CHAPTER 8

LONG-TERM USE OF BREEDING BIRD CENSUS PLOTS TO MONITOR POPULATIONS OF NEOTROPICAL MIGRANTS BREEDING IN DECIDUOUS FORESTS IN EASTERN PENNSYLVANIA, USA

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INTRODUCTION

Measuring and monitoring biological diversity in forest ecosystems is not easy. The structural complexity of forest vegetation that produces high diversity also makes that diversity difficult to assess (e.g. Peterken and Backmeroff, 1988). Given the problems inherent in measuring faunal diversity in forests, it is not surprising that birds are often chosen as faunal indicators of these habitats. Birds are useful indicators because they frequently exist at high trophic levels, depend upon many woodland features and functions, are sensitive to environmental change, and are more easily observed than many forest taxa. In addition, throughout Europe and North America, thousands of amateur bird watchers and professional ornithologists donate considerable time and effort to a number of avian-population monitoring schemes (Gill, 1994), many of which include sites in forested ecosystems (Sauer and Droege, 1990; Stastny and Bejcek, 1990; Spellerberg, 1991) (Table 8.1). Although the ultimate goals of these programs differ, all provide spatially explicit data sets of considerable value in ecological monitoring.

We present the results of a long-term study of ovenbird (*Seiurus aurocapillus*) and wood thrush (*Hylocichla mustelina*) populations at two Breeding Bird Census plots at Hawk Mountain Sanctuary in eastern Pennsylvania together with recent studies of the relative densities and reproductive success of these two relatively widespread and conspicuous species in large, contiguous forests and smaller woodlots in the region. We use this example to highlight the value and the limitations of long-term census plots in monitoring forest ecosystem function.

STUDY AREA

Deciduous forests of eastern North America consist of forest communities dominated by trees that drop their leaves each winter (Kricher and Morrison,

Table 8.1 Examples of bird monitoring programs that include forest ecosystems (after Spellerberg, 1991)

Monitoring program	*Year established and initial organizer*	*Reference*
North America		
Christmas Bird Count	1900, Nat'l Audubon Society	Butcher, 1990
Breeding Bird Census	1937, Nat'l Audubon Society	Johnston, 1990
Winter Bird Population Study	1948, Nat'l Audubon Society	Anonymous, 1947, 1950
Breeding Bird Survey	1966, US Fish & Wildlife Service, Canadian Wildlife Service	Droege, 1990
Europe		
Nest Record Scheme	1939, British Trust for Ornithology	O'Connor and Shrubb, 1986
Winter Bird Census	1956, Finnish Museum of Natural History	Hildén *et al.*, 1986
Common Bird Census	1961, British Trust for Ornithology	O'Connor and Shrubb, 1986
SOVON Bird Censuses	1970, Cooperating Organizations on Bird Census Work – The Netherlands	Saris *et al.*, 1990

1988). Although not as biologically diverse as some of their tropical forest counterparts, eastern deciduous forests are structurally and biologically complex (Brooks, 1965). More than 500 species of trees and shrubs occur within eastern deciduous forests, 67 of which are found mainly or only in this habitat (Brockman, 1968).

Eastern deciduous forests occur between 32° and 45°N latitude and 70° and 98°W longitude. They have temperate climates; January temperatures average –6.7 to 4.4 °C, while July temperatures average 21.1 to 26.7 °C. Annual precipitation ranges from 81 to 203 cm, including annual snowfalls of 20 to 244 cm (northeast to southwest) and relative humidities of 60% to 80% (Greller, 1988). Mature eastern deciduous forests have a closed canopy of about 30 m, a subcanopy, and one or two shrub layers (Greller, 1988). Although deciduous species dominate, dicotyledonous evergreen shrubs and trees co-occur with deciduous flora, especially at the northern and southern limits of the forest (Greller, 1988).

Prior to European settlement, deciduous forests consisted of large, unbroken stands interrupted only by bodies of water, small prairies, storm-induced windfalls, and Native American settlements (Greller, 1988). Native Americans lived in the forest at low densities, clearing small 8- to 80-ha parcels for crops

such as corn, squash, and tobacco. Most cultivated plots were abandoned after 8 to 10 years, as soil fertility declined and productivity dwindled (Greller, 1988). Natives used fire to clear undergrowth, enhance travel, and increase game and decrease pest populations (Cronon, 1983; Russell, 1983).

The deciduous forests of eastern North America were menacing to early European settlers, and forested habitats were cleared rapidly. Historians predicted the demise of the habitat as early as the mid-eighteenth century (Kalm, 1770–1). The first sawmill in eastern North America was built in Maine in 1623; by 1840, there were more than 30,000 mills in the region (Williams, 1989).

Faced with a seemingly endless supply of wood, European settlers switched from half- to full-timbered construction for their homes, which tended to be considerably larger than their European counterparts. Consumption of wood for fuel was far greater in the eastern United States than it was in Europe (Cronon, 1983). Trees were cut to clear land for agriculture, for fencing, for naval stores (i.e. masts, spars, planks, etc.), to produce charcoal to make iron, and, later, for railroad ties and mine timbers (Williams, 1989). By 1860, approximately 55 million ha of eastern forests had been cut; by 1910, the total approached 115 million ha (Williams, 1989). The deciduous forests of eastern North America were cut, almost in their entirety, from east to west by the end of the nineteenth century. Although the geographic distribution of most tree species has not changed from pre-colonial times, forest stands are now considerably smaller. Earlier in this century, the once-dominant American chestnut (*Castanea dentata*) was all but lost to an exotic blight (Braun, 1950).

In the mid-1800s, some North Americans began to question the wholesale loss of this habitat type (e.g. Marsh, 1864; Lapham *et al.*, 1867). As a result, in 1876, the US Congress established the Division of Forestry within the Department of Agriculture. In 1890, legislation permitting the federal government to establish public forest reserves was passed. By 1901, 24 million ha were in public hands. Five years later, the number stood at more than 60 million ha (Williams, 1989). Exactly how much of the original eastern deciduous forest exists today remains unknown.

Hawk Mountain Sanctuary (40° 38'N and 75° 59'W) is an 890-ha natural area in Berks and Schuylkill counties (Brett, 1991) along the Kittatinny Ridge, approximately 40 km north of Reading and 45 km northwest of Allentown, Pennsylvania. The Sanctuary lies within the Eastern Deciduous Forest Biogeographical Province (Udvardy, 1984) and is characterized by a temperate continental climate with warm, humid summers and cold winters. Annual precipitation averages 110 cm.

Most of Hawk Mountain is second growth mixed-deciduous forest, the result of human disturbances that have included lumbering, charcoal making, and burning to increase stands of native blueberry (*Vaccinium* spp.) (Braun, 1950). In the 1970s and 1980s, outbreaks of gypsy moths (*Lymantria dispar*) in eastern Pennsylvania triggered significant diebacks in the region. Sanctuary forests are part of a larger contiguous woodland consisting of adjacent segments of the

National Park Service's Appalachian Trail corridor and 8900 ha of Pennsylvania State Game Lands.

In an attempt to monitor forest diversity at the site, the Sanctuary began censusing bird populations at two Breeding Bird Census (BBC) plots (see below for details) in the spring of 1982. The Owl's Head and River of Rocks Breeding Bird Census (BBC) plots lie within 1.5 km of each other in the large (more than 10000 ha), contiguous, somewhat linear forest that straddles the southeastern-most ridge of the Central Appalachian Mountains in eastern Pennsylvania. Both are characteristic of second-growth oak–chestnut forests that occur throughout the region's Ridge and Valley Province (Braun, 1950). Following the loss of American chestnut as a canopy dominant earlier this century, *Quercus* species have come to dominate these forest types (Greller, 1988).

The Owl's Head site is a rectangular (490 × 400 m), 19.4-ha, oak–maple ridge-top (440 m in elevation) forest plot. Tree-ring cores suggest the forest at the site is at least 120 to 130 years old. Canopy trees attain heights of 12 to 22 m. Many trees at the site have multiple trunks, apparently the result of resprouting from cut stumps. The plot, which sits on a spur of the Kittatinny Ridge, has a gentle southwest-facing slope. Dominant canopy species, in descending abundance, include chestnut oak (*Quercus prinus*), red maple (*Acer rubrum*), red oak (*Q. rubra*), and scarlet oak (*Q. coccinea*), as well as a few pitch pines (*Pinus rigida*). Dominant understory trees are black gum (*Nyssa sylvatica*) and sassafras (*Sassafras albidum*). The shrub stratum consists of an open-to-closed layer of heaths, dominated by huckleberry (*Gaylussacia baccata*) and sheep laurel (*Kalmia angustifolia*), along with some blueberry and mountain laurel (*K. latifolia*). Twenty-four species of trees and shrubs are known to occur on the plot. White-tailed deer (*Odocoileus virginianus*) populations approach seven individuals/km² in the area, and the herbaceous layer is sparse and patchy. Two small (less than 0.1 ha) seasonal wetlands occur on the plot, and two unpaved, single-lane fire roads transect the plot for approximately 750 m. Trees on a 0.8-ha portion of the plot in the southeastern corner were cut in the mid-1970s, and the section was maintained as an opening until the mid-1980s, when the opening was allowed to enter secondary succession. A second small forest opening lies approximately 150 m west of the plot; otherwise, the plot is surrounded by similar forest (F. D. Watson unpublished data).

The River of Rocks site is a rectangular (430 × 400 m), 16.9-ha, oak–maple rocky slope (275 to 335 m in elevation) forest plot. It is better protected and mesic and more steeply sloped than the Owl's Head plot, with larger and more widely spaced canopy trees. Tree-ring cores indicate several canopy trees in excess of 200 years, while many other trees appear to be at least 100 to 120 years old. The plot slopes gently to steeply to the east. A large boulder field, known locally as the River of Rocks, covers a portion of the eastern third of the plot. Dominant canopy species, in descending order, include chestnut oak, red oak, sweet birch (*Betula lenta*), red maple, white oak (*Q. alba*), scarlet oak, and tulip tree (*Liriodendron tulipifera*), as well as scattered white pine (*Pinus*

strobus), pitch pine, and eastern hemlock (*Tsuga canadensis*). Black gum is principally an understory tree in the plot, where it co-occurs with sassafras. The closed shrub stratum is dominated by huckleberry and stands of blueberries, along with some mountain laurel wintergreen (*Gaultheria procumbens*). Virginia creeper (*Parthenocissus quinquefolium*) occurs in boulder fields. Thirty-six species of trees and shrubs are known to occur on the plot. The herbaceous layer, which is poorly developed, contains isolated stands of wild sarsaparilla (*Aralia nudicaulis*) and interrupted fern (*Osmunda claytoniana*) (F. D. Watson unpublished data). Chinese packing grass (*Microstegium vimineum*), an invasive exotic, is increasing on the plot.

Both plots, the perimeters of which were accurately surveyed in 1982, are gridded and marked with plastic flagging at 30.5-m intervals.

In 1988, we initiated comparative studies of ovenbird breeding biology at the two BBC plots and at 11 small woodlots within 12 km of the larger forest (Porneluzi *et al.*, 1993). In 1990, the studies were expanded to include wood thrushes (Hoover, 1992; Hoover, *et al.*, 1995). The woodlots, which range in size from 9 to 183 ha, are in heavily farmed lowlands southeast of the Sanctuary. All are characterized by upland, second-growth, mixed-deciduous forest typical of the area. The countryside surrounding the plots consists mainly of small (approximately 80 ha), owner-operated dairy, hog, poultry, Christmas tree, grain, and hay farms. Detailed descriptions of the woodlots, the sizes of their core areas (i.e. areas at least 100 m from the forest edge), distances to the large forest, and forest areas within a 2-km radius are in Porneluzi *et al.* (1993, Table 8.1). Data from the woodlots were used, together with those collected at the two BBC plots, as part of an effort designed to assess the impact of local landscape changes on the density, abundance, and reproductive success of these two Neotropical songbirds (Hoover, 1992; Porneluzi *et al.*, 1993; Hoover *et al.*, 1995).

METHODS

Breeding Bird Censuses (BBCs)

Initiated by the National Audubon Society in 1937, the BBC program is the longest-running, large-scale survey of breeding birds in North America. Like all good long-term monitoring programs, the BBC is characterized by its simplicity and stability (Spellerberg, 1991). BBCs estimate breeding bird densities in individual, relatively uniform habitat types throughout North America using the spot-mapping technique (Robbins, 1970). In general, BBCs follow the 'international standard for a mapping method in bird census work' adopted by the International Bird Census Committee in 1968 at Hillerød, Denmark (Svensson, 1970).

Most BBCs are conducted by experienced volunteers in the United States and Canada. In 1993, 140 censuses, 47 of which had been conducted for at least

a decade, were undertaken in 31 states, the District of Columbia, and one Canadian province. Most BBC sites, 61% of which are forested, are relatively secure plots of native habitat.

In most instances, forested BBC plots are relatively square areas of at least 10 ha, with a preferred size of 25 ha, within larger forested tracts. Detailed descriptions of each plot are provided by each cooperator. Descriptions include the plot's location with reference to existing names on official maps (usually 1:24 000-scale US Geological Survey topographic maps), general landscape and topographic characteristics, plot size, a large-scale vegetation map or verbal description including mention of dominant and important species (e.g. James and Shugart, 1970), and other pertinent information (cf. Robbins, 1970).

Plots are gridded at regular intervals (usually 50 m; the plots mentioned below are gridded at 30.5-m intervals) to aid consistent travel though the plot and enable accurate mapping of birds. Grid points are superimposed on maps used to record census results. BBCs encompass the nesting periods of most of the birds breeding on the plot, with intensive sampling restricted to 6 weeks. Sampling occurs in early morning, usually within 30 min of sunrise, and sometimes in late afternoon, with visits lasting 10 to 12 min/ha. Sampling consists of one or, more rarely, a pair of observers walking a series of parallel or near-parallel routes, with the observer recording birds within 50 m of either side of the route. Routes are reversed to avoid using the same starting and finishing points on sequential censuses. Ten to 12 visits are recommended; at least 8 are required. Counts are not conducted during heavy rains or high winds. Year-to-year consistency in protocol within plots is emphasized (cf. Robbins, 1970).

Observers record date, time, temperature, wind, and snow depth at the beginning of each visit, and all birds contacted (by sight or sound) during each survey. Population density is recorded as the number of stationary males, which, in turn consists of the number of mapped territories. Territories are determined on the basis of clusters of encounters, with at least three registrations recorded during 8 to 10 visits. Fractional territories representing edge clusters are allowed, with results being rounded to the nearest half territory (Robbins, 1970).

The Cornell Laboratory of Ornithology at Ithaca, New York, coordinates the BBC program and manages the resulting data base. Detailed instructions for conducting and completing official BBC forms are available from the laboratory.

One of the more remarkable aspects of the BBC program is the fact that summaries of each census in the program are published on a regular basis. Since 1989, census results have appeared in a supplement to the *Journal of Field Ornithology*. Prior to 1989, results appeared in *Bird Lore* (1937 to 1940), *Audubon Magazine* (1941 to 1946), *Audubon Field Notes* (1947 to 1970), and *American Birds* (1971 to 1984). The results of individual BBCs, which are available upon request, are archived and managed by the Cornell Laboratory of Ornithology. A computerized data base of more than 4000 BBCs existed as of 1992 (Butcher, 1993).

Census methods at Hawk Mountain Sanctuary BBC plots

The Owl's Head and River of Rocks plots have been censused on an annual basis since 1982, using the spot-census protocol described above. In all but a few instances, a single observer conducted each census within a given year. Censuses, which begin within 1.5 h of sunrise, usually take 1.5 to 2.5 h to complete. With the single exception of 1982, when censusing began in mid-March at Owl's Head and early April at River of Rocks and ended at the two sites in early June and late May, respectively, censusing typically occurs from early to mid-May through mid-June to mid-July (Table 8.2). The number of censuses and the number of hours spent in censusing have increased over the 13-year sampling effort (Table 8.2).

Although all birds seen were censused in both BBC plots, for the purposes of this report, we include data only for ovenbirds and wood thrushes. Annual variations in the numbers of ovenbirds and wood thrushes censused at the plots were analyzed using the SAS correlation procedure (SAS, 1988).

Table 8.2 Census effort at the Owl's Head and River of Rocks Breeding Bird Census plots at Hawk Mountain Sanctuary, eastern Pennsylvania, 1982–1994

Year	*Census plot*	*Dates of first and last census*	*Number of censuses (total h censused)*
1982	Owl's Head	15 March – 1 June	7 (14)
	River of Rocks	1 April – 27 May	7 (14)
1983	Owl's Head	2 May – 16 June	4 (8)
	River of Rocks	2 May – 24 June	4 (8)
1984	Owl's Head	15 May – 4 July	8 (19)
	River of Rocks	19 May – 3 July	8 (19)
1985	Owl's Head	13 May – 22 June	8 (18)
	River of Rocks	16 May – 1 July	8 (17)
1986	Owl's Head	23 May – 30 June	8 (17)
	River of Rocks	23 May – 8 July	8 (14)
1987	Owl's Head	26 May – 26 June	9 (18)
	River of Rocks	28 May – 26 June	9 (19)
1988	Owl's Head	23 May – 23 June	11 (21)
	River of Rocks	24 May – 22 June	10 (21)
1989	Owl's Head	3 May – 23 June	8 (16)
	River of Rocks	25 April – 28 June	9 (19)
1990	Owl's Head	25 April – 30 June	12 (24)
	River of Rocks	26 April – 27 June	11 (25)
1991	Owl's Head	2 May – 16 June	11 (24)
	River of Rocks	29 April – 20 June	10 (21)
1992	Owl's Head	28 April – 14 July	12 (26)
	River of Rocks	29 April – 23 June	13 (32)
1993	Owl's Head	29 April – 14 July	11 (25)
	River of Rocks	28 April – 12 July	10 (23)
1994	Owl's Head	2 May – 2 July	10 (23)
	River of Rocks	22 April – 9 July	11 (25)

Intensive studies of reproductive success at Hawk Mountain

Since 1988, we have captured and color-banded 95 to 100% of all territorial male ovenbirds residing in the two BBC plots. In 1990, banding efforts were expanded to include ovenbirds nesting on the woodlots. Since 1988 and 1990, respectively, ovenbirds have been censused at the two BBC plots and at nine of the 11 woodlots at approximately 7-day intervals.

Males are banded in May and censused at least weekly through late July. The locations of birds are noted on gridded maps during early morning censuses, using spot mapping (Bibby *et al.*, 1992). Ovenbird vocalizations are broadcast on a few occasions during the fledging period each season to help locate previously marked males and their fledglings. Male ovenbirds are considered paired if they are seen carrying food, defending a nest or fledglings, or interacting with a female. Each male's territory is checked three times during the fledging period (mid-June through mid-July) for evidence of fledglings. Because fledglings remain with their parents for up to 30 days of age (Hann, 1937), our estimates of minimum reproductive success should closely approximate actual rates. See Porneluzi *et al.* (1993) for additional details on ovenbird censusing techniques.

In 1990 and 1991, Hoover (1992) banded approximately 60% of territorial male wood thrushes at the two BBC plots and at 9 of the 11 woodlots, as part of an effort to determine nesting success of the species. Unlike ovenbird nests, the exact location of which were rarely determined, Hoover (1992) located most, if not all, wood thrush nests during the course of these efforts. Thrush nests were found by contacting and following territorial males and through methodical searches in appropriate vegetation. Once found, nests were monitored until they were abandoned or destroyed or until the young fledged. Success was assessed directly by monitoring activity at each nest site at approximately 4-day intervals and analyzed using the Mayfield method (Mayfield, 1975). Numbers of fledglings at successful nests were determined by visiting nests one to two days before nestlings were expected to fledge. See Hoover (1992) for additional details on wood thrush-censusing and nest-monitoring techniques.

RESULTS

Breeding Bird Censuses

BBC census results indicate that 4 to 13 pairs of ovenbirds and 1 to 3 pairs of wood thrushes used the Owl's Head plot and that 4.5 to 10.5 ovenbirds and 0 to 3.5 pairs of wood thrushes used the River of Rocks plot, respectively, between 1982 and 1994 (Figure 8.1). Numbers of ovenbirds at Owl's Head ($p < 0.0001$, $r = 0.88$), but not at River of Rocks ($p = 0.055$, $r = 0.54$), increased significantly in those years. Numbers of wood thrushes did not vary significantly among years at either BBC plot during the period (Owl's Head, $p = 0.70$, $r = -0.12$; River of Rocks, $p = 0.89$, $r = 0.043$). Overall, ovenbird numbers at the two plots

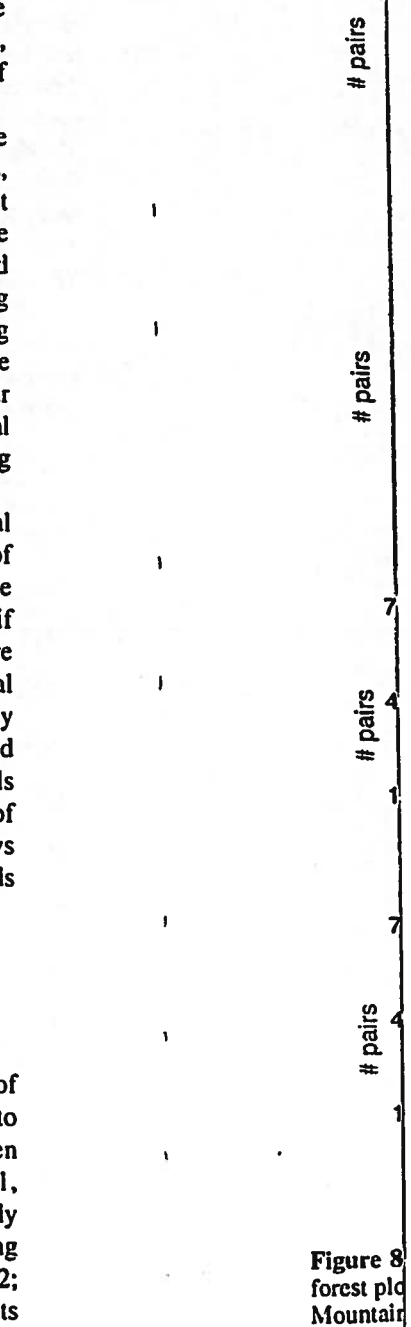

Figure 8
forest plo
Mountain

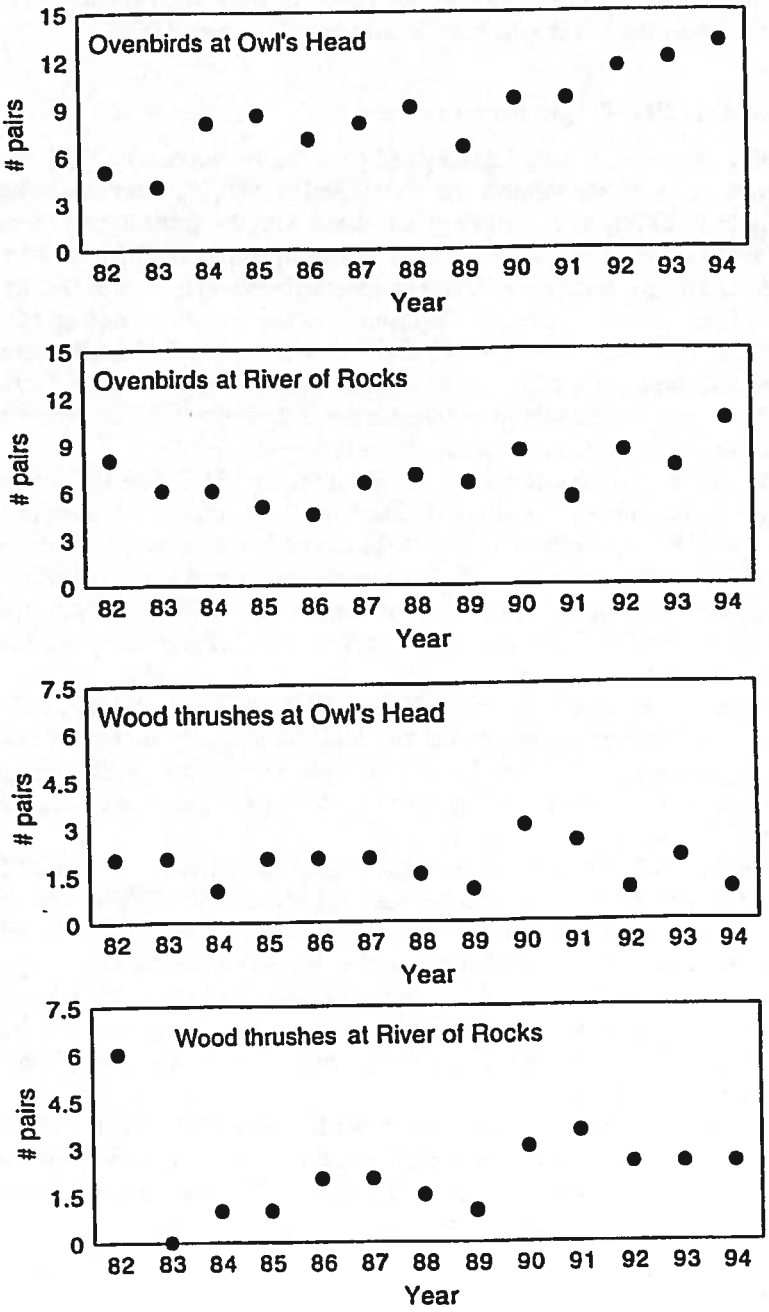

Figure 8.1 Breeding Bird Census results (1982-1994) for the oak-maple ridge-top forest plot (Owl's Head) and the oak-maple slope forest plot (River of Rocks) at Hawk Mountain Sanctuary, Pennsylvania. See text for results of correlation analyses

increased significantly from 1982 through 1994 ($p = 0.0002$, $r = 0.85$); wood thrush numbers did not change significantly ($p = 0.98$, $r = -0.0059$).

Intensive studies of reproductive success

Intensive studies of ovenbird density and reproductive success on BBC plots and small woodlots (see Methods above), initiated in 1988, indicate that ovenbird density in local forests is positively correlated with the percentage of forest area within a 2-km radius of the plot, the size of the forest in which the plot is located, and the percentage of core area (see Methods above) in the plot. Ovenbird density is negatively correlated with distance to the nearest large (larger than 10 000-ha), contiguous forest (Porneluzi *et al.*, 1993, unpublished data). Overall, ovenbird densities in smaller (smaller than 45-ha) woodlots averaged 0.048 birds ha^{-1}, versus 0.40 and 0.70 birds ha^{-1} in larger (larger than 100-ha) woodlots and the two BBC plots, respectively (Porneluzi *et al.*, 1993).

The breeding success of male ovenbirds at the two BBC plots did not vary between plots or among years from 1988 through 1990. In 1990, however, males in the two BBC plots were more likely to be paired than were males in woodlots of any size. Furthermore, in 1990, 27 males that attempted to breed in the two BBC plots were 10 times more successful than the 17 individuals that attempted to breed in woodlots (59% versus 5.9%, respectively) (Porneluzi *et al.*, 1993, unpublished data).

In spite of considerable interannual variation, the above-mentioned trends of substantially higher ovenbird densities and dramatically higher ovenbird breeding success in the forest-interior BBC plots versus the smaller woodlot plots has been maintained in data collected during the four years since 1990 (unpublished data).

Intensive studies of wood thrush density and reproductive success on BBC plots and small woodlots (see Methods above), initiated in 1990, indicate that, unlike that of ovenbirds, the density of wood thrushes was greater in small woodlots (smaller than 80 ha) than in woodlots larger than 100 ha and contiguous forests (0.37 birds ha^{-1} versus 0.11 birds ha^{-1}; Hoover *et al.*, 1995). As with ovenbirds, however, thrush breeding success was higher in large woodlots (69% and 77% in 1990 and 1991, respectively) than in small woodlots (42% and 43%) (Hoover *et al.*, 1995).

The above-mentioned trends of higher thrush densities but lower reproductive success in small woodlots versus large woodlots and contiguous forest, were maintained in data collected in 1992 through 1994 (G. Morgan personal communication, unpublished data).

DISCUSSION

The results of our studies suggest first that ovenbird numbers on the sanctuary's large, contiguous forest increased between 1982 and 1994, while those of wood

Table 8.3 Annual percentage changes in numbers of ovenbirds and wood thrushes on state-wide (Pennsylvania), region-wide (east of the Mississippi), and range-wide Breeding Bird Surveys collected from 1980-1994 (no asterisk: $p > 0.10$; *: $p < 0.01$; data presented below are the result of efforts by thousands of US and Canadian volunteers in the field and National Biological Service researchers at the Patuxent Environmental Science Center, Laurel, Maryland)

Species	*State-wide*	*Region-wide*	*Range-wide*
Ovenbird	4.3%* (90)	0.2% (941)	0.1% (1035)
Wood thrush	–0.7% (103)	–1.3%* (1225)	–1.2%* (1330)

thrushes remained relatively stable. Second, ovenbird populations are greater on the sanctuary's large contiguous forests than in surrounding isolated woodlots, while the reverse is true of wood thrush populations. Our results also suggest that ovenbirds and wood thrushes breeding in the sanctuary's large, contiguous forests may function as 'source' populations (*sensu* Pulliam, 1988) for birds breeding in the surrounding woodlots, which, in turn, may function as 'sink' populations. Taken as a whole, these results provide insights into the use of BBC plots in monitoring local, regional, and range-wide population trends.

Consider a comparison of our BBC results (increases in ovenbird populations, no significant change in wood thrush populations; Figure 8.1) with somewhat concurrent state-wide, region-wide, and range-wide analyses of Breeding Bird Survey routes for ovenbirds and wood thrushes (Table 8.3). Note that North American Breeding Bird Survey (BBS) routes are 40 km long and consist of 50 point counts spaced at 0.8-km intervals. Designed to provide information on long-term trends in the abundance and distribution of birds in the United States and Canada (Droege, 1990), BBSs have been widely used to document large-scale changes in populations of Neotropical migrants breeding in North American forests (see Hagen and Johnston, 1992 and references therein for numerous examples). We are not aware of any state-wide, regional, or range-wide analyses of BBC plots that are available for comparison.

At Hawk Mountain, BBC results for ovenbirds and wood thrushes agree with state-wide analyses of BBSs for these two species, but they do not agree with region-wide or range-wide analyses for the species (Table 8.3). The lack of agreement among state-wide, region-wide, and range-wide BBS analyses may reflect differences in the scales of the analyses (cf. Holmes and Sherry 1988) as well as geographic variation in population trends for the two species (cf. James *et al.*, 1992).

Our results suggest that on and near Hawk Mountain Sanctuary, ovenbird and wood thrush populations function differently in woodlots and contiguous forests and that populations in the two kinds of habitats may be linked via source/sink dynamics (Pulliam, 1988). In both species, populations in isolated woodlot (i.e. sink) habitats appear to be considerably more prone to nest predation than

are those breeding in large, contiguous forest (i.e. source) habitats (Porneluzi *et al.*, 1993; Hoover *et al.*, 1995, unpublished data).

This being the case, consider what would happen if the threat of nest predation in the region were to be reduced significantly (e.g. as the result of the introduction of an especially virulent pathogen). Almost certainly, the impact of this change would affect sink populations far more so than it would source populations, and monitoring only the former during such an event would yield considerably different results than monitoring only the latter.

Our results also have implications for judging the appropriateness of a habitat type based on the relative breeding abundances of a species in it versus other habitat types. The fact that one of the species we studied, the wood thrush, existed at higher densities in woodlots despite its considerably greater success in contiguous forest suggests that relative density alone is no indication of relative habitat value for a species. Hoover's (1992) initial results suggest that woodlots actually have about twice as many successful nests per unit area (i.e. 0.16 versus 0.08 ha^{-1}) as do large, contiguous forests. However, woodlots may still harbor sink populations if they are incapable of maintaining those populations without influxes from surrounding contiguous forest populations existing at lower densities overall.

In fact, higher densities in sink rather than in source habitats are likely to occur whenever minimally acceptable breeding sites are more common in sinks than in sources (Pulliam, 1988). In such instances, sink habitats may actually function as 'ecological traps', drawing large segments of regional populations into insufficient habitats. This is likely to occur whenever the habitat cues that a species uses to select superior breeding sites (e.g. species of nest trees or prey, forest/floor topography or microclimate, etc.) are no longer associated with the naturally functioning ecosystems they evolved to indicate (e.g. large, contiguous lowland forests), but rather with look-alike dysfunctional systems (small, isolated woodlots).

The sanctuary's large, contiguous forests appear to offer wood thrushes limited options for breeding and, consequently, a significant portion of the population is attempting to breed in habitats that, while meeting the minimum criteria for settlement, result in relatively low breeding success. This may partly explain why this species, and not the ovenbird, appears to be declining regionally (Table 8.3).

Implications for the use of BBC plots in regional and range-wide monitoring efforts

Many bird species breed in a variety of habitats. In most instances, both breeding density and breeding success vary considerably among habitat types (Pulliam, 1988). Large-scale monitoring schemes that fail to take this into account may yield spurious results.

The value of a monitoring site beyond its immediate borders depends on its representative nature. This raises a number of important questions regarding how BBC sites were originally chosen. Were they chosen because of easy

access?, because they were good birding spots?, because they were believed to be relatively secure from habitat alteration?, or because other monitoring or research was being conducted at the site (Johnston, 1990)? In fact, potential BBC participants have been cautioned to select their areas carefully, with preference given to 'uniform' and 'virgin or climax habitats' (Hall, 1964). As a result, in 1993, 61% (85 of 140) of all BBCs were conducted in deciduous or coniferous forests, and only 4% were conducted in successional fields and cultivated sites (Anonymous, 1994).

In many instances BBC locations were chosen because they represented late-successional tracts of remnant natural vegetation, not because they were typical of the region's existing habitat mosaic (Hall, 1964). As such, the principal monitoring value of most BBCs probably lies in their use as monitors of populations within their borders and only to a lesser extent as representatives of populations in larger regions. On the other hand, BBCs in stable landscapes that are representative of regional habitat types can serve as benchmarks for comparisons with and interpretations of BBS trends collected in more rapidly changing landscapes.

In addition, and as this study indicates, BBC plots can provide important research value as well. When coupled with intensive studies of reproductive success, long-term censusing efforts at BBC plots can provide important insights into the underlying causes of local population change (Holmes and Sherry, 1988), with implications reaching well beyond their borders. Recently, for example, several researchers have suggested that breeding habitat for forest-related Neotropical migrants has increased in North America (Birch and Wharton, 1982; Powell and Rappole, 1986). The results of our efforts suggest that although both ovenbirds and wood thrushes will occupy and attempt to breed in both contiguous forest and small woodlots, populations in the latter may depend upon populations in the former for their continued existence. Estimates of changes in forest cover in North America that fail to account for changes in the distribution, composition, and quality of that cover (i.e. relative amounts in large, contiguous forest versus small forest) may be less than helpful in predicting consequent shifts in populations of forest-dwelling birds.

In summary, our findings lead to two cautionary conclusions. First, long-term monitoring of forest-dwelling bird populations, such as that supplied by the current system of BBC plots, is capable of providing potentially accurate signals of population change within the habitat types represented by those plots, even though data collected therein are not necessarily representative of other habitat types in the region (e.g. Hagen and Johnston, 1992 and numerous contributions therein). Second, monitoring schemes that focus solely on population densities and do not also investigate the factors affecting such densities are less likely to produce results that are useful to conservationists than are more inclusive schemes that couple long-term monitoring of population densities with more intensive short-term investigations of the factors responsible for those densities (cf. Temple and Wiens, 1989).

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