goldfinch 0.411 ± 0.006, American Robin 2.161 ± 0.448), Broad-tailed Hummingbird 4.509 ± 0.718, and Yellow Warbler 3.107 ± 2.266. The two riparian dependent species presented here, Black-headed Grosbeak (*fig. 2A*) and Song Sparrow (*fig. 2B*), had higher annual density estimates in 1992, 1994-1995, and again in 1998. The two riparian independent species presented here, American Goldfinch (*fig. 2C*) and American Robin (*fig. 2D*), had higher annual density estimates in 1994 and 2000. Broad-tailed Hummingbird and Yellow Warbler are discussed separately.

Linear Trends

Linear trends for these six species (mean annual change expressed as a percentage of the mean of all years, here termed the grand mean), F, and p-values are given in *table 1*; comparable values for the Utah and Western Region BBS routes are also provided. The only species of these six to show significant statewide linear trends in density were Yellow Warbler and Broad-tailed Hummingbird (*figs. 2E* and *F, table 1*). For our data, all species showed large interannual variation in density estimates (*fig. 2*), and the linear models typically were not well fit (mean r^2 = 31.3, range = 6.4 – 70.9).

Non-Linear Trends

Generalized additive models were fit and abundance index values calculated for each of these six species (*fig. 3*). Index values consistently below 1 showed Black-headed Grosbeaks in an overall downward population trend. Yellow Warblers showed an overall increase in population trend, with index values consistently above 1. Three species (American Goldfinch, American Robin, and Broad-tailed Hummingbird) showed a pattern of general increase in 1992-1994, decrease in 1995-1998, followed by an upturn in the last 2-3 years. The trend pattern for Black-headed Grosbeak and Song Sparrow was almost the opposite, with modest decreases in the 1993-1996 period and increases in the 1997-1999 period.

Table 1— *Linear population trend estimates in Utah riparian habitat for the 1992-2001 period, expressed as a proportion of each species' mean statewide density (i.e., the grand mean). Comparable BBS data for Utah and the Western BBS region are also given (Sauer et al. 2003).*

Species	Riparian trend[a]	*P* (F)	UT BBS trend[b]	*P*	N	Western BBS trend[c]	*P*	N
American Goldfinch	- 2.2%	0.313 (1.16)	7.80%	0.137	20	- 4.15%	0.002	411
American Robin	- 11.9%	0.480 (0.55)	- 0.42%	0.627	58	- 0.04%	0.881	913
Black-headed Grosbeak	- 2.5%	0.153 (2.49)	3.82%	0.204	31	0.29%	0.598	499
Broad-tailed Hummingbird	- 63.1%	0.002 (19.45)	- 1.87%	0.369	40	- 0.48%	0.536	165
Song Sparrow	2.0%	0.419 (0.73)	7.43%	0.094	38	1.16%	0.014	691
Yellow Warbler	43.5%	0.004 (15.30)	3.40%	0.122	42	0.63%	0.183	651

[a]Linear trend derived from UDWR riparian study data, expressed as the per year percentage change in the grand mean.
[b]Linear trend derived from Utah BBS data, 1992-2001, expressed as annual percent change (Estimating equations method).
[c]Linear trend derived from Western US BBS region data, 1992-2001, expressed as annual percentage change (Estimating equations method).

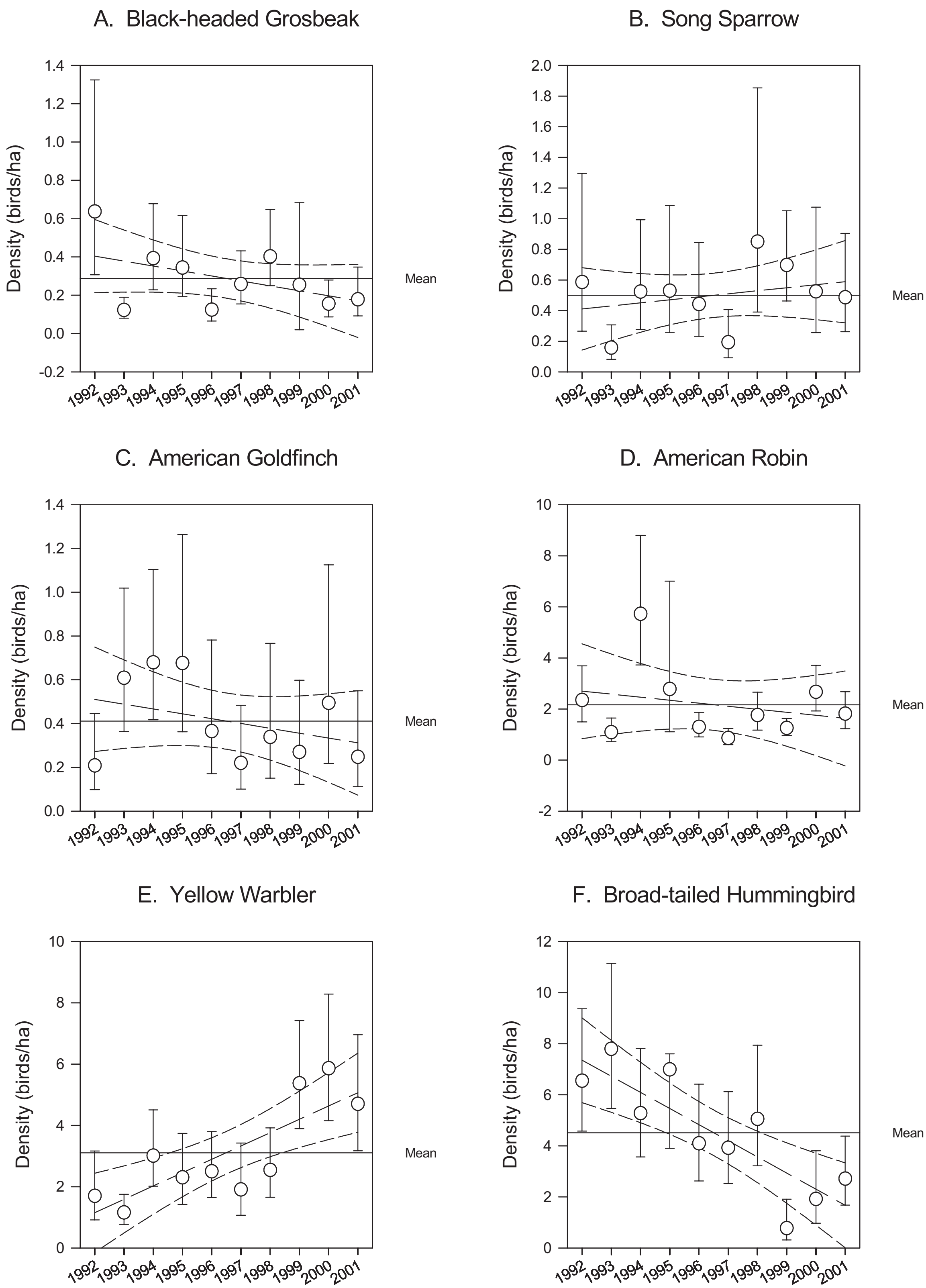

Figure 2— Annual density estimates (with 95 percent confidence intervals, shown as open circles) for the 1992-2001 period, overlain with the 10-year linear regression (long-dash line, with 95 percent confidence bands shown as short-dash lines) and 10-year grand mean (solid line). Species A, B, E, and F are considered riparian obligates in Utah, species C and D are not. Species E and F show significant increasing and decreasing linear trends respectively.

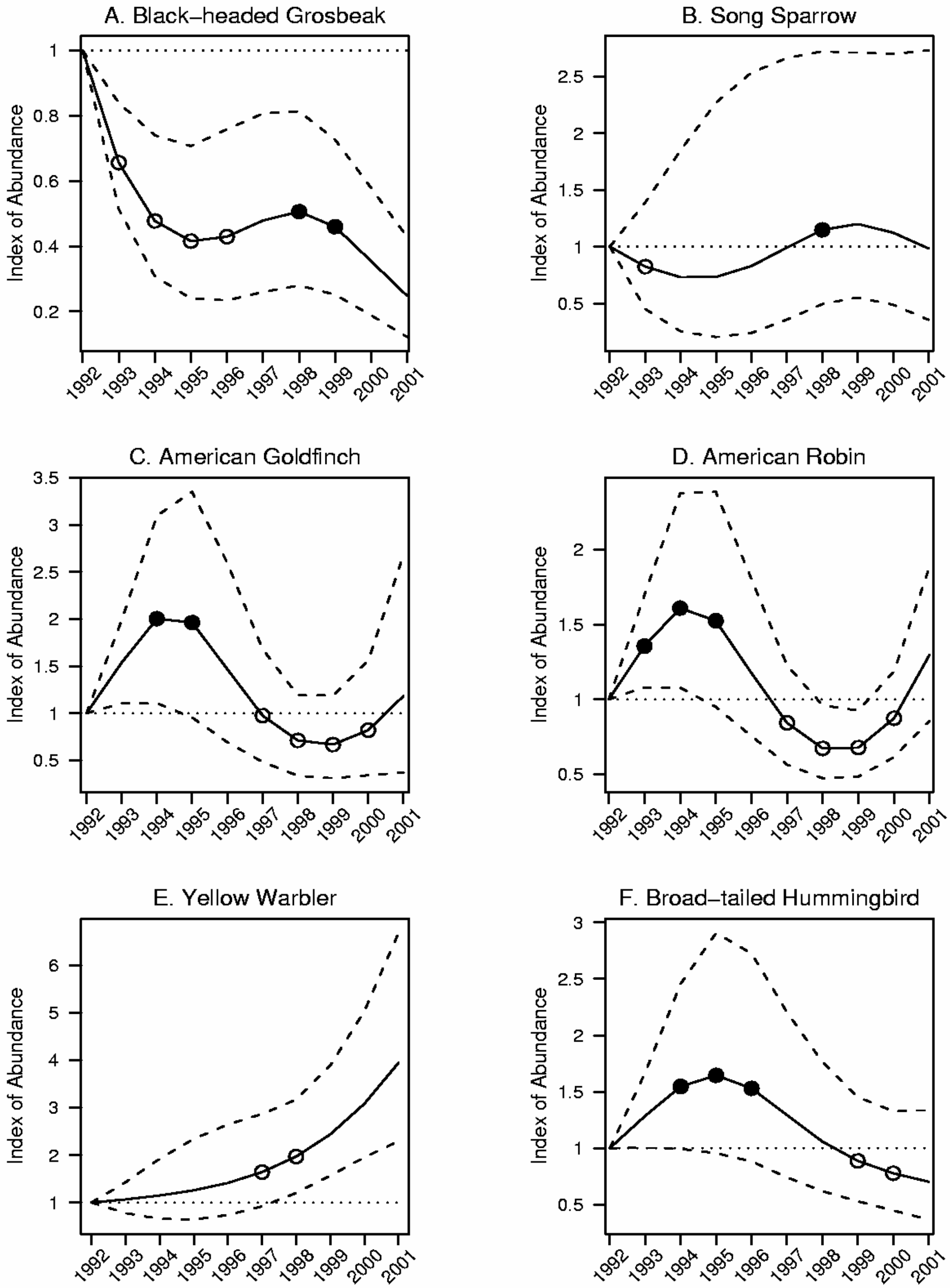

Figure 3— Density index curves for six species (solid line, with bootstrapped 95 percent confidence intervals shown as short-dash lines) from Generalized Additive Models with 3 degrees of freedom for the 1992-2001 period. Significant inflection points (years in which the second derivative of the annual abundance index curve differed significantly from zero, two-sided test, α = 0.05) are indicated by circles: closed for downturns, open for upturns. Both riparian species groupings (dependent: A and B, and independent: C and D) show fairly consistent patterns of years with significant up- and downturns.

The years in which significant upward (open circle) and downward (closed circle) inflection points in the rate of population change were also reasonably consistent within the riparian dependent and riparian independent species groupings (*fig. 3*). Black-headed Grosbeak and Song Sparrow results both showed significant upward inflections in the 1993-1996, and downward in the 1998-2000 period. Riparian independent species showed a roughly opposite pattern from these riparian dependent species with significant downturns in 1993-1995, and significant upturns in the 1997 -2000 period. The pattern of change in the abundance index curve for Broad-tailed Hummingbird followed that of the riparian independent species, while Yellow Warbler trends were consistently upward throughout, with significant upward inflections in the rate of population increase in 1997 and 1998 (*fig. 3*).

Discussion

Linear and non-linear trends in six species do not represent the totality of Utah's riparian bird population. Nor do they necessarily represent coherent patterns in the riparian dependent/independent groups to which they have been ascribed for a variety of reasons, not the least of which is the small number of species and their systematic selection. However, these six selected species are among the most abundant of Utah's riparian species and together comprise almost a quarter of all observations to date. Four of six linear trends are decreasing over a modest period in Utah's most important habitat and may be considered cause for concern, even though only two linear trends were even considered statistically significant, and one of these was increasing.

The 1992-2001 period was dominated by generally synchronous patterns of large interannual variation for each species grouping. While this study was not designed to investigate causal or even proximate factors influencing population trends, these patterns may provide a productive context for future research into population dynamics, responses, and conservation efforts (e.g., DeSante et al. 2001). For example, if the apparent distinction between the two groups' patterns holds up, it may imply a degree of separation of ecological processes driving annual densities in riparian and upland habitat contexts. Also, the relative consistency of these patterns suggests the potential for a productive, albeit retrospective (Nichols 2000), covariate analysis of the effects of weather and habitat change (e.g., Nott et al. 2002).

But the apparent synchrony of species' abundance fluctuations might also be a red herring. Within each of our riparian dependent/independent groups were a wide variety of body sizes, life spans, foraging habits, susceptibility to disease or predation, migration strategies, and wintering grounds. These suggest *a priori* that the range of observed trends within each riparian dependent/independent grouping would not be constrained to a discrete set of responses to affective environmental changes.

Also interesting is the haphazard extent of concordance between our data and the BBS in terms of either annual patterns of variation or long-term trends derived from Utah and Western BBS Regional data (Sauer et al. 2003). While local abundance is widely considered to be a dependent function of regional abundance (Ricklefs 1987, Cornell and Lawton 1992), spatial variation among areas of the state and between roaded and riparian habitats is the likely culprit confounding this relationship. It is, however, difficult to make much of this comparison given the obvious differences in our methodologies.

While tempered somewhat by the lack of agreement with BBS results, the recent conservation emphasis placed on Broad-tailed Hummingbirds in Utah does appear warranted (Parrish et al. 2002), and Black-headed Grosbeak populations bear watching. We are also getting reliable annual abundance estimates for riparian dependent species and populations largely underserved by the BBS, which remains our only viable alternate source of large-scale, long-term data. In terms of population trend analyses, this dataset remains a relatively young entity. Plots of long-term bird abundance (e.g., Holmes and Sherry 2001, Sauer et al. 2003) can often show 10-year periods of linearly increasing, decreasing and non-linear trends within a given species. In this context, we feel these trends should be considered preliminary, as even ten years is a brief period upon which to build trend analyses for notably variable populations. We are, however, approaching the point in Utah's riparian habitats where statistical power to detect more subtle trends becomes feasible for many species. The addition of non-linear trend estimation analysis tools show promise in distinguishing points where significant changes in population trajectories have occurred. Further investigation into the spatial and temporal qualities of these observed patterns may prove critical to the assessment of future avian conservation needs in Utah.

Acknowledgments

The authors would like to thank the Utah Division of Wildlife Resources, the many Utah Partners in Flight cooperators (the Department of Defense, the U.S. Bureau of Reclamation, U.S. Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, the Central Utah Project, and the Natural Resources Conservation Service), and the over 20 field crewmembers for their hard work and continued support that made this study possible.

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