Population Trends for Eastern Scrub-Shrub Birds Related to Availability of Small-Diameter Upland Hardwood Forests

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Chapter 9
Population Trends for Eastern Scrub-Shrub Birds Related to Availability of Small-Diameter Upland Hardwood Forests

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Abstract Early successional habitats are an important part of the forest landscape for supporting avian communities. As the frequency and extent of the anthropogenic disturbances have declined, suitable habitat for scrub-shrub bird species also has decreased, resulting in significant declines for many species. We related changes in the proportion and distribution of small-diameter upland hardwood forest throughout the eastern USA (US Forest Service Forest Inventory and Analysis data) with North American Breeding Bird Survey data (US Geological Survey) on population trends of 11 species that use early successional hardwood forest. The availability of small-diameter upland hardwood forest has changed over the past four decades, with the biggest differences seen as declines from the 1990s to the 2000s. Most scrub-shrub species also declined since the inception of the Breeding Bird Survey in 1966. The declines in most of the bird species, however, did not closely track the changes in small-diameter forest availability. Scrub-shrub birds use a variety of habitats that

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originate from a diverse array of disturbance sources. The total availability of these habitats across the region apparently limits the populations for these species. A comprehensive management strategy across all of these types is required to conserve these species.

9.1 Introduction

Conservation biologists have become increasingly aware of the plight of wildlife species that require the early stages of forest succession for habitat. Two journals recently dedicated sections on this topic (Thompson et al. 2001; Litvaitis 2003). Historically, disturbances in forest ecosystems from natural and anthropogenic sources created a mosaic of habitats ranging from the earliest stages of succession through old growth conditions (see Greenberg et al., Chap. 1; White et al., Chap. 3). A multitude of wildlife species are adapted to take advantage of young forest habitats created by these disturbances and populations of many are declining as abandoned farmland and pastures return to forest and recently harvested or disturbed forests re-grow (Greenberg et al., Chap. 1). For example, populations of many avian species that breed in small-diameter forested habitats are declining throughout the eastern United States (Askins 2001; Brawn et al. 2001; Hunter et al. 2001; Dettmers 2003), as are some that breed in mature forests but use small-diameter forested habitats during the post-breeding season (Marshall et al. 2003; Bulluck and Buehler 2006; Vitz and Rodewald 2006).

Early successional habitats arise from a variety of natural and anthropogenic disturbance sources, including catastrophic weather (tornados, hurricanes, severe ice storms, flooding), wild fire, grazing, clearing of land for agriculture and subsequent abandonment, insect outbreaks, creation and management of utility rights-of-way, roadside edges, mining, and forest management (Greenberg et al., Chap. 1). Numerous studies have documented avian response to various types of forest management at the stand scale (e.g., Annand and Thompson 1997; Krementz and Christie 2000; Pagen et al. 2000; Marshall et al. 2003; Rodewald and Vitz 2005; Vitz and Rodewald 2006; Campbell et al. 2007) and at the landscape scale (e.g., Thompson et al. 1992; Bourque and Villard 2001; Rodewald and Yahner 2001a; Rodewald and Yahner 2001b; Gram et al. 2003). The effect of clearcutting on birds at the stand scale in eastern forests has received the most research attention (Sallabanks et al. 2000). Studies on avian response to other sources of disturbance are available but less numerous (e.g., King and Byers 2002; Tingley et al. 2002; Confer and Pascoe 2003; Lacki et al. 2004; Bulluck and Buehler 2006). Maintaining a mosaic of different stand age classes (i.e., differing years post-harvest) in a forested landscape can provide habitat for a diversity of avifauna, especially when the requirements of regional species of concern, patch size, and landscape context are considered (King et al. 1998; Krementz and Christie 2000; King et al. 2001; Rodewald and Yahner 2001a; Rodewald and Yahner 2001b; Gram et al. 2003).

Our goals were to (1) summarize the changes in availability of small-diameter upland hardwood forests in the eastern USA over time based on analysis of US Forest Service Forest Inventory and Analysis (FIA) data, and (2) examine population trends for scrub-shrub avian species that use these small-diameter upland hardwood habitats based on US Geological Survey North American Breeding Bird Survey (BBS) data analyses. Finally, we evaluate how well the avian population trends track documented changes in small-diameter hardwood forest availability in the region. FIA data represent the only source of stand-level data collected over the entire area of upland hardwood forest in the eastern USA with a statistically-sound sampling design and standardized data collection protocols (Bechtold and Patterson 2005). We analyzed changes in small-diameter forests, rather than forest stand age, because birds respond to changes in the structural properties of forests (Raphael et al. 1987; Diaz et al. 2005), and those properties may vary considerably within the young age class depending on tree species composition and site productivity (Moran et al. 2000). We believe that tracking forests of the structure required by scrub-shrub birds would be a better fit than using age as the classification criterion. Even so, small-diameter forests in the FIA database represent a subset of the potential available habitat for many eastern scrub-shrub birds. Hence, we are assessing the relationship between FIA small-diameter forests and population trends for this suite of bird species.

9.2 Approach

We conducted analyses at three spatial scales: (1) the upland hardwood forest area of the eastern USA as defined by three Bird Conservation Regions (BCRs), (2) within three BCRs, and (3) within BCR-state intersections (Fig. 9.1). Bird Conservation Region boundaries are described on the BBS website (www.mbr-pwrc.usgs.gov/bbs/) and were designed to provide a spatial framework for avian conservation planning under the North American Bird Conservation Initiative (NABCI). Data from ten states within three BCRs (Central Hardwoods, Appalachian Mountains, and Piedmont; Fig. 9.1) are included in the analysis and largely overlap the Central Hardwood Region considered in this book (see Greenberg et al., Chap. 1). The Central Hardwoods BCR includes the Ozark Mountains on the west and extends eastward including the Interior Low Plateau with the entire area being dominated by oak-hickory (*Quercus-Carya*) deciduous forest. The Appalachian Mountains BCR contains the Blue Ridge, Ridge and Valley, Cumberland Plateau, Ohio Hills and the Allegheny Plateau. This area is characterized at lower elevations by oak-hickory and other deciduous forest types and at higher elevations by various combinations of pine (*Pinus* spp.), hemlock (*Tsuga canadensis*), spruce (*Picea* spp.), fir (*Abies* spp.), northern hardwoods, and northern red oak (*Q. rubra*). The Piedmont BCR is considered to be transitional between the rugged, mountainous Appalachians dominated by hardwoods and the relatively flat Coastal Plain dominated by pines and mixed southern hardwoods. For detailed descriptions of these upland hardwood forest types see Chap. 2 (McNab).

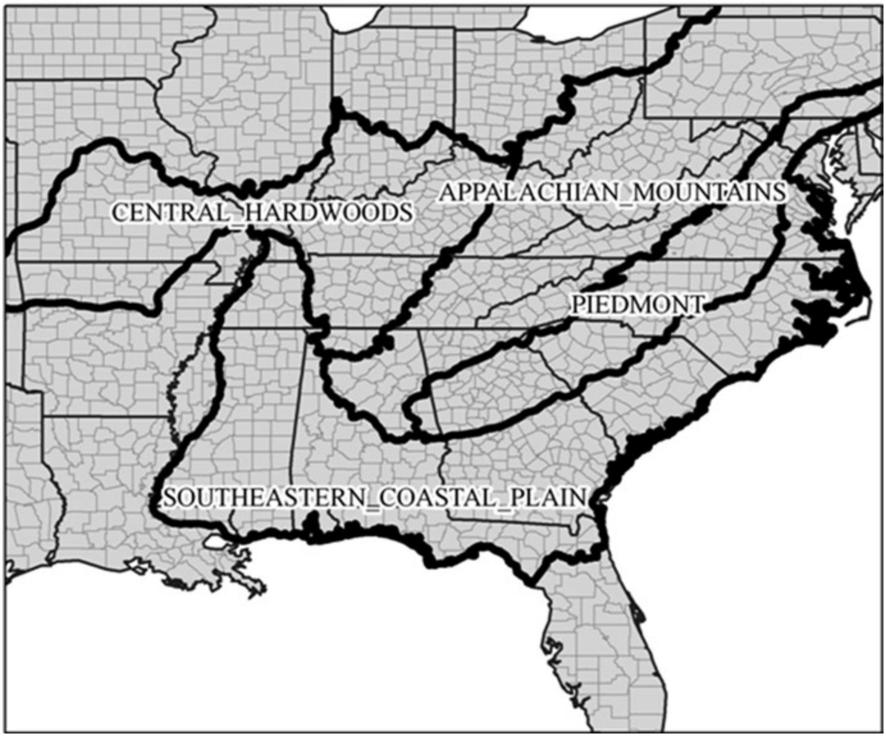

Fig. 9.1 States and Bird Conservation Regions used for the analysis of early successional upland hardwood forests and avian population trends

In addition, we examined data for ten states individually that were within the three referenced BCRs. Only FIA plots that fell inside the boundaries of the BCRs of interest were included in the state totals, thus the numbers do not represent complete state-level coverage. The states included were Alabama, Arkansas, Georgia, Kentucky, Missouri, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

9.2.1 Forest Inventory and Analysis (FIA)

We used FIA data to identify small-diameter hardwood forests, based on dominance at the stand level by small-diameter hardwood trees. We examined trends in availability of small-diameter hardwood forests across four decadal time periods (1970s, 1980s, 1990s, and 2000s) within the three BCRs of interest. The sample population was defined by intersecting the outline of BCRs with FIA plot locations in ten states using ESRI ArcGIS (Fig. 9.1). FIA plots were located on the map using actual coordinates collected in the field, with the exception of plot locations in Missouri

Table 9.1 States, years, and number of plots within three Bird Conservation Regions in the eastern USA used to analyze trends in availability of small-diameter hardwood forests by decade

	Year in decade			
State	1970s	1980s	1990s	2000s
Alabama	1972	1982	1990	2008
Arkansas	1978	1988	1995	2007
Georgia	1972	1989	1997	2008
Kentucky		1988		2007
Missouri		1989		2008
North Carolina	1974	1984	1990	2007
South Carolina	1976	1986	1993	2007
Tennessee	1980	1989	1999	2007
Virginia	1977	1985	1992	2008
West Virginia		1989		2006
Total Number of Plots	12,479	29,926	22,074	25,603

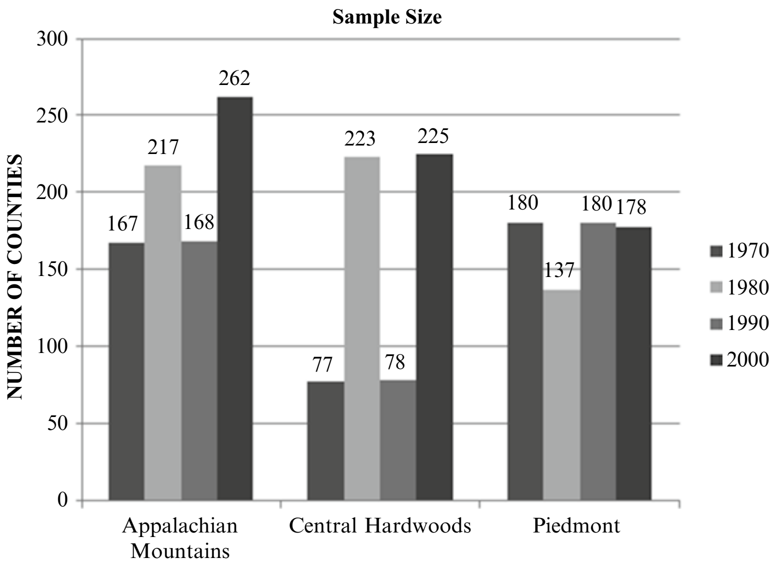

Fig. 9.2 Number of sample units (county aggregates of plots, n) used in statistical analysis by year and Bird Conservation Region

and West Virginia, where FIA "perturbed and swapped" locations were based on availability at the time of analysis (Bechtold and Patterson 2005). Survey periods and numbers of plots used in this analysis varied by state (Table 9.1).

We analyzed county aggregates of selected plots as the sample unit (Fei and Steiner 2007; Oswalt and Turner 2009; Fig. 9.2). We calculated metrics based on timberland areas within BCRs. Timberland is defined by FIA as "forest land that is producing or capable of producing in excess of 20 cubic feet per acre per year of wood at culmination of mean annual increment." This definition excludes reserved forest land and "unproductive" forest land. Until recently, FIA collected individual tree metrics only on timberland, thus, for trend analysis utilizing specific plot and tree metrics, timberland must be used (Bechtold and Patterson 2005). The total timberland area in hectares (TTA), total hardwood timberland area (THA), and total small-diameter hardwood timberland area (TSD) were calculated for each Decade-State-BCR-County combination. Some states were not sampled in some decades (for example, Kentucky only was sampled in two of the four decades). Thus, sample size and area differed through time. Therefore, to facilitate comparison among decades, area estimates were normalized for analysis by converting raw numbers to proportions, yielding the proportion of total timberland area that was hardwood (PTTA), the proportion of total timberland area that was small-diameter hardwood (PTSD), and the proportion of total hardwood timberland that was small-diameter (PTHA). Concerns that the use of proportions might produce erroneous results with regards to changes in avian habitat if raw TTA and raw TSD both experienced declines but PTSD remained stable were relieved by Smith et al. (2009), who showed that in the regions encompassing the BCRs of interest, timberland area has remained stable or increased since the mid-1970s. We were unable to use discrete area numbers because not all states were sampled in each decade. Thus, the sample area was not the same and discrete area values would reflect the differences in sample area instead of true differences in forest acreage. Hardwood stands were identified as those falling within a pre-selected set of FIA forest-type groups containing primarily hardwood species (Table 9.2). Small-diameter stands were identified using the FIA variable STDSZCD, which defines small-diameter stands as "stands with an all live stocking value of at least 10 (base 100) on which at least 50% of the stocking is trees less than 12.7 cm in diameter" (USDA Forest Service 2009).

Analyses of variance were used to determine changes in PTTA, PTSD, and PTHA over time across the whole study area, by BCR, and by state. Generalized least square means were compared among decades for each ANOVA. We also provide data from the latest publication of the nationwide USDA Forest Service, Forest Resources of the United States report (Smith et al. 2009) for comparison with localized results.

9.2.2 Breeding Bird Survey (BBS) Analyses

We used data analyses from the North American BBS to examine avian population trends covering the time periods 1966–1979 and 1980–2007, and the combined period of 1966–2007 (Sauer et al. 2008). We examined population trends for scrub-shrub species to determine which species were undergoing changes and the direction (increasing or decreasing) of change in the three BCRs and the ten aforementioned states. We used the species group designations of Sauer et al. (2008) to identify scrub-shrub species. In addition, we provide detailed analyses on 11 representative scrub-shrub species of eastern upland hardwood forest.

Table 9.2 Forest Inventory and Analysis forest types used in the analysis of trends in availability of small-diameter hardwood trees in three Bird Conservation Regions in the eastern USA

FIA code	Forest type	FIA code	Forest type
400	Oak (*Quercus* spp.)/Pine (*Pinus* spp.) group	510	Scarlet oak (*Q. coccinea*)
401	E. white pine (*P. strobus*)/n. red oak (*Q. rubra*)/white ash (*Fraxinus americana*)	511	Yellow-poplar
		512	Black walnut (*Juglans nigra*)
402	Eastern red cedar (*Juniperus virginiana*)/hardwood	513	Black locust (*Robinia pseudoacacia*)
403	Longleaf pine (*P. palustris*)/oak	514	Southern scrub oaks
404	Shortleaf pine (*P. echinata*)/oak	515	Chestnut oak (*Q. prinus*)/black oak (*Q. velutina*)/scarlet oak
405	Virginia pine (*P .virginiana*) /southern red oak (*Q. falcata*)	516	Cherry (*Prunus* spp.)/white ash /yellow-poplar
406	Loblolly pine (*P. taeda*) /hardwood	517	Elm (*Ulmus* spp.)/ash/black locust
407	Slash pine (*P. elliottii*)/hardwood	519	Red maple (*Acer rubrum*)/oak
409	Other pine/hardwood	520	Mixed upland hardwoods
500	Oak/hickory (*Carya* spp.) group	800	Maple (*Acer* spp.)/American beech (*Fagus grandifolia*)/birch (*Betula* spp.) group
501	Post oak (*Q. stellata*)/blackjack oak (*Q. marilandica*)		
502	Chestnut oak (*Q. prinus*)	801	Sugar maple (*A. saccharum*)/beech yellow/birch (*Betula alleghaniensis*)
503	White oak (*Q. alba*)/red oak (*Q. rubra*)/hickory		
504	White oak	802	Black cherry(*Prunus serotina*)
505	Northern red oak	805	Hard maple *(A. nigrum)*/basswood (*Tilia* spp.)
506	Yellow-poplar (*Liriodendron tulipifera*)/white oak/n. red oak	809	Red maple/upland
507	Sassafras (*Sassafras albidum*) /persimmon (*Diospyros virginiana*)	905	Pin cherry (*P. pensylvanica*)
		962	Other hardwoods
508	Sweetgum (*Liquidambar styraciflua*)/yellow-poplar	971	Deciduous oak woodland
509	Bur oak (*Q. macrocarpa*)	976	Misc. woodland hardwoods

Beginning in 1966, the BBS has been conducted annually and provides the only long-term database on breeding birds in North America. During the survey, observers collect data along a series of 24.5 mile routes using the point count method of recording all birds heard or seen within 0.25 miles of the point over a three-minute period. Points are established every 0.5 mile along the routes and data are collected using standardized collection protocols. The data are then forwarded to the US Geological Survey (USGS) for analysis by BBS staff using the route-regression procedure (Geissler and Sauer 1990) and modified through the use of estimating equations (Link and Sauer 1994). Their null hypothesis is that there has been no population change for the time period with a significance level of $P<0.10$. BBS data do not categorize vegetation or stand type at the point or route level. Hence, the data presented here are not restricted to only situations where the species occurred in early successional habitats.

Considerable controversy exists regarding the methods used to collect and analyze BBS data and, hence, the conclusions derived from it. Limitations of the methodology have been discussed in various venues (Sauer and Droege 1990; Peterjohn et al. 1995; James et al. 1996; Thomas and Martin 1996) and will not be discussed further here. In spite of this controversy, the different methods usually yield similar results, although the estimated rates of change may differ (Peterjohn et al. 1997).

9.2.3 Bird-Habitat Change Analyses

We regressed annual bird population change on annual change in availability of small-diameter hardwood forests using simple linear regression to test hypotheses that bird population trends were related to changes in small-diameter forest habitat availability for the 11 focal avian species. The percent change per year in small-diameter upland hardwood forest for each state ($n=10$ states) was the independent variable. The annualized change in the index of relative abundance for a given avian species was the response variable. We measured total change in small-diameter forest hectares per time period as described above and then calculated a percent change per year index. We used the earliest forest inventory date and the latest forest inventory date for each state to determine the number of years in the time period. We then used that same time period for calculating the percent change/year in bird relative abundances based on analysis tools provided by Sauer et al. (2008). The number of years used in the analyses varied depending on when the first forest inventory was completed in a given state (range = 17 years from 1989 to 2006 for West Virginia to 36 years from 1972 to 2007 for Georgia). Regression assumptions include (1) linearity of the relationship between dependent and independent variables; (2) independence of the errors (no serial correlation); (3) homoscedasticity; and (4) normality of the error distribution. We evaluated regression models for compliance with these assumptions with plots of residuals versus predicted values and normal probability plots of residuals. In general, the individual regressions met assumptions, thus no transformations were required. The regression assumption of measurement of the x and y variables without error was generally not met because data used in the regression were averaged values.

9.3 Results and Discussion

9.3.1 Availability of Small-Diameter Upland Hardwood Forests

Hardwood area trends, as a proportion of total timberland, varied by BCR and time. In the Appalachian Mountains BCR, PTTA increased between the 1970s and 1990s, and then increased again between the 1990s and 2000s (P=0.0075; Fig. 9.3). In the Central Hardwood BCR, PTTA remained stable across all four decades (P=0.0810). The PTTA increased in the Piedmont BCR between the 1980s and 1990s (P<0.0001). Timberland in the Appalachian Mountains and Central Hardwoods BCRs was predominantly hardwood, and contained the highest proportion of hardwood to softwood timberland in the study (91.2±4.1 and 86.2±0.9% in the 2000s, respectively). In comparison, the Piedmont BCR sample area was composed of approximately 60.8±1.4% hardwoods in the 2000s.

Proportionally, the area of small-diameter hardwood timberland across the entire sample of interest remained stable from the 1970s to the 1980s (27.0±0.7 and 26.8±0.7%, respectively), increased in the 1990s to 32.3±0.8%, then declined in the 2000s to 21.7±0.6% (P<0.0001; Fig. 9.4). In the Appalachian Mountains BCR, no differences occurred from the 1970s to the 1980s (18.0±1.3 and 16.0±0.9%, respectively), but small-diameter area increased in the 1990s to 19.6±1.4% of hardwood timberland before declining precipitously to 11.7±0.9% in the 2000s (P<0.0001). Small-diameter hardwood area was stable in the Central Hardwoods BCR from the 1970s through the 1990s (23.8±2.2, 21.5±1.2, and 21.8±1.8%,

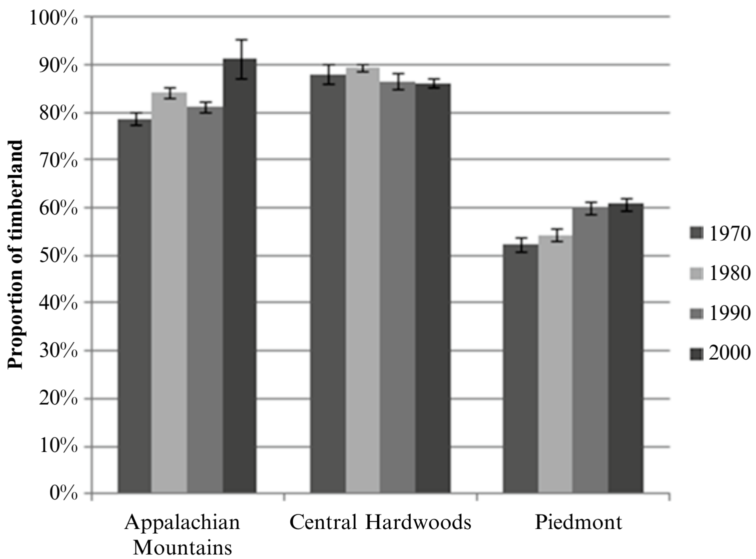

Fig. 9.3 Proportion of timberland in selected hardwood forest types by Bird Conservation Region and time period for all size classes

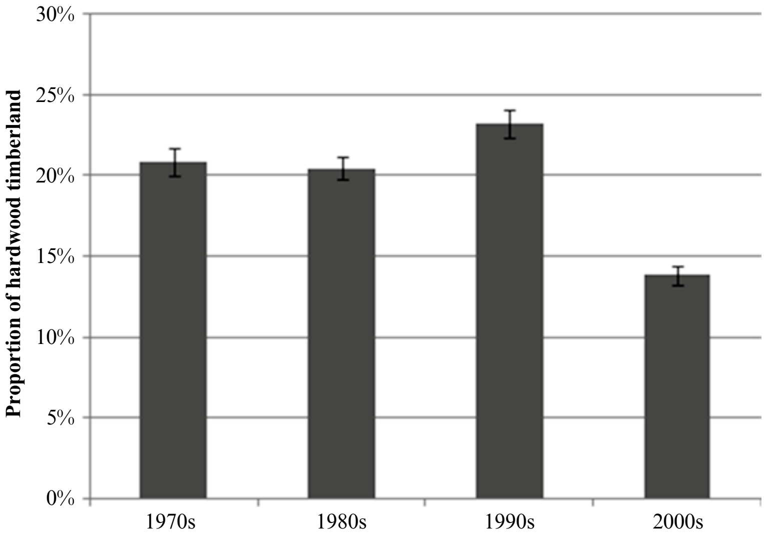

Fig. 9.4 Proportion of timberland that is small-diameter hardwood within three hardwood-dominated Bird Conservation Regions, eastern USA

Table 9.3 Proportion (in percent) of hardwood timberland comprised of small-diameter stands (+/− 1 se) by state and year within three Bird Conservation Regions in the eastern USA

State	1970	1980	1990	2000	P-value
Alabama	38.3 (2.7)^{A}	33.4 (2.4)^{A}	34.8 (2.5)^{A}	24.7 (2.2)^{B}	0.0013
Arkansas	35.0 (4.9)^{A}	32.0 (4.4)^{A}	22.9 (4.0)^{AB}	8.4 (1.2)^{B}	<0.0001
Georgia	16.6 (1.9)^{A}	24.0 (2.0)^{B}	26.4 (2.1)^{C}	18.9 (2.0)^{A}	0.0014
Kentucky	–	18.8 (1.7)^{A}	–	10.1 (0.9)^{B}	<0.0001
Missouri	–	20.9 (1.2)^{A}	–	7.7 (0.8)^{B}	<0.0001
North Carolina	16.6 (2.0)^{A}	17.3 (1.9)^{A}	21.4 (2.3)^{A}	22.7 (2.8)^{A}	0.1643
South Carolina	25.6 (2.8)^{A}	24.0 (2.5)^{A}	31.1 (2.4)^{A}	26.1 (3.2)^{A}	0.3040
Tennessee	17.5 (1.4)^{A}	16.9 (1.3)^{A}	21.0 (1.7)^{AB}	9.3 (0.9)^{C}	<0.0001
Virginia	17.9 (1.7)^{A}	–	15.5 (1.3)^{A}	11.3 (1.2)^{B}	0.0058
West Virginia	–	10.8 (0.8)^{A}	–	10.7 (2.5)^{A}	0.9808

P-values are for ANOVA tests for differences among decades within each state; values are generalized least square means and values in a row with the same letter are not significantly different ($P > 0.05$)

respectively), but declined in the 2000s to $9.1 \pm 0.6\%$ of total hardwood timberland area ($P < 0.0001$). In the Piedmont BCR, small-diameter hardwood forest area increased between the 1970s and the 1990s from 22.3 ± 1.3 to $27.1 \pm 1.3\%$, then decreased in the 2000s to $23.0 \pm 1.4\%$ ($P = 0.0418$).

Within the BCRs of interest, state-level changes in the proportion of hardwood timberland that consisted of small-diameter stands varied by state and by year, and were not consistent across the region, though most states did show overall declines from the 1970s to the 2000s (Table 9.3). Small-diameter area as a proportion of total hardwood timberland decreased in Alabama between the 1990s and 2000s, after three decades of remaining stable (P = 0.0013). In Arkansas, the small-diameter area declined, but the decline occurred gradually across all four decades (P < 0.0001). Unlike Arkansas, the small-diameter proportion of hardwood area in Georgia increased from the 1970s to the 1990s, but then decreased in the 2000s to levels that were similar to those noted in the 1980s (P = 0.0014). Observations for both Kentucky and Missouri only existed for two time periods, the 1980s and the 2000s; the proportion of hardwood area in small-diameter timberland declined between those decades in both states (P < 0.0001 and P < 0.0001, respectively). In Tennessee, small-diameter timberland increased in proportion from the 1970s to the 1990s, then declined significantly by the 2000s (P < 0.0001). Virginia, like Arkansas, experienced a steady decline in the proportion of hardwood timberland in small-diameter stands (P = 0.0058). Finally, North Carolina, South Carolina, and West Virginia experienced no changes in small-diameter area proportions among decades (P =0.1643, 0.3040, and 0.9808, respectively).

The Forest Resources of the United States, 2007 report (Smith et al. 2009) allows for comparisons from 1953 to 2007, but does not discriminate between hardwood and softwood forest types. Although total timberland area increased in the Northeast, proportionally, the area of small-diameter stands has declined since 1977. In the North Central Region, despite increases in total timberland since 1977, declines in small-diameter stands have occurred while large-diameter stands (≥28 cm diameter at breast height [dbh] for hardwoods and ≥ 23 cm dbh for softwoods) increased proportionally (Fig. 9.5). In contrast, Southeast and South Central Regions have maintained

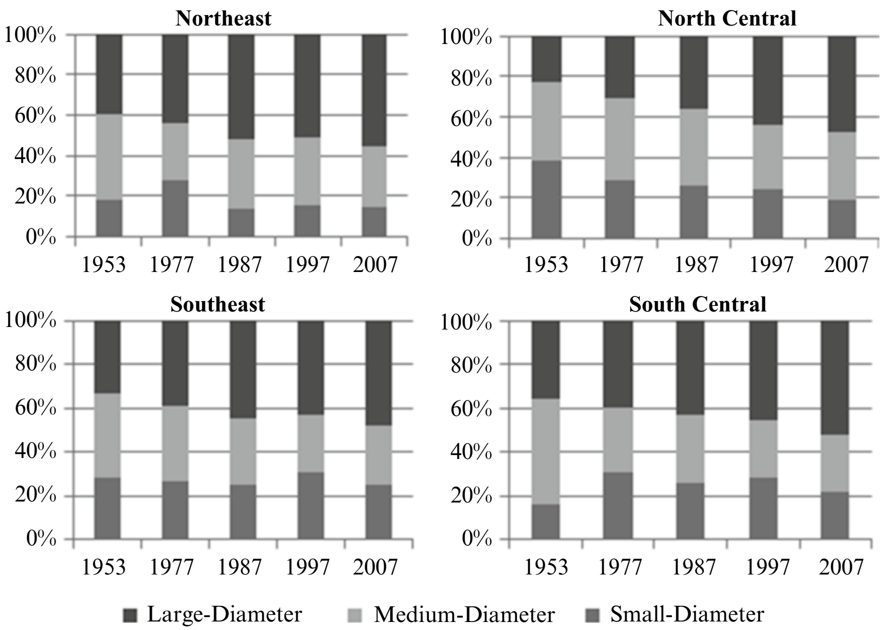

Fig. 9.5 Timberland area in four sub-regions of the USA by stand-size class (data from the Forest Resources of the United States, 2007 (Smith et al. 2009))

relatively constant proportions of small-diameter timberland on an expanding timberland base since the 1950s, with decadal fluctuations in the South Central Region, particularly. While the proportion of large-diameter area has increased steadily in both southern regions, the amount of medium-diameter rather than small-diameter area has decreased.

Our results suggested that hardwood forest area increased from the 1970s–2000s in the Appalachian Mountains and Piedmont BCRs and remained stable in the Central Hardwoods BCR. Because of the stability of the total timber resource, and the relative stability of the overall hardwood resource, we were able to focus on the proportion of that resource that was small-diameter, or early successional, habitat. Declines in small-diameter stands as a proportion of the overall hardwood resource were most notable in the Central Hardwoods and Appalachian Mountains BCRs where declines resulted in small-diameter stands comprising less than 12% of hardwood timberland by the 2000s. In contrast, while we noted proportional declines from the 1990s to the 2000s in the Piedmont BCR, there was no net change from the 1970s, and small-diameter stands still comprised between 34% and 36% of total hardwood timberland. In comparison to our study, Oswalt and Turner (2009) reported that the area of timberland in the Appalachian Hardwood Region (having only slightly different boundaries than our Appalachian Mountains BCR) remained stable during the 1980s–2000s, but acreage in the small-diameter stand size decreased while the larger diameter size classes increased. In addition, they note that total diameter distributions of hardwood trees shifted to larger diameter classes during the same period (Oswalt and Turner 2009).

Within the area of interest at the state level, overall declines in the PTSD from the 1970s to the 2000s were noted in Alabama, Arkansas, Kentucky, Missouri, Tennessee, and Virginia. In contrast, Georgia, Mississippi, and South Carolina experienced increases through the 1990s followed by declines to pre-1990s levels, while North Carolina experienced overall increases and West Virginia experienced no change.

The USDA Forest Service national report (Smith et al. 2009) showed declines in small-diameter timberland acreage across all forest types, not just hardwoods, between the 1990s and 2000s in the Southeast, South Central, and North Central Regions while the area of large-diameter timberland acreage has increased across those regions. Small-diameter area in the southern regions in that report was likely influenced by pine plantation dynamics (Smith et al. 2009). The most notable decline shown in the report was in the North Central Region, where the area of timberland comprised of small-diameter stands has been steadily declining since the 1950s (Smith et al. 2009).

The FIA program has undergone many changes since the 1970s, including switching from measuring plots using a variable-radius prism plot design to a fixed-radius, annual remeasurement plot design, changing plot remeasurement cycles, fluctuating plot lists, and changes in definitions and estimation methods (Bechtold and Patterson 2005). These changes have accompanied the transition of FIA from a series of regional programs to a nationally consistent program that is comparable from state to state across regional boundary lines. Therefore, some changes noted in our analysis may reflect changing FIA methodologies.

9.3.2 Bird Trends

Mean annual indices of relative abundance (individuals per BBS route per year) declined for eight of the nine focal species that occurred in the Central Hardwoods BCR over the three time periods (Fig. 9.6). In the Appalachian Mountains BCR, the pattern of change is clearly stronger than in the other BCRs, as declines are more pronounced for almost all the species (Fig. 9.7). In the Piedmont BCR, the species declined more frequently during 1966–1979 than in 1980–2007 or the overall period (1966–2007) (Fig. 9.8).

Of the eleven focal species, the Eastern Bluebird *(Sialia sialis)* was the only species that increased (0.4–2.4%/year) in all three BCRs and survey-wide (2.2%/year) (Fig. 9.9). Seven of eleven species declined across all of the BCRs in which they occurred (Fig. 9.9). Golden-winged Warblers (*Vermivora chrysoptera)* in the Appalachian Mountains BCR appeared to be undergoing the greatest population decline (−8.9%/year) of any of the 11 focal species (Fig. 9.7). Population trends for 1966–2007 in the three BCRs indicate that there were seven species-time period combinations in which focal species were increasing and 22 combinations in which they were decreasing (Fig. 9.9).

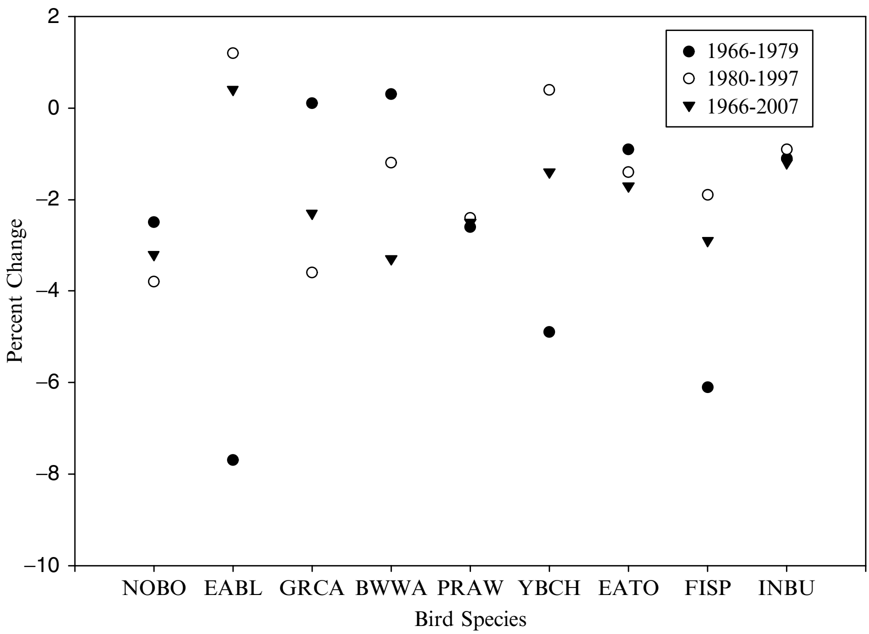

Fig. 9.6 Percent change in relative abundance (individuals/route/year) for scrub-shrub focal avian species in the Central Hardwoods Bird Conservation Region (1966–1979, 1980–1997, 1966–2007) based on North American Breeding Bird Survey data analyses (Sauer et al. 2008). Bird species abbreviations: *NOBO* Northern Bobwhite, *EABL* Eastern Bluebird, *GRCA* Gray Catbird, *BWWA* Blue-winged Warbler, *PRAW* Prairie Warbler, *YBCH* Yellow-breasted Chat, *EATO* Eastern Towhee, *FISP* Field Sparrow, *INBU* Indigo Bunting

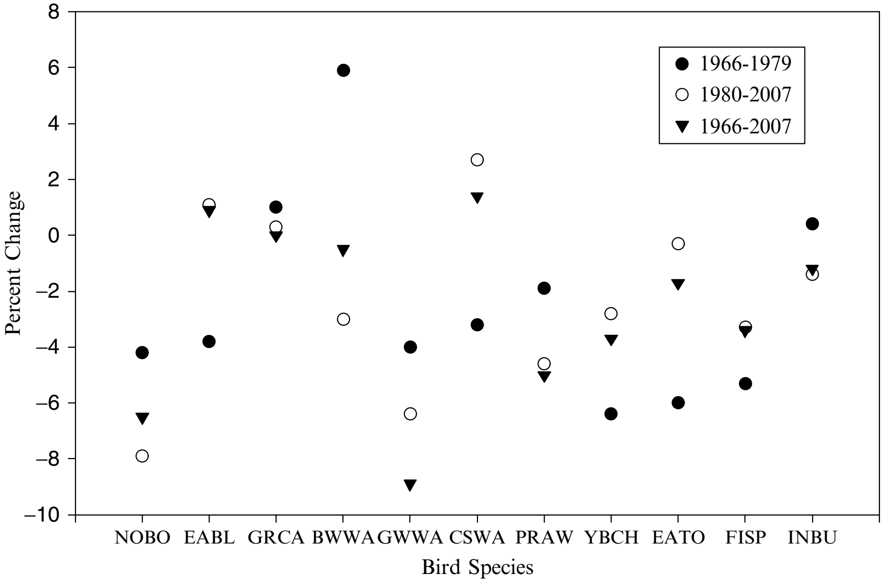

Fig. 9.7 Percent change in relative abundance (individuals/route/year) for scrub-shrub focal avian species in the Appalachian Mountains Bird Conservation Area (1966–1979, 1980–1997, 1966–2007) based on North American Breeding Bird Survey data analyses (Sauer et al. 2008). Bird species abbreviations: *NOBO* Northern Bobwhite, *EABL* Eastern Bluebird, *GRCA* Gray Catbird, *BWWA* Blue-winged Warbler, *GWWA* Golden-winged Warbler, *CSWA* Chestnut-sided Warbler, *PRAW* Prairie Warbler, *YBCH* Yellow-breasted Chat, *EATO* Eastern Towhee, *FISP* Field Sparrow, *INBU* Indigo Bunting

Considering all scrub-shrub breeding bird species, the Central Hardwoods and Appalachian Mountains BCRs experienced the greatest number of significantly declining species, 14 (64%) and 15 (54%) respectively (Table 9.4). These estimated losses ranged from a low of –0.32%/year in the Central Hardwood BCR for the Northern Cardinal *(Cardinalis cardinalis)* to a high of −17.28%/year for the Bewick's Wren *(Thryomanes bewickii)* in the Appalachian Mountains BCR (Table 9.4). In contrast, 23% (five species) and 12% (four species) were estimated as having long-term increases in population trend for the Central Hardwoods and Appalachian Mountains BCRs, respectively (Table 9.4). Fewer species were undergoing significant declines in the Piedmont BCR (seven species), although species with declining trends still outnumbered those with apparent significant increasing trends (Table 9.4).

In all ten states, there have been significant population declines in the Northern Bobwhite *(Colinus virginianus)*, ranging from −1.97%/year in Missouri to −8.86%/year in West Virginia (Table 9.5). Prairie Warblers *(Dendroica discolor)* experienced the highest rate of loss (–22.66%/year) of any species in these states (Table 9.5). Species with significant population declines appeared to be declining in all states in which they were observed (Table 9.5). There were at least five species each in Arkansas and Georgia and 12 species each in Kentucky and Tennessee that

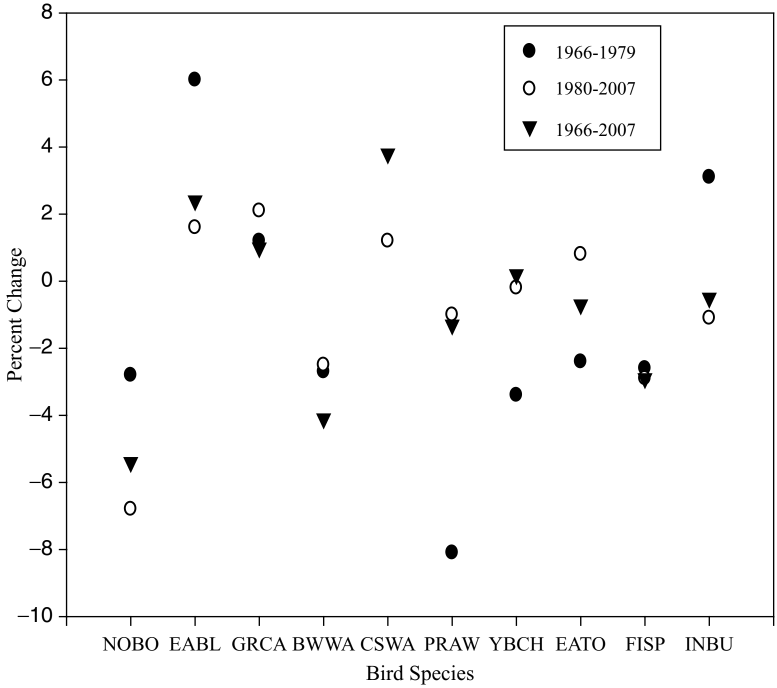

Fig. 9.8 Percent change in relative abundance (individuals/route/year) for scrub-shrub avian focal species in the Piedmont Bird Conservation Area (1966–1979, 1980–1997, 1966–2007) based on North American Breeding Bird Survey data analyses (Sauer et al. 2008). Bird species abbreviations: *NOBO* Northern Bobwhite, *EABL* Eastern Bluebird, *GRCA* Gray Catbird, *BWWA* Blue-winged Warbler, *CSWS* Chestnut-sided Warbler, *PRAW* Prairie Warbler, *YBCH* Yellow-breasted Chat, *EATO* Eastern Towhee, *FISP* Field Sparrow, *INBU* Indigo Bunting

apparently experienced significant long-term population losses (Table 9.5). The proportion of species with significant population declines ranged from a low of 14% in Mississippi to a high of 63% for Tennessee (Table 9.5).

Of the ten states, only Alabama had no species that were apparently undergoing a population increase (Table 9.5). Georgia and Kentucky each had five species that were increasing (Table 9.5). Approximately 28% of the species in Georgia were increasing, the highest proportion of any of these states (Table 9.5). Population trend increases were found for the Carolina Wren *(Thryothorus ludovicianus)* (1.21–3.73%/year), House Wren *(Troglodytes aedon)* (2.57–9.84%/year), and American Goldfinch *(Carduelis tristis)* (1.61–3.29%/year) (Table 9.5). More species were experiencing apparent significant declines in their long-term populations than were increasing and the rates of loss were more pronounced than were the gains (Table 9.5).

Based on our review of regional and state-level BBS data on scrub-shrub birds, it is clear that this group of species has consistently declined across the region over the past 40+ years that surveys have been conducted. The relative rates of decline vary

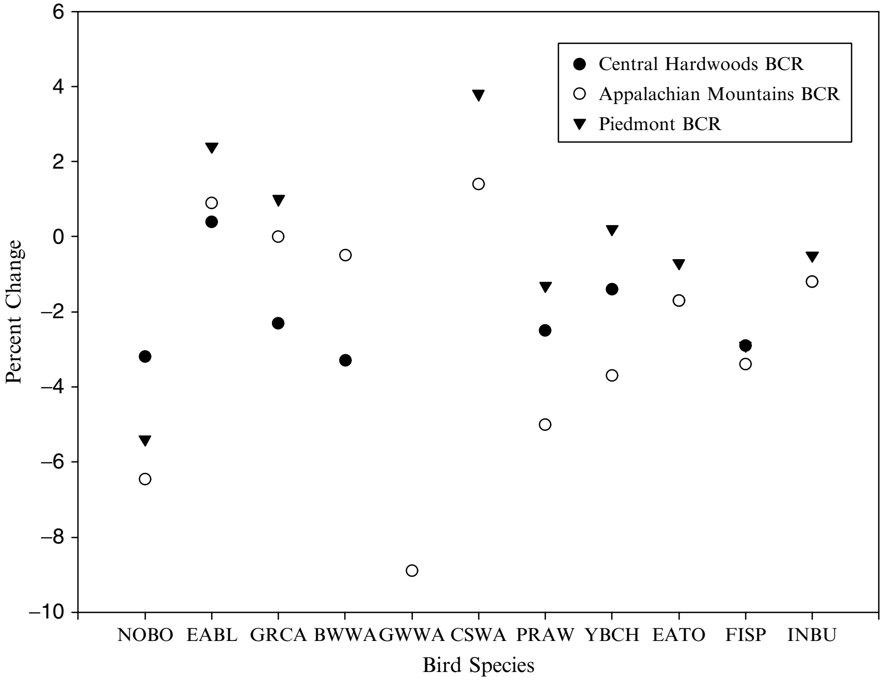

Fig. 9.9 Percent change in relative abundance (individuals/route/year) for scrub-shrub avian focal species by Bird Conservation Region, 1966–2007 based on North American Breeding Bird Survey data analyses (Sauer et al. 2008). Bird species abbreviations: *NOBO* Northern Bobwhite, *EABL* Eastern Bluebird, *GRCA* Gray Catbird, *BWWA* Blue-winged Warbler, *GWWA* Golden-winged Warbler, *CSWS* Chestnut-sided Warbler, *PRAW* Prairie Warbler, *YBCH* Yellow-breasted Chat, *EATO* Eastern Towhee, *FISP* Field Sparrow, *INBU* Indigo Bunting

by species, time period, region, and state. Eastern Bluebirds, for example, generally have been increasing. Eastern Bluebirds will use the early stages of forest succession but also occur in a variety of field habitats and have benefitted from the extensive use of nest boxes in rural areas across the region (Gowaty and Plissner 1998).

9.3.3 Relationship Between Bird Trends and Small–Diameter Forest Trends

Several scrub-shrub species are declining precipitously and have already attracted considerable conservation attention. Based on our regression analysis, the apparent reasons for these declines go beyond the decline in availability of small-diameter hardwood forest habitats as defined in this study. Golden-winged Warblers, for example, are declining along BBS routes at an incredible rate of almost 9% per year in the Appalachian Mountains BCR, resulting in loss of over 98% of the 1966 population. The decline of

Table 9.4 Significant (P<0.10) population trends (% change/year) for scrub-shrub breeding bird species by Bird Conservation Region (BCR) based on North American Breeding Bird Survey data analyses (Sauer et al. 2008) for 1966–2007

	BCR trend (% change/year)		
	Central Hardwoods	Appalachian mountains	Piedmont
Decreasing species			
Northern Bobwhite *(Colinus virginianus)*	−3.15	−6.47	−4.92
Bewick's Wren *(Thryomanes bewickii)*	−4.71	−17.28	
House Wren *(Troglodytes aedon)*		−1.05	
Gray Catbird *(Dumetella carolinensis)*	−2.28		
Brown Thrasher *(Toxostoma rufum)*	−1.48	−1.19	
Blue-winged Warbler *(Vermivora pinus)*	−2.80		−3.13
Golden-winged Warbler (*V. chrysoptera)*		−8.73	
Nashville Warbler (*V. ruficapilla)*		−5.49	
Yellow Warbler *(Dendroica petechia)*	−2.44		
Prairie Warbler *(D. discolor)*	−2.43	−4.97	−1.22
Common Yellowthroat *(Geothlypis trichas)*	−1.04	−0.52	
Yellow-breasted Chat *(Icteria virens)*	−1.38	−3.70	
Eastern Towhee *(Pipilo erythrophthalmus)*	−1.71	−1.68	
Field Sparrow *(Spizella pusilla)*	−2.83	−3.44	−2.77
Lark Sparrow *(Chondestes grammacus)*	−3.10		
Song Sparrow *(Melospiza melodia)*		−0.58	
Northern Cardinal *(Cardinalis cardinalis)*	−0.32		
Blue Grosbeak *(Guiraca caerulea)*			−0.67
Indigo Bunting *(Passerina cyanea)*	−1.25	−1.19	−0.52
American Goldfinch *(Carduelis tristis)*		−1.21	
Species with significant negative trends (%)	64	54	32
Increasing species			
Willow/Alder Flycatcher *(Empidonax spp.)*		1.28	2.41
White-eyed Vireo *(Vireo griseus)*			1.21
Carolina Wren *(Thryothorus ludovicianus)*	2.47	2.33	1.29
House Wren *(T. aedon)*	3.71		
Eastern Bluebird *(Sialia sialis)*	2.4	0.9	2.4
Chestnut-sided Warbler *(D. pensylvanica)*		1.32	
Song Sparrow *(M. melodia)*	0.79		
Northern Cardinal *(C. cardinalis)*			0.50
Blue Grosbeak *(G. caerulea)*	2.32		
American Goldfinch *(Carduelis tristis)*	0.70		2.00
Species with significant positive trends (%)	23	12	26

this species has led to the formation of the Golden-winged Warbler Working Group that is focused on developing and implementing conservation strategies for this and other scrub-shrub species (Buehler et al. 2007). Although Golden-winged Warblers use small-diameter upland hardwood forests, their habitat requirements are more specialized in that they require herbaceous components interspersed with saplings, shrubs, and mature trees (Klaus and Buehler 2001). These conditions are seldom found in regenerating

Table 9.5 Significant (P < 0.10) population trends for scrub-shrub breeding bird species by southeastern state based on data from the North American Breeding Bird Survey (Sauer et al. 2008) for 1966–2007

	% Change per year									
	AL	AR	GA	KY	MO	NC	SC	TN	VA	WV
Decreasing species										
Northern Bobwhite *(Colinus virginianus)*	–4.90	–4.78	–4.35	–2.59	–1.97	–4.41	–4.68	–3.97	–3.78	–8.86
Bewick's Wren *(Thryomanes bewickii)*				–6.08				–15.86		
Gray Catbird *(Dumetella carolinensis)*				–2.05		–1.44	–3.06	–4.59	–2.38	
Brown Thrasher *(Toxostoma rufum)*		–5.66		–1.17	–2.23			–1.37		–1.86
Blue-winged Warbler *(Vermivora pinus)*	–5.97			–5.07						–2.64
Golden-winged Warbler *(V. chrysoptera)*										–9.18
Yellow Warbler *(Dendroica petechia)*	–5.94			–2.93		–3.10		–4.13	–3.75	
Prairie Warbler *(D. discolor)*	–1.72	–22.66	–2.36	–2.46	–4.23			–2.59		–5.91
Common Yellowthroat *(Geothlypis trichas)*		–7.76		–0.85		–1.36	–2.54	–0.87		–2.73
Yellow-breasted Chat *(Icteria virens)*				–1.48				–1.86		–4.18
Eastern Towhee *(Pipilo erythrophthalmus)*	–0.85		–1.41		–2.39		–1.87	–1.64	–1.65	–1.29
Field Sparrow *(Spizella pusilla)*	–4.08	–22.70	–2.01	–2.98	–2.13	–1.87		–1.35	–3.08	–3.13
Lark Sparrow *(Chondestes grammacus)*					–2.43					

Northern Cardinal	−0.64							−0.70		
(Cardinalis cardinalis)										
Indigo Bunting	−0.68			−1.57			−2.45	−0.90	−0.67	−2.43
(Passerina cyanea)										
American Goldfinch										−3.84
(Carduelis tristis)										
Proportion of species with significant negative trends	0.44	0.31	0.22	0.58	0.27	0.29	0.33	0.63	0.35	0.55
No. of species with significant negative trends	9	5	5	12	6	6	6	12	6	11
Increasing species										
White-eyed Vireo	0.75									
(Vireo griseus)										
Carolina Wren			1.21	3.73	3.07			1.89	1.56	1.67
(T. ludovicianus)										
House Wren			9.84	5.06		2.57		7.00		
(Troglodytes aedon)										
Chestnut-sided Warbler										2.02
(D. pensylvanica)										
Yellow-breasted Chat			1.65							
(I. virens)										
Song Sparrow			3.83	1.57	1.95			1.51		
(Melospiza melodia)										
Blue Grosbeak				4.15				2.31		
(G. caerulea)										
American Goldfinch	1.94		3.29	1.61		1.84	3.08			
(Carduelis tristis)										
Proportion of species with significant positive trends	0.11	0.00	0.28	0.26	0.09	0.12	0.07	0.21	0.06	0.10
No. of species with significant positive trends	2	0	5	5	2	2	1	4	1	2

forests unless the forests are located in northern regions where tree growth is slow (e.g., Wisconsin), or if management action is taken to slow tree growth and promote herbaceous plant growth, such as with herbicides, grazing, or prescribed burning. Although the regression analysis was suggestive of a relationship with availability of small-diameter hardwood forests, Golden-winged Warbler population declines far exceed the rates of decline in small-diameter forests in the Appalachian Mountains BCR over the past 20 years. The decline in small-diameter forests in concert with the decline of other early successional habitats, however, may be a contributing factor in the decline of this species. Golden-winged Warblers are Nearctic-Neotropical migrants that winter in Central and South America. Extensive deforestation of their wintering habitat is also likely contributing to their decline (Buehler et al. 2007).

Northern Bobwhites also have declined sharply across all three BCRs, averaging 3–6% per year depending on region (Table 9.4). The decline of Northern Bobwhites has attracted considerable conservation attention, leading to formation of the Southeast Quail Study Group and development of the Northern Bobwhite Conservation Initiative (Dimmick et al. 2002). Bobwhites use a diverse configuration of habitats during their annual cycle, using grassland habitats for nesting and brooding but often using small-diameter forests for winter cover, especially in the northern parts of their range (Brennan 1999). Based on the regression results, population declines in this species appear to be more strongly related to other components of their habitat than small-diameter upland forest availability.

There were no consistent relationships between percent annual change in small-diameter upland forest and change in avian relative abundance for any of the 11 species analyzed (Table 9.6). Chestnut-sided Warbler *(Dendroica pensylvanica)* ($r^2=0.385$),

Table 9.6 Regression coefficients, F values and P values for regression analyses relating annual change in relative abundance of 11 scrub-shrub bird species by state to annual change in amount of small-diameter upland hardwood forest by state across three Bird Conservation Regions in the eastern USA

Species	n	β	95%	CI	r^2	F	P-value
Blue-winged Warbler *(Vermivora pinus)*	7	−1.874	−5.477	1.730	0.263	1.786	0.239
Chestnut-sided Warbler *(D. pensylvanica)*	5	−1.990	−6.615	2.635	0.385	1.875	0.264
Eastern Bluebird *(Sialia sialis)*	10	0.284	−0.376	0.945	0.110	0.986	0.350
Eastern Towhee *(Pipilo erythrophthalmus)*	10	−0.020	−0.518	0.477	0.001	0.009	0.927
Field Sparrow *(Spizella pusilla)*	10	0.042	−0.774	0.857	0.002	0.014	0.909
Gray Catbird *(Dumetella carolinensis)*	10	−0.157	−1.005	0.690	0.022	0.183	0.680
Golden-winged Warbler *(V. chrysoptera)*	5	−175.574	−773.586	422.438	0.225	0.873	0.419
Indigo Bunting *(Passerina cyanea)*	10	−0.269	−0.712	0.174	0.197	1.964	0.199
Northern Bobwhite *(Colinus virginianus)*	10	0.294	−1.782	2.369	0.013	0.107	0.752
Prairie Warbler *(D. discolor)*	10	0.471	−0.208	1.150	0.243	2.563	0.148
Yellow-breasted Chat *(Icteria virens)*	10	0.195	−0.683	1.074	0.032	0.263	0.622

Blue-winged Warbler *(Vermivora pinus)* ($r^2=0.263$), Prairie Warbler ($r^2=0.243$), and Golden-winged Warbler ($r^2=0.225$) had the strongest relationships with small-diameter forest availability but none of these regressions met traditional alpha decision criteria for significance (i.e., $\alpha<0.10$ or 0.05). The other species analyzed showed no apparent relationship with the change in small-diameter forest availability (Table 9.6).

In general, the strongest relationships (r^2s) between birds and small-diameter hardwood forests occurred for scrub-shrub species that are more associated with forested habitats than with field habitats (Blue-winged Warbler, Chestnut-sided Warbler, Prairie Warbler, and Golden-winged Warbler). These species require varying amounts of woody plants (saplings and shrubs) in their habitat that can be found in abundance in regenerating forests (Richardson and Brauning 1995; Nolan et al. 1999; Gill et al. 2001; Klaus and Buehler 2001). The lack of a strong relationship between population declines in these species with small-diameter forest availability suggests that other factors are also linked to the population declines. All four species mentioned above are Nearctic-Neotropical migrants, therefore habitat losses on their wintering grounds or along their migration routes may also be contributing to their population declines.

Declines have also varied by BCR. In general, the Appalachian Mountains BCR appears to be experiencing the greatest declines in small-diameter forested habitats and scrub-shrub birds, the Central Hardwoods BCR is intermediate and the Piedmont BCR is experiencing the least declines. Appalachian Mountains and Central Hardwoods Joint Ventures are underway to address the declines in priority bird species and their habitats. The boundaries of these joint ventures coincide with those of the respective BCRs. The prevalence of pine plantation management in the Piedmont region may explain the improved status of scrub-shrub species that use small-diameter pine forests compared to their status in other regions where pine plantations are less common.

9.4 Conclusion

We demonstrated that the availability of small-diameter upland hardwood forest habitat has changed across the eastern USA over the past four decades, and has declined significantly over the past decade, especially in the Appalachian Mountains BCR. Scrub-shrub birds as a group are also declining significantly across the region over the past four decades, with some species declining precipitously. The decline in small-diameter forested habitats is undoubtedly contributing to the decline for some scrub-shrub species. The FIA database is the only regional database that tracks this forest resource, although its usefulness for tracking change in the habitat availability for specific scrub-shrub birds appears to be somewhat limited. The loss of habitat alone (as measured by FIA data defined by this study) is not solely related to the population trends. Some of the scrub-shrub birds examined are more closely tied to old field habitats. There are no databases that track the availability of this habitat type. In addition, some of the scrub-shrub species are Nearctic-Neotropical migrants that may be experiencing habitat loss along their migration routes or on their wintering grounds.

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