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RESULTS OF THE VERMONT FOREST BIRD MONITORING PROGRAM, 1989-1996

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ABSTRACT - We conducted a statistical analysis of breeding census data from the first 8 years (1989-1996) of the Vermont Forest Bird Monitoring Program (FBMP). Data were collected at 17 study sites located in large tracts (= 40.5 ha) of mature, forested habitats in Vermont. A route regression model was used to produce population trends for 67 species and 3 groups of species categorized by wintering range. Power analyses conducted for 4 species revealed that the FBMP adequately sampled species which occurred on at least 9 or more of the 17 study sites and that our ability to detect small (=2%) population changes will increase dramatically after 15 years of monitoring. FBMP data showed significant declines in breeding populations of black-capped chickadee, solitary vireo, and Canada warbler, but a significant increase in rose-breasted grosbeak. When species were categorized by wintering range, neotropical migrants showed a significant overall increase and year-round residents declined. The negative trend for Canada warbler, corroborated by Breeding Bird Survey (BBS) data and migration monitoring data from Long Point Bird Observatory in Ontario, suggest that this species is experiencing widespread declines over a significant portion of its breeding range. Rates of population change in FBMP data were poorly correlated to BBS trends. We found significant positive correlations between Vermont's average winter temperatures and the relative abundances of brown creeper, downy woodpecker, and for all resident species combined. We evaluated the number of brown-headed cowbird occurrences by study site and physiographic region. Most cowbirds (95.3%) occurred at FBMP sites located in the predominately agricultural Champlain Lowlands, suggesting that even relatively large forested tracts in this region may be subject to high rates of cowbird parasitism.

INTRODUCTION

Numerous recent studies have documented declines in populations of neotropical migratory birds inhabiting highly fragmented landscapes (Donovan et al. 1995, Hagan and Johnston 1992, Robinson et al. 1995, Terborgh 1989). These studies have typically focused on forest-dwelling species in regions where formerly extensive, contiguous tracts of forest habitat have been broken and isolated into increasingly smaller patches. Accelerated rates of fragmentation are thought to have resulted in increased rates of nest predation and brood parasitism, which have

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contributed to declines in many breeding populations (Paton 1994, Robinson et al. 1993, Wilcove 1985). Recent research has shown that while breeding densities of some neotropical migrants may increase shortly after fragmentation of forest stands, subsequent productivity may be lower in fragments than in nonfragmented forests (Hagan et al. 1996).

To more clearly understand the effects of habitat fragmentation on birds, it is critical to collect long-term population trend data from both impacted areas and from protected, non-fragmented habitats (Arcese and Sinclair 1997, Temple and Wiens 1989). Data from protected sites serve as controls with which to assess population changes due to local or widespread environmental changes.

In 1989 the Vermont Institute of Natural Science (VINS) initiated the Vermont Forest Bird Monitoring Program (FBMP). The program was modeled after the Ontario FBMP, which the Canadian Wildlife Service (CWS) launched in 1987 (Welsh 1995). The Vermont FBMP was designed to detect changes in breeding populations over time for all forest-dwelling songbirds, and to collect habitat-specific baseline data on species composition and relative abundance at undisturbed, interior forest sites in Vermont.

We undertook a statistical analysis of data collected from 17 study sites between 1989 and 1996. Our analysis included population trend estimates, a comparison of FBMP trends to those from other long-term data sets, and an evaluation of brown-headed cowbird occurrences on FBMP study sites. We also conducted power analyses using the 8-year data set to determine whether FBMP sampling protocols were adequate to detect meaningful trends. This paper summarizes these analyses and discusses future goals of the FBMP.

METHODS

Site and Observer Selection

Several criteria were used to select FBMP study sites. Minimum requirements were that sites: 1) consist of mature, contiguous stands of homogeneous forest type; 2) be 40.5 ha or larger in order to avoid "edge effects;" and 3) be permanently protected from silvicultural practices, development, and other large-scale human-induced habitat changes. These criteria ensured that the study sites were located in relatively undisturbed, interior forest habitats that will remain relatively stable over the long-term, and in which bird populations should be little affected by the problems associated with forest fragmentation.

At each site, 5 point counts (stations) were established at least 100 m from the nearest forest edge and 200 m apart. Each station was clearly marked and labeled with survey flagging and an aluminum tree tag.

Volunteer observers were encouraged to participate in the project if they possessed a high degree of competency in both aural and visual bird identification, and could make a multi-year commitment.

Survey Methods

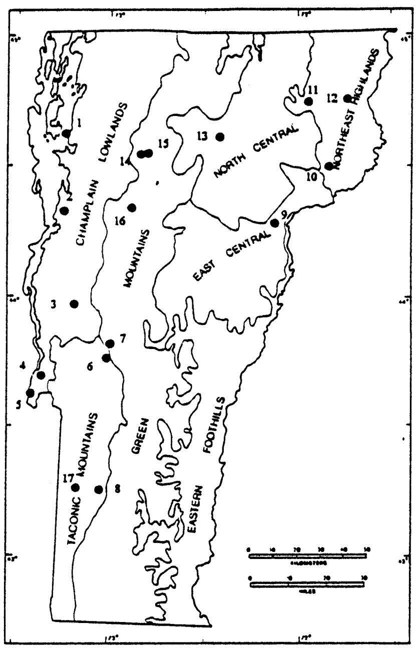
Survey methods consisted of unlimited distance point counts, based on the approach described by Blondel et al. (1981) and used in Ontario (Welsh 1995). The count procedure was as follows:

1) Counts began shortly after dawn on days where weather conditions were unlikely to reduce count numbers (i.e., calm winds and very light or no rain). Censusing began shortly (<1min.) after arriving at a station.
2) Observers recorded all birds seen and heard during a 10-min sampling period, which was divided into 3 time intervals: 3, 2, and 5 mins. Observers noted in which time interval each bird was first encountered and were careful to record individuals only once. To reduce duplicate records, individual birds were mapped on standardized field cards and known or presumed movements noted. Different symbols were used to record the status of birds encountered (i.e., singing male, pair observed, calling bird, etc.).
3) Each site was sampled twice during the breeding season; once during early June (ca. 2-12 June) and once during late June (ca. 14-25 June). Observers were encouraged to space their visits 7-10 days apart. For each site visit, all stations were censused in a single morning and in the same sequence.
4) Following each survey, field data were transcribed by the observer from the field cards onto data coding sheets. The level of breeding evidence determined whether a bird was assumed to indicate a pair or a single bird: singing males, observed pairs, occupied nests, and family groups were considered to represent a pair and counted as 2 birds. All other individuals seen or heard were counted as singles.

In 1989, 11 sites (55 stations) were established and censused by VINS staff and volunteers. Two additional sites were added in 1990, 3 in 1991, and 1 in 1992, bringing the total number of study sites to 17 (85 stations) (Fig.1). Six sites were located in northern hardwood forests; 6 were in transition hardwood forests dominated by oak (*Quercus* sp.), hickory (*Carya* sp.), maple (*Acer* sp.), and American beech (*Fagus grandifolia*); 3 were in lowland spruce (*Picea* sp).-balsam fir (*Abies balsamea*) forests; and 2 were in montane red spruce (*Picea rubens*)-balsam fir forests.

Data Analysis

In preparing the data for population trend and power analyses, we used the higher of the 2 values recorded for each species as the station estimate for each year. Due to differences in the ability of observers to census birds, resulting in biased trend estimates (Sauer et al. 1994), only data from the same observer in consecutive years at the same site were used for trend estimates. To improve the comparability of observations at sites that experienced a change in observer, data were divided into subsets corresponding to different observers. Since trends cannot be calculated from subsets of a single year, data were discarded from trend analyses if an observer surveyed a site for just one year. Kendall et al. (1996) recommend that count data from an observer's first year be removed from trend analyses due to a novice effect which was demonstrated to bias BBS trend results. We chose not to eliminate these data (N = 26) for this analysis in order to avoid further reducing sample sizes. For FBMP trend analyses, we used a route regression technique with several weighting factors to produce robust estimators of trend from a multiplicative model. With this method, population trends are estimated



SITE #	SITE NAME	TOWN
1	Sandbar	Milton
2	Pease Mt.	Charlotte
3	Cornwall Swamp	Cornwall
4	Shaw Mt.	West Haven
5	Bald Mt.	West Haven
6	Sugar Hollow	Pittsford
7	The Cape	Chittenden
8	Dorset Bat Cave	Dorset
9	Roy Mt.	Barnet
10	Concord Woods	Concord
11	May Pond	Barton
12	Moose Bog	Ferdinand
13	Bear Swamp	Wolcott
14	Underhill State Park	Underhill
15	Mt. Mansfield	Stowe
16	Camel's Hump	Huntington
17	Merck Forest	Rupert

Figure 1. Distribution of Vermont Forest Bird Monitoring Program sites by physiographic region, 1989-1996.

on individual FBMP sites, then a composite trend estimate is derived from a weighted average of the site-specific trends (Geissler and Sauer 1990). The route regression program that we used was generously provided by the CWS and used to produce trend analyses for both the Ontario FBMP and the Breeding Bird Survey in Canada (Collins and Wendt 1989).

In addition to calculating trends for individual species, we categorized species by wintering range as either neotropical migrants (Latin America or Caribbean winter range), short-distance migrants (southeastern U.S.), or residents (northeastern U.S.). We then examined population trends for these three groups at all 17 study sites and in hardwood forest sites only. We chose not to produce habitat-specific population trends for individual species because it would further reduce sample sizes. As additional study sites have been, and continue to be established in each habitat type, we plan to evaluate population trends on a habitat-specific basis in future analyses.

The annual percent population change of FBMP trends were compared to those from the North American Breeding Bird Survey (BBS), a continent-wide, road-based census conducted once per year since 1966 (Droege 1990, Robbins et al. 1986), and to those from the Ontario FBMP for data collected between 1987-1997 (Anonymous 1998). We used BBS data from Vermont and northern New England (BBS physiographic strata 27, defined in Robbins et al. 1986) collected between 1989-1996 (Sauer et al. 1996). These comparisons were made using the Spearman rank correlation in SYSTAT 7.0.

We conducted power analyses of FBMP data for 4 species over 4 different time periods using *Monitor 6.2* software (Gibbs 1995) specifically designed to estimate the statistical power of population monitoring programs to detect trends. Because the sample size required for statistical significance can be dramatically affected by the magnitude of change and the variance patterns of individual species (Welsh 1995), we calculated power using 4 species with different sample sizes and variability. These ranged from Ovenbird (large sample size and low variability) to Canada Warbler (relatively small sample size and high variability).

RESULTS

Trend Analysis

Population trend analyses were performed on data collected between 1989 and 1996. We produced trend estimates for 67 species recorded at 2 or more sites for at least 2 years (Table 1). Twenty-eight of these species were recorded on 2-5 sites during the 8-year period, 20 were

Table 1. Population trends of breeding birds from Vermont FBMP data, 1989-1996. N = sample size (# of FBMP sites at which species was recorded); TREND = % population change per year; *P* Value = probability of trend occurring; CI = confidence Interval (95% probability that the trend lies between the 2 confidence limits); * trend is statistically significant at $P < 0.05$. Species are listed in taxonomic order.

SPECIES	N	Trend	*P* Value	Lower CI	Upper CI
Common Snipe (*Gallinago gallinago*)	3	35.5*	0.03	22.2	50.1
Mourning Dove (*Zenaida macroura*)	5	-16.8	0.51	-50.0	38.5
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	10	11.6	0.32	-9.6	37.8
Downy Woodpecker (*Picoides pubescens*)	12	-18.1	0.22	-39.7	11.1
Hairy Woodpecker (*Picoides villosus*)	13	-15.2	0.13	-30.9	4.0
Black-backed Woodpecker (*Picoides articus*)	2	-31.6	0.37	-50.2	-5.9
Yellow-shafted Flicker (*Colaptes auratus*)	8	-21.2	0.17	-42.1	7.4
Pileated Woodpecker (*Dryocopus pileatus*)	11	2.9	0.81	-17.9	28.9
Olive-sided Flycatcher (*Contopus cooperi*)	2	-29.0	0.29	-58.5	21.5
Eastern Wood Pewee (*Contopus virens*)	10	-2.2	0.46	-7.6	3.6
Yellow-bellied Flycatcher (*Empidonax flaviventris*)	5	0.1	0.99	-16.9	20.4
Least Flycatcher (*Empidonax minimus*)	5	46.4	0.11	1.3	111.7
Eastern Phoebe (*Sayornis phoebe*)	3	-15.0	0.46	-40.4	21.2
Great Crested Flycatcher (*Myiarchus crinitus*)	9	4.2	0.30	-3.3	12.3
Blue Jay (*Cyanocitta cristata*)	16	7.1	0.23	-4.0	19.4
American Crow (*Corvus brachyrhynchos*)	11	-26.1*	0.037	-42.4	-5.0
Common Raven (*Corvus corax*)	7	-3.9	0.56	-15.7	9.4
Black-capped Chickadee (*Parus atricapillus*)	14	-15.8*	0.04	-27.8	-1.8
Eastern Tufted Titmouse (*Parus bicolor*)	2	136.8	0.45	76.5	217.8
Red-breasted Nuthatch (*Sitta canadensis*)	7	-13.7	0.087	-25.2	-0.3
White-breasted Nuthatch (*Sitta carolinensis*)	11	-9.7	0.31	-25.5	9.4
Brown Creeper (*Certhia americana*)	11	-4.9	0.38	-14.8	6.1
Winter Wren (*Troglodytes troglodytes*)	12	-7.4	0.12	-15.4	1.4
Golden-crowned Kinglet (*Regulus satrapa*)	5	-13.7	0.14	-26.6	1.5
Ruby-crowned Kinglet (*Regulus calendula*)	5	-1.2	0.92	-20.9	23.4
Veery (*Catharus fuscescens*)	13	-9.7	0.43	-29.7	16.0
Bicknell's Thrush (*Catharus bicknelli*)	2	10.9	0.29	-5.9	30.7
Swainson's Thrush (*Catharus ustulatus*)	5	-4.1	0.51	-14.7	7.7
Hermit Thrush (*Catharus guttatus*)	15	1.0	0.90	-13.0	17.1
Wood Thrush (*Hylocichla mustelina*)	8	0.2	0.98	-16.1	19.8
American Robin (*Turdus migratorius*)	16	22.8	0.06	0	50.8
Gray Catbird (*Dumetella carolinensis*)	2	53.4	0.31	-13.8	173.2
Cedar Waxwing (*Bomycilla cedrorum*)	8	-6.2	0.73	-34.2	33.5
Solitary Vireo (*Vireo solitarius*)	10	-21.7*	0.048	-36.8	-3.0
Yellow-throated Vireo (*Vireo flavifrons*)	4	-6.2	0.82	-43.8	56.5
Red-eyed Vireo (*Vireo olivaceus*)	15	-5.8	0.45	-19.4	10.0
Nashville Warbler (*Vermivora ruficapilla*)	5	-0.3	0.93	-5.6	5.3
Northern Parula Warbler (*Parula americana*)	3	1.2	0.78	-6.1	9.0
Yellow Warbler (*Dendroica petechia*)	2	48.5	0.23	-39.2	263.0
Chestnut-sided Warbler (*Dendroica pensylvanica*)	6	21.6	0.2	-6.5	58.3
Magnolia Warbler (*Dendroica magnolia*)	6	2.0	0.76	-10.0	15.7
Black-throated Blue Warbler (*Dendroica caerulescens*)	10	-9.8	0.53	-34.3	23.9
Myrtle Warbler (*Dendroica coronata*)	10	-1.3	0.76	-9.2	7.3
Black-throated Green Warbler (*Dendroica virens*)	12	6.5	0.15	-1.9	15.7
Blackburnian Warbler (*Dendroica fusca*)	7	0.6	0.93	-11.3	14.2
Blackpoll Warbler (*Dendroica striata*)	2	-0.1*	0.02	-2.9	2.9
Black And White Warbler (*Mniotilta varia*)	11	2.1	0.64	-6.3	11.3
American Redstart (*Setophaga ruticilla*)	10	22.2	0.068	0.7	48.2
Ovenbird (*Seiurus aurocapillus*)	15	6.7	0.16	-2.2	16.5
Northern Waterthrush (*Seiurus noveboracensis*)	4	2.8	0.87	-24.3	39.5
Mourning Warbler (*Oporornis philadelphia*)	3	-19.9	0.74	-74.4	150.6
Common Yellowthroat (*Geothlypis trichas*)	8	18.6	0.08	0.5	39.8
Canada Warbler (*Wilsonia canadensis*)	7	-13.2*	0.02	-20.5	-5.1

found on 6-10 sites, and 19 were found on 11-16 sites. No species was recorded on all 17 sites for 2 or more years.

While trend estimates for 9 of the 67 species were statistically significant (Table 1), 5 of these were of species with inadequate sample sizes or those not accurately surveyed with the point count method (e.g., American crow). Among the remaining significant trends, only rose-breasted grosbeak increased (P=0.02), while black-capped chickadee (P=0.04), solitary vireo (P=0.048), and Canada warbler (P=0.02) declined.

Separating the species into wintering groups revealed that neotropical migrants (N=31 species) sampled in hardwood forests increased significantly (P=0.002), but showed virtually no trend when all forested sites were combined (Table 1). Short-distance migrants (N=23 species) showed no distinct trends, while year-round residents (N=13 species) declined significantly (P=0.04) over all study sites but showed no trend in hardwood forests only.

To determine if the population changes estimated by the Vermont FBMP were similar to those from other long-term data sets, we correlated annual rates of FBMP trends for 22 selected woodland species with those from the BBS in Vermont and northern New England (NNE), and from the Ontario FBMP. Rates of change in FBMP trends showed positive, but weak correlations with VT BBS (R^2 = 0.229, P = 0.25), NNE BBS (R^2 = 0.350, P = 0.11), and Ontario FBMP (R^2 = 0.319, P = 0.15) trends (Fig 2.).

Table 1, continued.

SPECIES	N	Trend	*P* Value	Lower CI	Upper CI
Scarlet Tanager (*Piranga olivacea*)	14	-0.7	0.93	-16.3	17.8
Northern Cardinal (*Cardinalis cardinalis*)	4	-16.7	0.55	-51.9	44.3
Rose-breasted Grosbeak (*Pheuticus ludovicianus*)	11	18.6*	0.02	4.4	34.7
Song Sparrow (*Melospiza melodia*)	4	-10.1	0.38	-26.9	10.7
Swamp Sparrow (*Melospiza georgiana*)	3	72.9*	0.02	47.5	102.7
White-throated Sparrow (*Zonotrichia albicolis*)	9	-0.7	0.89	-9.3	8.8
Slate-colored Junco (*Junco hyemalis*)	11	-4.9	0.30	-13.3	4.4
Red-winged Blackbird (*Agelaius phoeniceus*)	4	33.0	0.48	-34.7	171.0
Common Grackle (*Quiscalus quiscula*)	3	7.2	0.73	-24.7	52.8
Brown-headed Cowbird (*Molothrus ater*)	5	63.0*	0.008	34.0	98.2
Baltimore Oriole (*Icterus galbula*)	2	20.4	0.30	-7.8	57.2
Purple Finch (*Carpodacus purpureus*)	6	32.7	0.06	5.0	67.6
American Goldfinch (*Carduelis tristis*)	8	-13.7	0.36	-36.1	16.7
Evening Grosbeak (*Coccothraustes vespertinus*)	4	-5.4	0.58	-21.1	13.4
Neotropical Migrants in Hardwood Forests	12	1.8*	0.002	0.9	2.7
Neotropical Migrants in All Sites	17	0.1	0.95	-2.4	2.6
Resident Species in Hardwood Forests	12	-8.0	0.12	-16.6	1.6
Resident Species in All Sites	17	-7.4*	0.04	-13.6	-0.7
Short-distance Migrants in Hardwood Forests	12	-2.4	0.35	-7.2	2.6
Short-distance Migrants in All Sites	17	-3.2	0.12	-6.9	0.7

To test whether the FBMP was capable of tracking population changes resulting from natural phenomena such as weather or food availability, we used the Pearson product-moment correlation to com-

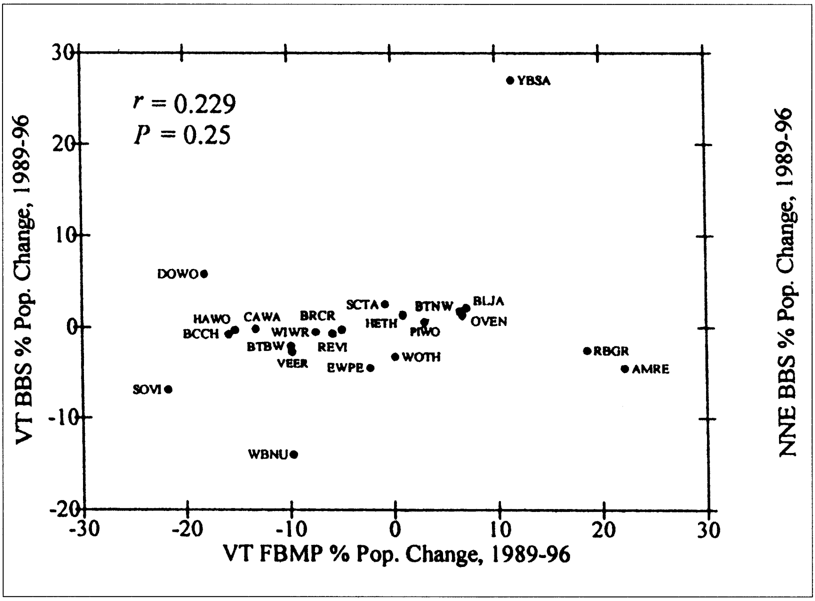
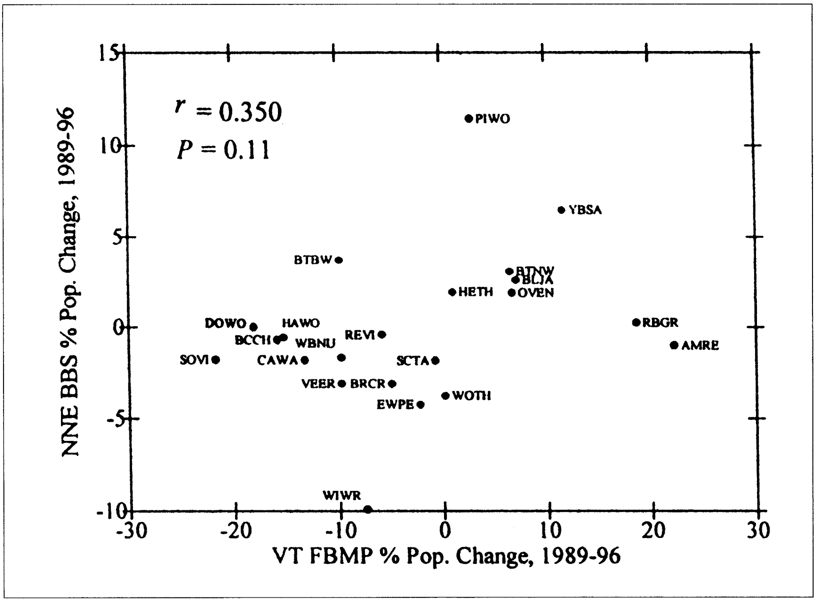
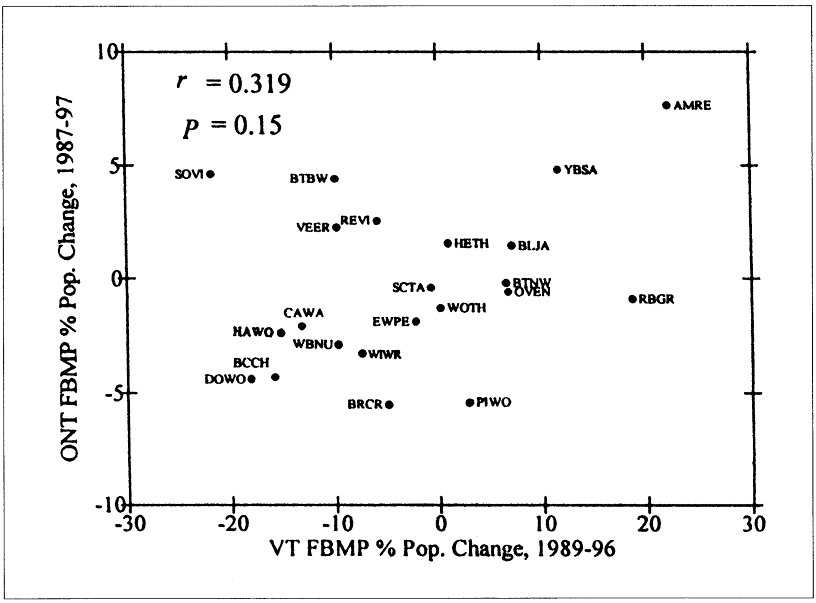


Figure 2. Comparisons of the percent population change per year for 22 selected woodland species in the Vermont FBMP, with trends from the Breeding Bird Survey in Vermont and northern New England (NNE), and the Ontario FBMP.

Key to abbreviations: AMCR - American crow; AMGO - American goldfinch; AMRE - American redstart; AMRO - American robin; BAOR - Baltimore oriole; BAWW - Black and white warbler; BBWO - Black-backed woodpecker; BCCH - Black-capped chickadee; BHCO - Brown-headed cowbird; BITH - Bicknell's thrush; BLBW - Blackburnian warbler; BLJA - Blue jay; BLPW - Blackpoll warbler; BRCR - Brown creeper; BTBW - Black-throated blue warbler; BTNW - Black-throated green warbler; CAWA - Canada warbler; CEDW - Cedar waxwing; COGR - Common grackle; CORA - Common raven; COSN - Common snipe; COYE - Common yellowthroat; CSWA - Chestnut-sided warbler; DOWO - Downy woodpecker; EAPH - Eastern phoebe; EAWP - Eastern wood pewee; ETTI - Eastern tufted titmouse; EVGR - Evening grosbeak; GCFL - Great crested flycatcher; GCKI - Golden-crowned kinglet; GRCA - Gray catbird; HAWO - Hairy woodpecker; HETH - Hermit thrush; LEFL - Least flycatcher; MAWA - Magnolia warbler; MODO - Mourning dove; MOWA - Mourning warbler; MYWA - Myrtle warbler; NAWA - Nashville warbler; NOCA - Northern cardinal; NOPA - Northern parula warbler; NOWA - Northern waterthrush; OSFL - Olive-sided flycatcher; OVEN - Ovenbird; PIWO - Pileated woodpecker; PUFI - Purple finch; RBGR - Rose-breasted grosbeak; RBNU - Red-breasted nuthatch; RCKI - Ruby-crowned kinglet; REVI - Red-eyed vireo; RWBL - Red-winged blackbird; SCJU - Slate-colored junco; SCTA - Scarlet tanager; SOSP - Song sparrow; SOVI - Solitary vireo; SWSP - Swamp sparrow; SWTH - Swainson's thrush; VEER - Veery; WBNU - White-breasted nuthatch; WIWR - Winter wren; WOTH - Wood thrush; WTSP - White-throated sparrow; YBFL - Yellow-bellied flycatcher; YBSA - Yellow-bellied sapsucker; YSFL - Yellow-shafted flicker; YTVI - Yellow-throated vireo; YWAR - Yellow warbler.

pare the relative abundance of year-round residents on FBMP sites to Vermont's average winter temperatures, using National Climatic Data Center weather data collected in Montpelier, Vermont. The breeding populations of hairy woodpecker generally followed the average winter





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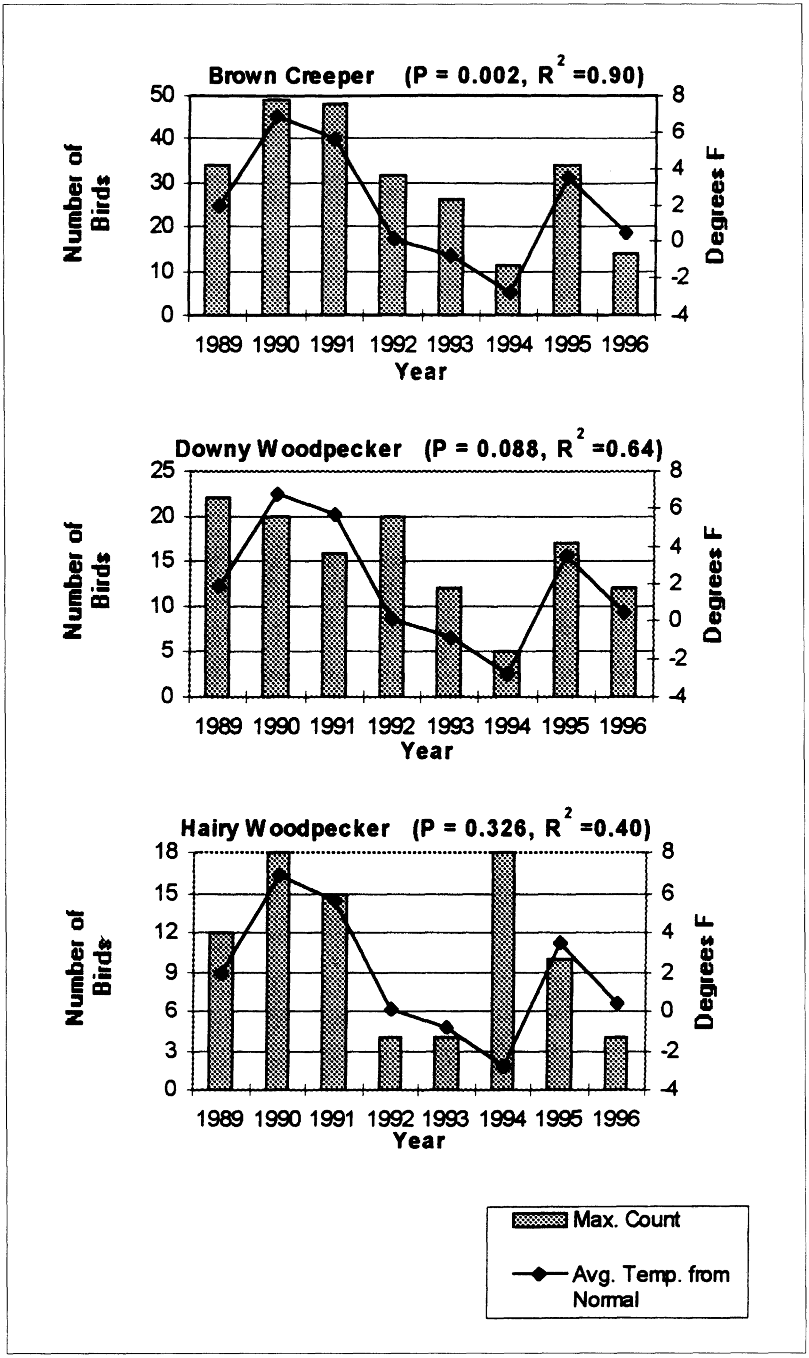

Figure 3. Comparison of maximum counts of 4 resident species and all residents grouped together, with average winter temperatures for Vermont from normal.

temperature change from year to year. Downy woodpecker ($R^2 = 0.64$, $P = 0.088$), brown creeper ($R^2 = 0.90$, $P = 0.002$), and all residents combined ($R^2 = 0.64$, $P = 0.090$) showed a significant correlation between weather and relative abundance (Fig. 3).

To determine the extent to which brown-headed cowbirds penetrated into interior FBMP forest sites, we examined occurrence data for this species by physiographic region (Table 3). Ten of 17 study sites recorded at least 1 occurrence of brown-headed cowbird, and the species was recorded on 28.5% of all FBMP site visits, with a total of 128 individual occurrences. While these numbers were higher than anticipated for this species, most cowbirds (95.3%) were found at 5 FBMP sites located in the Champlain Lowlands, a physiographic region of the state that is largely agricultural with a highly fragmented forest landscape (Fig. 1, Table 3).

Power Analysis

Statistical power analysis is a technique advocated to improve research study designs and to facilitate interpreting results by helping to

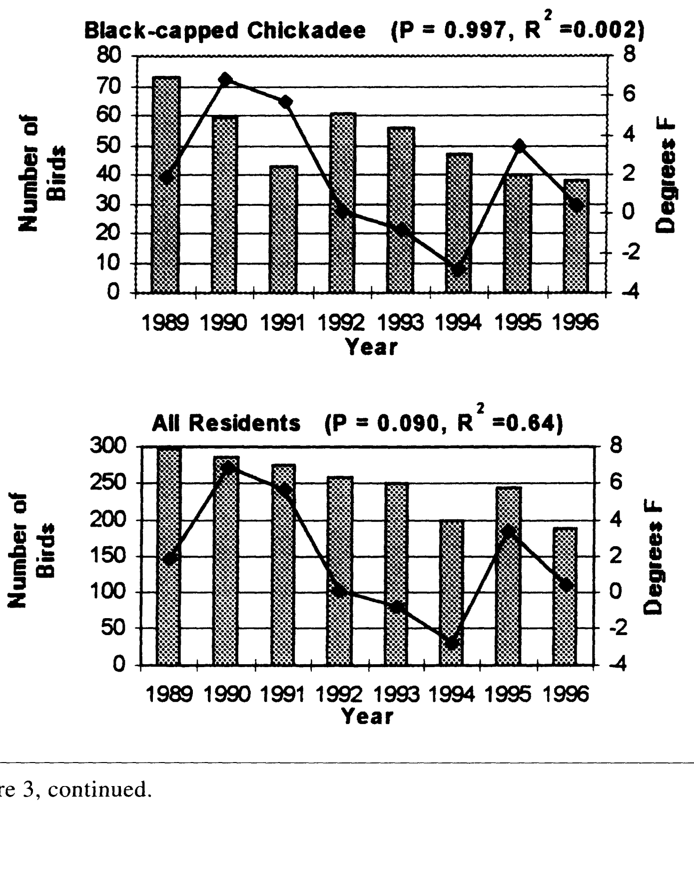

Figure 3, continued.

determine basic sampling criteria needed to achieve a desired result (Gerrodette 1987, Steidl et al. 1997). For long-term monitoring, statistical power can be defined as the probability that a trend will be detected when the trend is occurring, despite any "noise" in the data.

We conducted a power analysis of FBMP data for 4 species over 4 different time periods (Table 4). The probability that FBMP data would detect a 0-10% population increase or decrease was calculated for 4 neotropical migrants over 10, 15, 20, and 25 years. Using black-throated blue warbler as an example, after 10 years of data collection, we would only have a 35% probability of detecting a 2% increase for this species should it occur, but we would have a 99% probability of detecting a 5% increase (Table 4). After 15 years of monitoring, our power to detect a 2% increase jumps to 84.8%. In all cases, increasing trends are more readily detected than decreasing trends, and small population changes are more difficult to detect than large changes.

DISCUSSION

An examination of 8 years of point count data from a long-term forest bird monitoring program demonstrated that the FBMP is useful to detect population changes in at least some species. However, these trend estimates must be interpreted with caution, as 8 years is a relatively short period over which to assess meaningful changes in bird populations. At this temporal scale, it is impossible to determine whether increases or decreases in relative abundance are due to "normal" short-term population fluctuations or whether they reflect long-term trends.

An especially noteworthy result is the significant decline detected for Canada warbler. Although FBMP sample size for Canada warbler

Table 3. Annual brown-headed cowbird occurences by FBMP site and physiographic region, 1989-1996.

Site name	Physiographic region	1989	1990	1991	1992	1993	1994	1995	1996	Total
Bald Mt.	Champlain Lowlands	3	3	6	5	2	2	2	2	25
Pease Mt.	Champlain Lowlands	0	0	0	3	4	4	4	4	19
Cornwall Swamp	Champlain Lowlands	3	1	1	0	0	4	5	3	17
Sandbar	Champlain Lowlands	5	3	3	0	3	6	0	6	26
Shaw Mt.	Champlain Lowlands	3	9	9	9	5	0	0	0	35
Bear Swamp	North Centeral	0	0	0	0	2	0	0	0	2
Roy Mt.	East Central	1	0	0	0	0	0	0	0	1
Dorset Bat Cave	Taconics	0	0	1	0	0	0	0	0	1
Merck Forest	Taconics	0	0	0	0	0	1	0	0	1
Sugar Hollow	Taconics	0	1	0	0	0	0	0	0	1
	Total count	15	17	20	17	16	17	11	15	128

was small (N=7), the decline is disturbing since it is strongly corroborated by data from other sources. Long-term BBS data show Canada warbler declining significantly in Vermont, New Hampshire, the Adirondack Mountains of New York, Ontario, and across U.S. Fish and Wildlife Service (USFWS) Region-5, which includes New England, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and West Virginia (Rosenberg and Wells 1995). Migration count data from Long Point Bird Observatory in Ontario further support this down-

Table 4. Results of statistical power analysis to detect trends for 4 species over 4 time periods, using FBMP data from 1989-1996. N = number of sites used to calculate power; bold brackets denote power estimates >0.80 probability.

Black-throated Blue Warbler (N=11)

	PERCENT POPULATION CHANGE																				
YEARS	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
10	.984	.982	.978	.904	.892	.824	.656	.454	.214	.112	.028	.130	.350	.670	.900	.990	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	.998	.988	.984	.952	.862	.584	.222	.030	.284	.848	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.986	.866	.450	.052	.620	.992	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.994	.694	.050	.860	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Ovenbird (N=15)

	PERCENT POPULATION CHANGE																				
YEARS	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
10	1.00	1.00	.994	.994	.974	.908	.788	.606	.372	.130	.046	.126	.464	.840	.968	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00	1.00	.996	.968	.762	.290	.034	.354	.926	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.980	.620	.050	.762	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.998	.850	.052	.958	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Canada Warbler (N=9)

	PERCENT POPULATION CHANGE																				
YEARS	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
10	.992	.974	.948	.886	.844	.738	.578	.460	.220	.092	.046	.092	.326	.626	.850	.978	.998	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	.998	.980	.944	.818	.582	.218	.046	.280	.772	.988	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.839	.452	.065	.484	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.970	.646	.048	.846	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Hermit Thrush (N=15)

	PERCENT POPULATION CHANGE																				
YEARS	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
10	.992	.980	.958	.928	.858	.778	.634	.442	.234	.110	.066	.100	.324	.642	.896	.982	.998	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	.998	.998	.988	.954	.858	.606	.236	.062	.286	.840	.994	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.990	.888	.410	.048	.520	.998	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.998	.984	.698	.042	.830	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

ward trend for Canada warbler, with a significant decline noted between 1961 and 1988 (Hussell et al. 1992).

It seems apparent that Canada warbler is declining over a significant portion (at least 49%) of its breeding range, with USFWS Region-5 comprising 16% of the species' breeding range and Ontario accounting for 33% (Rosenberg and Wells 1995). While the reasons for such a widespread decline may not be immediately apparent, habitat loss on the species' wintering grounds may be a contributing factor. The primary winter habitat of the Canada warbler is mature, submontane broad-leaved forests in the Andean foothills from Venezuela to southern Peru (Curson et al. 1994, Rappole et al. 1995). This region has undergone tremendous habitat change over the past 50 years. By the late 1980s little forested habitat remained that had not been significantly altered by humans (Robbins et al. 1992). In addition to burgeoning human populations in Columbia, Venezuela, and Peru, the climatic conditions and fertile soils of the Andean foothills make it the principal region for large-scale agricultural development. The cerulean warbler (*Dendroica cerulea*), which also winters in this region of the Neotropics, although within a narrower ecological zone than the Canada warbler, has also declined significantly across much of its breeding range. These declines have, at least in part, been attributed to loss of wintering habitat (Robbins et al. 1992). Likewise, breeding populations of Canada warblers may be severely affected by loss of wintering habitat. However, without demographic and reproductive data from the species' breeding grounds, it is impossible to determine what factors are contributing to the noted declines. Identified as a species deserving special conservation attention (James et al. 1996, Rosenberg and Wells 1995), the Canada warbler warrants intensive study.

FBMP trends for migratory groups showed that neotropical migrants increased significantly in samples from hardwood forests. Sherry and Holmes (1992) demonstrated that the productivity of migrants in New England's large contiguous forests is highly correlated with population changes, and is usually driven by factors such as weather or major insect outbreaks (Holmes et al. 1986). While this suggests that long-distance migrants may have experienced relatively high productivity in the large tracts of mature, unmanaged hardwoods sampled by the FBMP over the 8-years, productivity data are needed to confirm this. In Maine, Hagan et al. (1996) demonstrated that the densities of some neotropical migrants increased shortly after a forest was fragmented, due to displaced individuals moving into available habitat. Along with these higher densities however, the productivity of at least one species, the ovenbird, was lower in the fragments than in nonfragmented forests. We do not believe the increase observed for neotropical migrants during the FBMP was due to recent fragmentation effects. With the exception of one FBMP site, Concord Woods, which became a 40 ha habitat "island" during the study period due to logging around its perimeter, no gross habitat changes were noted at or around other FBMP sites.

Although populations of short-distance migrants appeared to be stable during the period, the majority of these species occupy early-successional or second-growth habitats and were not well represented in the FBMP data set. Year-round residents, however, declined significantly, and the relative abundances of brown creeper, downy woodpecker, and all residents combined showed positive correlations with severe winter weather (Fig. 3). With the exception of one year (1994), hairy woodpecker populations also tracked weather data closely. Populations of black-capped chickadees did not correlate closely with winter temperatures, perhaps due to supplemental feeding at bird feeders, which has been shown to increase the over-wintering survival rates of chickadees (Brittingham and Temple 1988). Brown creepers do not frequent seed and suet feeders as consistently as other winter residents and they have been shown to be susceptible to severe winter weather (Graber and Graber 1979). The highly significant correlation between brown creeper breeding populations and winter temperatures suggests that the FBMP may track changes in bird populations in response to a natural phenomenon.

The positive, but weak, correlations between VT FBMP and BBS trends for 22 forest interior-breeding species may reflect sampling biases between the two methods. Since the FBMP samples off-road, relatively stable interior forest habitats, while the BBS samples roadside habitats in various successional stages, a strong relationship between these data sets would not be expected, particularly for a suite of woodland breeding species. While the FBMP controls for habitat variability more than the BBS, for this analysis we chose not to produce habitat-specific trends due to small sample sizes. Therefore, trends were calculated for each species from all sites on which they were recorded, regardless of the habitat's suitability for that species. For example, hermit thrushes were abundant in hardwood forest sites, but occurred in coniferous sites at lower densities. As a result, trends from either data set may have been obscured by differences in the quality of breeding habitats sampled (e.g. populations breeding in poor quality habitats often fluctuate more than those in high quality habitats). It is also possible that the short temporal period over which the trends were calculated may have reduced the accuracy of at least some of the estimates. We believe however, that because the FBMP collects habitat-specific data from relatively large tracts of unmanaged forests, future comparisons with the BBS may help to identify species that are most affected by forest fragmentation. Lack of agreement between Vermont and Ontario FBMP trends may be due to regional differences of the breeding populations being sampled.

Although the FBMP was designed to monitor forest interior species and to avoid sampling those species, such as brown-headed cowbird, associated with the habitat edges created by forest fragmentation, we found a relatively high percentage of cowbirds at FBMP sites located in one physiographic region of Vermont - the Champlain Lowlands. This corroborates the results of Coker and Capen (1995), who found that cowbirds in Vermont were most likely to occur in forested habitats if they were near large cleared areas (>9.8 ha) with high concentrations of livestock. Conversely, Coker and Capen (1995) found that small forest openings (< 4 ha) located at least 7 km from livestock areas were unlikely to attract cowbirds. Airola (1986) demonstrated that distance from a cowbird feeding area was an indicator of the rate of cowbird parasitism; sites that were closer to feeding areas had higher parasitism rates. We suspect that many species breeding at FBMP sites in the Champlain Lowlands may experience relatively high rates of parasitism by brown-headed cowbirds, while those at study sites in the other physiographic regions probably have much lower rates. The fragmented forests of the Champlain Lowlands may act as population sinks for many migratory species, with high rates of brood parasitism and nest predation resulting in extremely low reproductive rates (e.g., see Brawn and Robinson 1996, Brittingham and Temple 1983). At the same time, the large interior forests of nearby areas may support source populations which produce enough surplus birds to sustain the losses of the sinks. Further research is needed to investigate this.

Power analyses from the FBMP data set show that this monitoring program can detect fairly small population changes (2% increases and 3% declines), even for species with relatively small sample sizes and high variability, especially after 15 years of monitoring. Considering that 1997 represented the 9th year of FBMP data collection, and that additional study sites have been added over the last few years to increase our sample sizes (with plans to establish more sites in upcoming years), future power to detect changes in forest bird populations should increase.

Conclusions and Future Directions

The Vermont FBMP provides habitat-specific information about breeding bird populations in protected, unmanaged, interior forests.

The project's statistical power to detect population trends for most forest-dwelling landbirds is adequate, and the results provide conservation biologists with useful control data for comparison against trend estimates derived from the road-side BBS. Once FBMP data are correlated with detailed habitat information being collected at each study site and landscape attributes from a Geographic Information System database, a better understanding should emerge of how different forest features such as canopy closure, vegetation type and structure, patch size, and distance to agricultural areas, affect bird populations in Vermont. The scope of the Vermont FBMP has recently been expanded by establishing additional study sites in northern hardwood forests in Vermont, as well as in montane spruce-fir habitat in Vermont, New York, New Hampshire, and Maine. We encourage other states in the northeast to initiate similar programs. Such a region-wide monitoring scheme may lead to the development of more meaningful conservation strategies and the identification of at-risk species, such as the Canada warbler. However, an inherent limitation of point count monitoring programs is that they estimate trends, not productivity. Brawn and Robinson (1996) showed that lack of a declining trend does not necessarily signify the viability of local populations, especially in fragmented habitats. This underscores the need for supplementing monitoring programs with long-term data on reproductive success and demographics.

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