LANDBIRD DEMOGRAPHIC MONITORING IN VIRGINIA

AN ANALYSIS OF HISTORICAL MAPS DATA IN VIRGINIA AND SURROUNDING REGION

A REPORT TO

THE STATE OF VIRGINIA

DEPARTMENT OF GAME AND INLAND FISHERIES

PROVIDING

ANALYSES TO DETERMINE SPATIO-TEMPORAL RELATIONSHIPS BETWEEN CLIMATE, WEATHER, LANDSCAPE PATTERNS AND LANDBIRD DEMOGRAPHICS IN VIRGINIA AND SURROUNDING REGION

PREPARED BY

M. PHILIP NOTT, PH.D., KELLY GORDON, DANIELLE KASCHUBE, AND TERYK MORRIS

OF

THE INSTITUTE FOR BIRD POPULATIONS

March 31, 2008

Recommended citation

Nott, M. P., K. Gordon, D. R. Kaschube, and T. Morris. 2008. Landbird Monitoring in Virginia: An Analysis of Historical MAPS data in Virginia and Surrounding Region. *A Report to the State of Virginia, Dept. of Game and Inland Fisheries, Richmond, VA. Contribution No.294 of The Institute for Bird Populations, Point Reyes Station, CA.*

LANDBIRD DEMOGRAPHIC MONITORING IN VIRGINIA

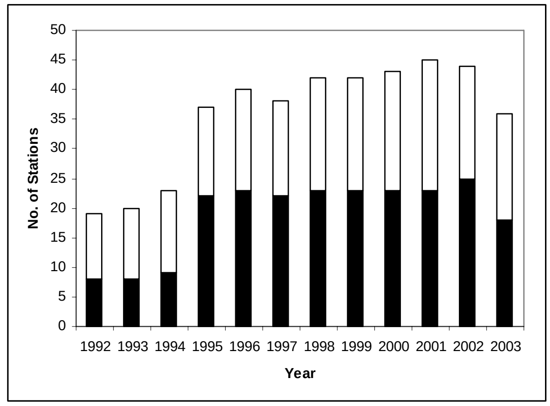
EXECUTIVE SUMMARY OF AN ANALYSIS OF MAPS DATA IN VIRGINIA AND REGION

The Virginia Department of Game and Inland Fisheries' mission is to "*manage Virginia's wildlife and inland fish to maintain optimum populations of all species to serve the needs of the Commonwealth*".

Virginia's avifauna totals 427 species (American Birding Association). Maintaining this diversity and healthy populations of landbirds, especially species of conservation concern, requires knowing how populations are affected by changes in the pattern and structure of breeding and winter habitats. We also need to understand how fluctuations in climate and weather affect populations on both their breeding and wintering grounds.

Although Wood Thrush reproductive success declined steeply between 1992 and 2003, overall adult numbers were stable.

The Institute for Bird Populations collected landbird banding data (1992–2003) from a network of 71 Monitoring Avian Productivity and Survivorship (DeSante et al. 2004) demographic monitoring stations (14 locations) within Virginia (34 stations) and within 150km of the state boundary (37 stations). Many stations were located on federal land and represented various habitat types from high elevation mature forest, to lowland riparian areas, or coastal habitats. From these data we estimated annual survival rates and calculated annual numbers of birds by sex and age.



A total of 71 MAPS stations operated in Virginia (black bars) and within 150km of the Virginia border (white bars) between 1992 and 2003.

We estimated demographic parameters for 41 landbird species. Reliable regional adult survival rate estimates were obtained for 23 of these species and the trends in numbers of adults and young were calculated. From these 23 species we selected 14 focal species based on their status as Virginia Species of Greatest Conservation Need and whether adult populations declined in MAPS data and/or Breeding Bird Survey data (1980-2005).

Survival rate estimates for the 23 species were generally higher than those calculated for the larger-scale Bird Conservation Regions that encompass Virginia. However, for four of the 14 focal species, survival rates were low in comparison. Trends in the numbers of adults declined in only four species, including Gray Catbird. Trends in the numbers of young declined in three focal species, Wood Thrush, Gray Catbird, and Prothonatory Warbler.

Station-specific and regionally pooled numbers of adult birds, numbers of young, and the ratio of young to adults (reproductive index) were also calculated. When these demographic parameters were compared to changes in forest cover (National Land Cover Dataset), and weather patterns, interesting and important relationships were revealed.

The table (below) lists 23 species captured at MAPS monitoring stations in Virginia and the surrounding region. A species was included if survival rate estimates were associated with coefficients of variation (CV) less than 30%. Focal species of concern included six US Fish and Wildlife Birds of Conservation Concern (FWS BCC). Three population performance measures (PM) are presented along with the numbers of MAPS stations (No. Sta.) that contributed to the measures.

The first set of performance measures (PM1) were considered high when the survival rate (Phi) exceeded those for at least three of four neighboring Bird Conservations Regions (Southeastern Coastal Plain [27]; Appalachian Mountains [28]; Piedmont [29]; New England/Mid-Atlantic Coast [30]). Five of eight species that showed low survival rates were focal species of conservation concern. Low survival rates can be caused by low fidelity to breeding locations or by high mortality experienced on migration routes and wintering habitats.

The second and third sets of performance measures were based on the direction of trends in adult (PM2) and young (PM3) captures which declined (Dec.) or increased (Inc.) with a P value of <=0.10 (bold type).

Only four adult trends significantly declined while seven significantly increased. Gray Catbird (species of concern), and Common Yellowthroat both showed low survival rates and severe declines in the numbers of adults and young. Annual captures of Wood Thrush and Prothonotory Warbler young also significantly declined, however, annual numbers of Louisiana Waterthrush young significantly increased.

Table A. Demographic summaries for 23 species including 14 focal species of conservation concern (bold type), including apparent survival rates and MAPS trends expressed as annual % change (relative to mean).

Species	**FWS**	**Survival Rate**			**MAPS Adult Trends**			**MAPS Young Trend**			No.
	BCC	**PM1**	Phi	CV%	**PM2**	%/yr	P	**PM3**	%/yr	P	Sta
Eastern Wood-Pewee		**Low**	0.489	16.8	Stable	2.24	0.32	Stable	8.69	0.62	32
Acadian Flycatcher	**X**	**Low**	0.486	6.0	Stable	1.66	0.21	Stable	-3.77	0.28	41
White-eyed Vireo		High	0.462	9.9	Stable	2.87	0.16	Stable	-0.78	0.82	29
Red-eyed Vireo		High	0.604	3.5	**Dec.**	**-1.71**	**0.10**	Stable	1.23	0.85	44
Tufted Titmouse		High	0.542	5.2	**Dec.**	**-1.74**	**0.06**	Stable	-1.35	0.61	46
Carolina Wren		**Low**	0.292	9.5	**Inc.**	**4.40**	**0.03**	Stable	0.09	0.97	47
Veery		High	0.593	3.8	Stable	-1.41	0.67	Stable	-4.90	0.38	22
Wood Thrush	**X**	Even	0.426	5.5	Stable	0.35	0.81	**Dec.**	**-4.37**	**0.00**	46
Gray Catbird		**Low**	0.475	8.4	**Dec.**	**-11.53**	**0.00**	**Dec.**	**-17.03**	**0.00**	40
Black-and-white Warbler		High	0.568	11.8	**Inc.**	**6.38**	**0.00**	Stable	2.44	0.44	35
American Redstart		Even	0.591	4.8	Stable	0.35	0.89	Stable	-6.12	0.12	28
Prothonotary Warbler	**X**	High	0.498	12.5	Stable	-1.02	0.80	**Dec.**	**-12.92**	**0.00**	20
Worm-eating Warbler	**X**	High	0.621	7.6	**Inc.**	**4.59**	**0.01**	Stable	-3.24	0.39	36
Ovenbird		Even	0.545	3.5	**Inc.**	**3.29**	**0.06**	Stable	-1.26	0.57	45
Louisiana Waterthrush	**X**	High	0.508	12.6	**Inc.**	**7.03**	**0.00**	**Inc.**	**7.23**	**0.03**	33
Kentucky Warbler	**X**	High	0.552	9.4	Stable	2.13	0.30	Stable	-6.38	0.12	29
Common Yellowthroat		**Low**	0.332	19.6	**Dec.**	**-3.62**	**0.05**	**Dec.**	**-10.99**	**0.00**	34
Hooded Warbler		High	0.492	6.1	**Inc.**	**4.03**	**0.04**	Stable	0.12	0.97	37
Scarlet Tanager		**Even**	0.674	12.0	Stable	2.24	0.17	Stable	9.88	0.24	32
Eastern Towhee		High	0.517	9.0	**Inc.**	**2.87**	**0.01**	Stable	-1.73	0.62	31
Dark-eyed Junco		**Low**	0.363	15.9	Stable	3.18	0.29	Stable	-1.06	0.75	7
Northern Cardinal		**Low**	0.520	5.0	Stable	1.78	0.20	Stable	0.10	0.98	43
Indigo Bunting		**Low**	0.447	9.4	Stable	4.20	0.63	Stable	-2.32	0.75	36

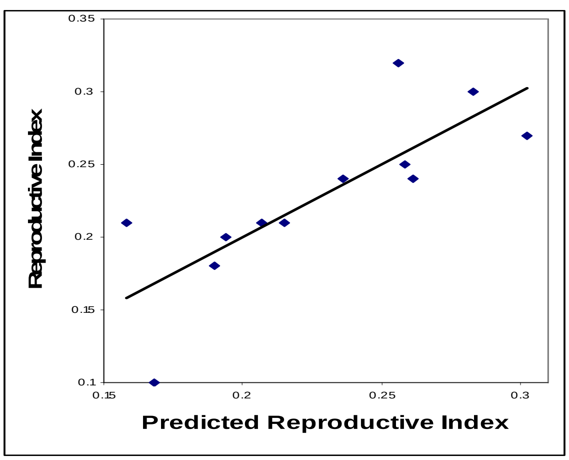
Table B. Effective MAPS monitoring of 14 focal species of conservation concern in the state of Virginia. Thirty stations are identified by the station number (Station), State abbreviation, Bird Conservation Region (BCR), and years of operation (Operation). These stations operated for more than one year or are expected to operate for at least four years. Species are marked with an ‘X’ if an average of four or more captures were recorded per year of operation. Stations shown in bold are still active and all other stations are inactive. Stations are ranked from high to low based on the number of SCC species that they effectively monitor. Also shown are the total number of stations at which each species was effectively monitored and how many of those stations were non-operational at the time of writing (Fall 2007). Four Virginia MAPS stations totaled zero SCC species and are not shown.

Station	**BCR**	**Operation**	**Eastern Wood-Pewee**	**Acadian Flycatcher**	**Veery**	**Wood Thrush**	**Gray Catbird**	**Black-&-white Warbler**	**Prothonotary Warbler**	**Worm-eating Warbler**	**Ovenbird**	**Louisiana Waterthrush**	**Kentucky Warbler**	**Scarlet Tanager**	**Eastern Towhee**	**Indigo Bunting**	**Total SCC**
15541	28	93-03				X		X		X	X			X	X	X	7
15550	28	93-03			X	X	X	X			X				X	X	7
15548	28	93-03			X	X				X	X				X	X	6
15549	28	93-03						X		X	X			X	X	X	6
16711	**29**	**03-**		**X**		**X**		**X**			**X**	**X**				**X**	**6**
16721	**29**	**03,05-**	**X**	**X**		**X**	**X**							**X**		**X**	**6**
15537	28	92-03			X	X					X				X	X	5
15533	28	92-03			X		X				X				X		4
16648	27	95-03		X		X		X			X						4
16676	**29**	**97-**				**X**	**X**	**X**			**X**						**4**
16601	**27**	**90-00, 02-**							**X**	**X**	**X**						**3**
16613	**30**	**92-02**		**X**		**X**					**X**						**3**
16647	**30**	**95-**		**X**		**X**			**X**								**3**
16655	27	95-02		X		X					X						3
16664	**29**	**95-**		**X**		**X**					**X**						**3**
16665	**29**	**95-**		**X**		**X**					**X**						**3**
15639	28	01-02		X		X											2
16644	30	95-02		X							X						2
16646	**27**	**95-**		**X**		**X**											**2**
16649	27	95-03		X							X						2
16650	27	95-02				X					X						2
15554	28	94-96					X									X	2
16666	29	95-96		X		X											2
16686	29	98-02									X					X	2
15642	**28**	**02-**					**X**										**1**
15643	**28**	**02-**					**X**										**1**
16645	30	95-02		X													1
16651	27	95-02									X						1
16652	27	95-02									X						1
16654	27	95-02				X											1
Operational Stations			1	7	0	8	4	2	2	1	6	1	0	1	0	2	35
No. of non-operational			0	7	4	10	3	4	0	3	14	0	0	2	6	7	60

The network of Virginia MAPS stations was historically more extensive with 20-25 stations operating between 1995 and 2002. By 2005 only 11 stations remained in operation. The monitoring potential in terms of species-stations was 35, however, a total of 60 species stations were lost due to station closures.

Acadian Flycatcher, Wood Thrush, and Ovenbird are the only species effectively monitored by currently operational MAPS stations in Virginia (Table B).

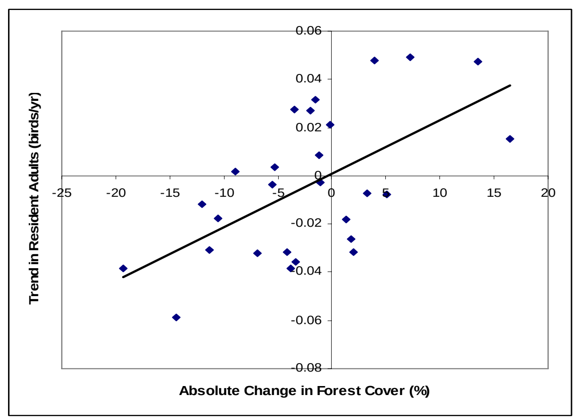
The closure of the Shenandoah NP stations lost the potential to effectively monitor a diverse avifauna including Veery, Wood Thrush, Worm-eating Warbler, Ovenbird, Eastern Towhee, and Indigo Bunting. These stations should be reestablished to monitor these species in the higher elevation (>450m) forests where climate change is first expected to change the forest botanical community and avifuana.



Predictive model of annual reproductive indices using February-April indices of ESPI and NAO.

In this study we constructed a highly predictive model of Wood Thrush annual productivity (above). Annual productivity was a combined linear function of a) pre-migration conditions in Mexico and central America as indicated by the El Nino Southern Precipitation Index (ESPI), and b) pre-breeding conditions in Virginia as indicated by the activity of the North Atlantic Oscillation (NAO index) which influences winter and early springtime weather in Atlantic coastal states. In summary, increased precipitation benefits Wood Thrush survival and productivity.

These changes may include earlier springs, and population responses to pest outbreaks, as have been documented in Pacific Northwest forests (Nott et al. 2002). In fact, annual changes in the numbers and productivity of species at Shenandoah changed dramatically to the Gypsy Moth outbreaks of the 1990's.



Trends in resident Wood Thrush adults as a function of absolute change in forest cover.

Above we see trends in the numbers of adult Wood Thrushes as a function of forest cover change (NLCD derived). Identifying such relationships within species is essential to predicting population changes due to forest fragmentation

MAPS demographic monitoring is underrepresented in other habitats, many of which are threatened by development. In the Southern Appalachian Piedmont region, extensive pre-settlement Northern hardwood forest has since been severely cut over and fragmented. Development and agricultural land use change, especially in riparian habitats and forested bottomland, will affect populations of many Neotropical migrants of conservation concern. Demographic monitoring of these habitats and subsequent modeling could provide management guidelines for maintaining or creating “source” habitat. This approach has been successfully adopted in providing land managers of DoD properties with specific management guidelines relating to minimum forest patch size or optimal canopy cover percentages for a suite of landbirds (Nott et al. 2005).

The Mid-Atlantic Coastal Plain is more heavily populated and the forests are more fragmented (48% cover). However, this region provides the richest avifaunal diversity in the state and provides opportunities for demographic monitoring of 15-18 of Virginia’s SGCN Tier IV species, and target monitoring of Swainson’s Warbler (Tier II).

Southwest Virginia includes portions of the Appalachian Ridge and Valley landscapes, including the high elevation mature forests that are slowly being developed for residential and recreational purposes. Inevitably, fragmentation will affect forest-interior species, such as Cerulean Warbler, and other less abundant species (e.g. Yellow-throated Vireo).

In the past, the placement of MAPS stations in Virginia were either opportunistic or part of another network of concurrently operating stations. Although the Virginia network has few stations left operational, the historical data analyzed here demonstrates the value of MAPS monitoring in obtaining reliable demographic estimates of survivorship and productivity.

Clearly, the State of Virginia can provide extensive opportunities for targeted demographic monitoring of suites of species of conservation need in threatened habitats. Logistically, it is preferable to operate clusters of six MAPS stations such that can be operated on a six-of-ten day cycle throughout the breeding season.

The secretive Veery is little studied

To better monitor the demographics of Virginia landbird populations we recommend the initiation (or reestablishment) of clusters of stations in a) Shenandoah to target several species including Veery, b) riparian habitats to target Swainson’s Warbler, c) northern hardwood remnants of central Virginia to quantify patch size dynamics of forest-interior obligates, and d) mature forests of Appalachian ridge and valley landscapes to monitor the effects of increasing fragmentation.

This report was researched and prepared by Phil Nott, Kelly Gordon, Danielle Kaschube and Teryk Morris of The Institute for Bird Populations, P.O. Box 1346, Point Reyes Station, California, CA 94956 with funding provided by Virginia Department of Game and Inland Fisheries. The Institute for Bird Populations is an independent California non-profit corporation with 501(c)(3) tax-exempt status.

We also wish to acknowledge the operators of the MAPS stations listed in this study.

TABLE OF CONTENTS

INTRODUCTION

The Virginia Department of Game and Inland Fisheries' mission is to "*manage Virginia's wildlife and inland fish to maintain optimum populations of all species to serve the needs of the Commonwealth*". Virginia's avifauna totals 427 species (American Birding Association). Maintaining this diversity and healthy populations of landbirds, especially species of conservation concern, requires knowing how populations are affected by changes in the pattern and structure of breeding and winter habitats. We also need to understand how fluctuations in climate and weather affect populations on both their breeding and wintering grounds.

The state of Virginia has a very high avian diversity due to the varied habitat types offered by the coastal plain, piedmont, and ridge and valley geographic features of the state. The Virginia Wildlife Action Plan (Virginia Department of Game and Inland Fisheries 2005) has a four-tier list of Species of Greatest Conservation Need (SGCN) which lists 96 bird species and was used as one of our criteria for selecting focal species in this study. The Breeding Bird Survey (BBS) reports trend estimates (1980-2005 data) for a set of 96 species that were effectively monitored in Virginia (i.e. detected upon more than 14 routes). Of these 96 species, 55% show negative population trends (Sauer et al. 2005) and 45% show positive trends. An additional 21 species were encountered at fewer than 14 routes. In this study we intend to report the demographic values for a suite of these species including focal species of concern to Virginia using landbird banding data derived from The Institute for Bird Populations' Monitoring Avian Productivity and Survivorship (MAPS) dataset. We also report on species not effectively monitored by BBS. The banding data was associated with MAPS monitoring stations that lie within the Virginia border plus monitoring stations that lie with 150km of the Virginia border (Figure 1).

Species of conservation concern, which breed or overwinter in Virginia, are defined in a number of sources, and include Neotropical migrant species (Executive Summary, Table A). Firstly, the threatened and endangered (T&E) list for Virginia includes 14 species of birds, of which eight are threatened (e.g. Bachman's Sparrow) and six are endangered (e.g. Bewick's Wren). More recently, the Partners in Flight (PIF) organization completed the Continental Plan (PIF 2004) which provides plans for "avifaunal biomes" that are made up of several adjoining NABCI Bird Conservation Regions (BCR). PIF have also prepared plans for individual states and the BBS physiographic provinces. The state of Virginia (Figure 1, Table 1) covers 22,312,500 hectares and partially overlaps four BCRs: Appalachians (BCR#28) to the west; Piedmont (BCR#29) running northeast-southwest through the middle; a small portion of the Southeastern Coastal Plain (BCR#27) in the eastern third, and the New England/Mid-Atlantic Coast (BCR#30) in which more than two thirds of the Virginia coastal plain lies.

Partners in Flight bird conservation plans are available for 93 PIF Physiographic Areas (http://www.blm.gov/wildlife/pifplans.htm), each providing habitat-specific priority lists. Virginia MAPS stations can be found in four of seven PIF physiographic areas (PA), for which we identified the listed landbird species that are also commonly captured by MAPS and the broad-scale habitats with which they are associated. The eastern third of Virginia, which covers a portion of the mid-Atlantic Coastal Plain physiographic area (44), features 5 critical habitats, pine savannah, salt marsh, forested wetlands, mixed upland forests, and early successional habitat. In the central third the Mid-Atlantic Piedmont features three critical habitat types, deciduous and mixed forests, shrub-scrub barrens, and agricultural grasslands. In the west, the Mid-Atlantic Ridge and Valley features four critical habitat types, early-succession scrub, mature deciduous forest, grasslands, and northern hardwood/spruce-fir forests. To the south of this area, the Southern Blue Ridge physiographic area provides critical forested habitats including High Peaks spruce/fir forest, disturbed forest, and mature hardwood forest. Other physiographic provinces associated with Virginia are the South Atlantic Coastal Plain (3), Northern Cumberland Plateau (21), and Ohio Hills (22). To maintain avian diversity and maximize the annual reproductive success among the species of concern associated with these 12 critical habitats, will require careful management, maintenance, protection of existing large contiguous patches of those habitats, and restoration of degraded habitats.

The landbird demographic monitoring data used in this report were collected by the Institute for Bird Populations (IBP), through its Monitoring Avian Productivity and Survivorship (MAPS) program (DeSante et al. 2003). During the period 1992-2003 IBP collected breeding season mist netting and banding data from 34 constant-effort monitoring stations in Virginia, and an additional 37 stations within a 150 kilometer buffer around the Virginia border. Pooling of the Virginia and non-Virginia data afforded sufficient sample size to estimate survival rates and construct species-landscape models of demographics for more species. We collected and analyzed banding data from each station to obtain study-wide, and station-specific demographic parameters for up to 41 species. The identities, locations, primary habitats, BCR affiliations, and operational histories of each MAPS station in the study are shown in Table 1.

We focused on twenty-three species for which it was possible to calculate reliable survival rate estimates based on MAPS data (Table A). Fourteen of these are effectively monitored by MAPS, are listed in one or more PIF plans, or are listed as a Virginia Species of Greatest Conservation Need in the Virginia Wildlife Action Plan, and significantly ($P<0.05$) declined in BBS trend between 1980 and 2005. We attempted to construct species-landscape models for all 23 species by calculating various spatial statistics (using National Land Cover Dataset; NLCD 1992 and NLCD 2001) at multiple scales represented by increasing radii surrounding each station, and relating them to species- and station-specific demographic data. Such models can be used to assess the impact of landscape change on adult population size and/or productivity. Only four of the models revealed statistically significant results.

Here we describe the methods used, data incorporated, and general results. The results of demographics analyses for the 23 species are presented in Appendix 1 entitled "Species Accounts Derived from Analyses to Determine Spatio-Temporal Relationships between Landscape Patterns and Landbird Demographics in Virginia and Surrounding Region". Appendix 2 provides a case study of factors affecting Wood Thrush population dynamics and presents evidence of a "carry over" influence of wintering conditions on subsequent reproductive success.

METHODS

In this investigation we constructed species-landscape models using multiple years of bird banding data (MAPS data) from 71 monitoring stations (Figure 1) to provide a list of 41 species for which we recorded an average of at least 4 aged individuals per year (including at least one hatching-year individual in at least one year). We superimposed the Virginia stations upon the Virginia GAP land cover layer and analyzed a one-kilometer radius about each station to quantify the three most prominent cover classes (habitat types) associated with each station (Figure 2, Table 2). We analyzed the MAPS data to obtain demographic parameters that could be modeled as functions of landscape pattern and change derived from USGS National Land Cover Datasets from 1992 and 2001. Appropriate MAPS demographic parameters were also compared with Breeding Bird Survey results. Finally, to investigate the relationships between avian demographics and seasonal rainfall we extracted and analyzed Global Precipitation Climatology Project data for six 2.5 degree cells covering Virginia and surrounding region, and for multiple cells in Mexico and Central America..

Collection of MAPS Data

The Institute for Bird Populations (IBP), through its Monitoring Avian Productivity and Survivorship (MAPS) program (DeSante et al. 2003), collected breeding season mist netting and banding data from 71 constant-effort monitoring stations including 34 stations in Virginia. The remaining 37 stations were located within 150 kilometers in the neighboring states of Kentucky (3), Maryland (10), North Carolina (9), New Jersey (3), Pennsylvania (2), Tennessee (5), and West Virginia (5).

A MAPS stations normally consists of ten 12 m, four-tier, 36 mm mesh nets distributed among the central 8 hectares of a 20 hectare area. Effort was standardised in that each station was operated each year for six morning hours once during each of eight ten-day periods. In the northeastern United States, the first ten-day period starts May 21st after the majority of spring migrants have passed through and breeding territories have been established. The last period ends August 8th during post-fledgling dispersal but before birds have amassed enough fat to begin their fall migration (IBP, unpublished data). We assume, therefore, that the majority of captures consist of breeding (or unmated) adults and young from within the boundaries of the station and from the local landscape surrounding the station. This assumption is supported by an analysis of data from six stations located at Big Oaks National Wildlife Refuge, Indiana, that showed reproductive indices for four forest-interior species increased as a function of mean size of woodland patches within a 4 km radius of the station (Nott, 2000).

Survival Rate Estimation

We estimated annual adult apparent survival rates (phi), adult recapture probabilities (p), and the proportions of residents of birds seen once in the year they were banded (tau), using modified Cormack-Jolly-Seber capture-recapture models. Specifically, we used the *ad hoc* Robust Design model described by Nott and DeSante (2002) and Hines et al. (2003). We provided parameter estimates from time-constant models for regionally pooled MAPS mark-recapture data. For these mark-recapture models, we only included data from stations that operated for at least four contiguous years during the study period. If a year was missed (or did not have sufficient effort to be used) for a station that was operated during 4+ contiguous years, the longest contiguous segment of data was retained for analyses (this only resulted in dropping data from three stations). For stations that stopped operating prior to 2003, records from the last year of operation were marked as lost on capture (i.e., they were removed from the sample). All capture-recapture models were implemented using the computer program TMSURVIV (http://www.mbr-pwrc.usgs.gov/software.html). This program was designed and implemented by Phil Nott and David DeSante of IBP in collaboration with Jim Nichols and Jim Hines of Patuxent Wildlife Research Center, MD (Hines et al. 2003). The model is a modification of SURVIV (White 1983) and provides survival rate estimates based on both between-year and within-year information (*sensu* Pradel 1997, Nott and DeSante 2002). Such estimates are less biased by the numbers of transient adults captured each year. Transient individuals are those individuals captured in only one year or, if captured more than once, all captures spanned a period less than seven days apart. Conversely, individuals marked as *a priori* residents were captured in more than one year or within a single year but seven or more days apart.

Demographic Parameters: Adults, Residents, Young and Reproductive Indices

At the level of individual stations we calculated eight species-specific demographics, four of which are time-constant (pooled over years) means for the period of station operation and four which reflect time-dependent (annual variation) in those demographics over the period of station operation.

Time-constant parameters

AHY mean annual numbers of after-hatch-year (AHY) adult birds.

RES the mean number of *a priori* residents included adult individual birds captured in more than one year or within a single year but seven or more days apart.

YNG the mean annual number of hatch year (HY) individuals captured.

PI (mean) the productivity index expressed as the mean annual proportion of young individuals captured [HY/(HY+AHY)].

Time-dependent parameters

AHY/yr the annual change in the number of adult birds derived from regressions of the annual numbers of AHY individuals against year.

RES/yr the annual change in the number of resident adult birds derived from regressions of the annual numbers of resident individuals against year.

YNG/yr the annual change in the number of hatch year birds derived from regressions of the annual numbers of HY individuals against year.

PI/yr the annual change in the number of adult birds derived from regressions of the number of AHY individuals against year.

For each species we also calculated these demographic parameters at the regional scale and provided visualizations in individual species accounts.

We then collated multiple spatial statistics associated with 1, 2, 4, 6, 8, and 10 kilometer radius circles centered on each MAPS station by analyzing reclassified portions of two publicly available National Land Cover Datasets identified as NLCD 1992 and NLCD 2001 (Homer et al. 2004). Time-constant (i.e., pooled across years) demographic parameters were regressed against the mean forest cover. Fortunately, however, these two datasets span approximately the same time period as the MAPS data so that each of four time-dependent demographic parameters could be regressed against the difference between 2001 and 1992 forest cover statistics.

Collection of Breeding Bird Survey Trend Data

Using the Breeding Bird Survey trend analysis interface we prepared a table of BBS trends for species that are counted among Virginia BBS routes for the years 1992-2005, which parallels the period of the MAPS data. A total of 119 species were listed in Table 3 combining those species monitored by BBS and all Virginia bird Species of Greatest Conservation Need (SGCN). We collated paired MAPS and BBS trend data for 21 of the 23 target species and tested for correlations between them.

National Land Cover Dataset

We obtained the National Land Cover Datasets for 1992 and 2001 (Homer et al. 2004) for Virginia and surrounding states such that 1, 2, 4, 6, 8, and 10 kilometer "cookies" could be cut for each of the 34 Virginia stations and for each of 37 stations that lay within 150 kilometers of the Virginia border (Figures 3 and 4). We reclassified each of these Level II layers to Level I classes (after Anderson 1971) such that, for example, the forest classes 41, 42, and 43 were collapsed into a single forest class (Figures 3 and 4). We developed scripts within ArcView 9.2 (ESRI) to collate spatial statistics output from Fragstats (McGarigal and Marks 1995) for each of the six different radii cookies. From this dataset and for each station and radius we extracted the mean forest cover (%), forest edge density (m/ha), and mean core forest cover (%) using a 90m interior buffer to each forest patch. We calculated these statistics for both NLCD datasets. From these data we calculated mean spatial statistics (i.e. [NLCD1992 + NLCD2001]/2) to compare with the time-constant demographic estimates. We also calculated the difference between the years (i.e. NLCD2001-NLCD1992) to compare with time-dependent demographics. Furthermore, we estimated forest cover change for both the spatial extent of Virginia and the entire Virginia region (150km buffer).

We calculated means and differences for the following landscape statistics relating to the combined forest class:

- **Percentage Forest Cover (Forest%) -** Percentage of landscape in forest.
- **Percentage of Forest Core Area (Core%) -** Core Area as Percentage of Landscape. Core Area is defined as the area within a patch beyond some specified distance to edge influence. For this study we used an internal buffer width of 90m.
- **Edge Density (Edge) -** Edge Density is a measure of the lengths of all edge segments involving the corresponding patch type measured in meters per hectare.

Appendix 1 presents summaries of the demographic analyses for most of the species shown in Table A, but model descriptions were only given for the four species for which we obtained statistical significance in the models.

Virginia GAP Land Cover Data

The Virginia GAP Dataset is a 30 meter resolution land cover dataset which was derived from Landsat TM imagery (1986-1994) and further classified with ancillary information (topography and Relative Phenological Index). See http://gapanalysis.nbii.gov/ for details. We analyzed the Virginia GAP land cover dataset (http://gapanalysis.nbii.gov/) using Hawth's Tools to create cookie cuts and FRAGSTATS to calculate the Percentage of Landscape (PLAND) for each vegetation type within each cookie cut. We tabulated the three predominant vegetation classes within a 1km radius of each of 34 MAPS Stations in Virginia (Table 2). Unfortunately, the habitat classifications associated with the stations were too numerous for constructing species-landscape data from these data. However, the sub-regional analysis described later included groups of stations closely related to the GAP groupings.

Climate Data - ENSO Precipitation and North Atlantic Oscillation Indices

Monthly ESPI values, dating back to January 1979, were collected from the National Aeronautics and Space Administration (NASA, 2001). We chose this metric because the commonly cited Southern Oscillation Index (SOI) is based on sea-level pressure differences between only two points, Tahiti and Darwin, and is therefore subject to localized noise (Curtis, *pers. comm*.). In contrast, ESPI is a satellite-based measure of larger-scale atmospheric circulation (Curtis & Adler, 2000) that determines the wind and storm patterns that likely affect birds' breeding or wintering habitat as well as their migratory routes. An inverse relationship exists between ESPI and SOI, such that ESPI is more positive during ENSO events when precipitation increases in the subtropical and tropical Pacific Ocean, whereas SOI is more negative during these events.

Similarly, we chose an index of NAO that reflects broad scale spatial atmospheric pressure patterns (Barnston & Livezy, 1987) in preference to other NAO indices that may also be subject to localised noise. Monthly North Atlantic Oscillation indices (henceforth referred to as NAOI) dating back to 1950 are archived at the National Oceanic and Atmospheric Administration's Climate Prediction Center website, (http://www.cpc.ncep.noaa.gov/data/teledoc/nao.shtml; March 2007). A positive NAO index signifies that the atmospheric pressure over the subtropical portion of the North Atlantic is higher than normal and the atmospheric pressure over Iceland is lower than normal. This results in an increased pressure difference that causes stronger winter storms to cross the Atlantic Ocean on a more northerly track. This, in turn, leads to warm, wet winters in Europe; cold, dry winters in northern Canada and Greenland; and mild, wet winters in the eastern United States. A negative NAO index reflects a reduced pressure gradient between the sub-tropical North Atlantic and Iceland. This results in fewer and weaker winter storms crossing the Atlantic on a more west-east track, which brings cold air to northern Europe, moist air to the Mediterranean region, and increases the chance of snowfall in the eastern United States. From these data we formulated three month indices from mean monthly indices for the period February to April, which is the period immediately prior to the start of spring migration on the wintering grounds, and the low rainfall period prior to the growing season in Virginia.

Precipitation Data

Precipitation data were provided by the Global Precipitation Climatology Project (GPCP), which is maintained by the National Aeronautical and Space Agency and made available through the University of Washington's Joint Institute for the Study of the Atmosphere and Ocean (JISAO) as 2.5° resolution gridded monthly precipitation data in netCDF format (Huffman et al. 1997, Rew et al. 1993). We chose the geographic coordinates 38.75°N 78.75°W (Figure 1) to identify the center of the GPCP cell that has northeast corner coordinates of 40°N 77.5°W, and southeast coordinates of 37.5°N 80°W. Using proprietary software written in MatLab (Mathworks Inc.) we extracted seasonal datasets spanning 1981 to 2005. Figure 5 reflects precipitation patterns a) during the non-breeding season including the drier winter months (October to March), and b) during the period April to September inclusive which includes the landbird breeding season (May to August) when monthly rainfall is highest.

Normalized Difference Vegetation Indices

A measure of canopy density (or cover) is provided by the US Geological Survey's Normalized Difference Vegetation Index (NDVI), a one degree latitude-longitude resolution gridded dataset. The Normalized Difference Vegetation Index NDVI provides a rough measure of photosynthetic activity which has been shown to be correlated with green leaf biomass and green leaf area index (Cihlar et al. 1991). Although NDVI provides a good measure of green canopy cover it is not a good indicator of physiological activity (Stylinski 2000). Unfortunately, the gridded dataset only covers the period 1980-1999 but was still analyzed to explore any annual trend in the index which might indicate that the canopy is generally closing or opening. We analyzed data from the cell encompassing Shenandoah National Park to show annual mean monthly values of NDVI for the period May to August (breeding season).

Sub-regional Analyses

Three sub-regions were defined to encapsulate three sets of long-running MAPS stations for comparative analysis (Table 7); Shenandoah National Park (SH) including 6 stations; the southeast (SE) included 7 stations; and the northeast sub-region (NE) included 13 stations. We analyzed the data from each of the three sub-regions to compare demographic parameters of survival rate and reproductive index. We selected the three most frequently captured Neotropical migrant forest species (Acadian Flycatcher, Wood Thrush, and Ovenbird) for a sub-regional analysis of a) gender-specific body condition expressed as the ratio of weight to wing chord length, and b) gender-specific wing chord lengths.

RESULTS

A total of 71 MAPS stations were selected in Virginia and seven neighboring states (Table1, Figure 1). The Virginia MAPS Stations were predominantly located in three areas, in and near Shenandoah National Park, in the north-east corner including Clark, Frederick, Fairfax, Stafford, Loudoun, Prince William, and King George Counties, and in the southeast counties of Chesapeake, Suffolk, and Virginia Beach. Two Stations are located in the middle of the state in Goochland and Powhatan County. Collectively, the 71 stations are associated with a variety of habitat types in the Virginia GAP coverage (Table 2, Figure 2).

The network of MAPS stations within the state of Virginia (Table B, Figure 1) was historically more extensive with 20-25 stations operating between 1995 and 2002. By 2005 only 11 stations remained in operation. The monitoring potential in terms of species-stations was 35, however, a total of 60 species stations were lost due to station closures.

Acadian Flycatcher, Wood Thrush, and Ovenbird are the only species effectively monitored by currently operational MAPS stations in Virginia (Table B). Unfortunately, the closure of the Shenandoah NP stations in 2003 lost the potential to effectively monitor a diverse avifauna including Veery, Wood Thrush, Worm-eating Warbler, Ovenbird, Eastern Towhee, and Indigo Bunting. These stations should be reestablished to monitor these species in the higher elevation (>450m) forests where climate change is first expected to change the forest botanical community and avifauna.

The Shenandoah National Park stations are the highest MAPS stations in Virginia with elevations in the range of 488 to 1067 meters in the Appalachian ridge and valley geomorphology. The dominant vegetation type for all these stations is *dry montane deciduous forest*. Secondary habitat types are primarily *mesic montane deciduous forest* or *montane dry oak* dominated. A few stations, however, are associated with tertiary habitats of *montane yellow pine* and *mixed central hardwood*.

The northeastern part of the region was more populated with humans and more dominated by *Agricultural vegetation* types than any other part; agricultural cover types were found in Clark, Frederick, and Loudoun Counties. In Fairfax County a *Piedmont/coastal plain forest complex* was the dominant vegetation type surrounding the MAPS stations, followed by *Virginia deciduous forest complex* and types classified as "*other*" which included high proportions of *open water* or *wetland*. No class was associated with two stations, both near the town of Woodbridge situated on the Virginia – Washington DC border because there is no data on the Washington DC border. However, we know that both stations are on the waterfront and should attract species that prefer more mesic lowland habitats.

The southeastern stations are at lower coastal plain elevations. In Chesapeake County, s*parse herbaceous/row crops* was the dominant type, while in Suffolk County *Tupelo-red maple wet forest* was strongly dominant. Virginia Beach stations occur in a diverse mixture of types with *forested wetland* as the dominant vegetation type. These stations are the only stations that featured *high density disturbed* habitat in the top three dominant cover types.

Overall, the distribution of MAPS stations shows a large gap in the central and western half of the state. In fact there are no stations west of approximately 78 degrees longitude west and nothing south of 37 degrees 38 minutes and 40 seconds latitude except for the cluster in the southeast corner of the State.

Effective demographic monitoring of species of concern

Table 3 shows a list of 119 landbird species, which includes 97 species monitored by the Breeding Bird Survey, 49 landbird species listed as Species of Greatest Conservation Need by the Virginia Department of Game and Inland Fisheries, and 23 species captured by the MAPS program for which reliable adult survival rates could be estimated. Only one species effectively monitored by the MAPS program, Veery, is not effectively monitored by the BBS, due to its limited high elevation Appalachian distribution, and is not listed as a SGCN species either.

From this list of 119, a total of 60 species were selected as potential focal species in this study, including all landbird species listed in any of the four SGCN tiers, as well as species significantly ($P<0.10$) declining in BBS data (1980-2005) or in MAPS adult capture data. Of these 60 species 49 are listed as SGCN landbird species. Sixteen of the 60 species were not effectively monitored by the BBS (1980-2005), or by MAPS (Table 3). However, approximately 85% of Veery captures and 64% of Canada Warbler captures were recorded at stations in Shenandoah National Park; both species require more widespread monitoring. Yellow-bellied Sapsucker, Brown Creeper, and Golden-winged Warbler were other species captured (but not effectively monitored) at MAPS stations in this region. With placement of new MAPS stations in appropriate habitats, however, it should be possible to monitor up to eleven species that are currently under-represented and obtain survival rate estimates and reproductive indices; Marsh Wren; Winter Wren; Black-throated Blue Warbler; Sharp-tailed Sparrow; Seaside Sparrow; and Red Crossbill. These species, however, are not particularly suited to MAPS monitoring because they are canopy birds, grassland birds, or wetland birds that normally require target banding to acquire sufficient numbers for survival analysis.

Survival Rate Estimates

Apparent survival rates were estimated for 41 species represented in the Virginia region MAPS dataset (Table 5, Table 6). Estimates for 23 of these species were considered reliable and were compared with estimates derived from pooled data associated with each of four Bird Conservation Regions that Virginia overlaps (Table 6). The remaining 18 species that exhibited highly variable survival rate estimates (Table 5) included eight focal species. These included three Neotropical migrants, two short-distance migrants, and one year-round resident.

Comparisons between survival rate estimates for Virginia data and those of overlapping BCRs were possible for all 23 species that exhibited low variation on survival rate estimates (i.e. $CV<=0.30$). Survival rate estimates for eight species were lower than those of the BCRs, and 15 were higher or even. Of the 23 species 14 were defined as focal species (Table 3) including 13 Neotropical migrants and one short-distance migrant. These were adequately monitored by MAPS in Virginia and surrounding area and generally exhibited higher survival rates than those derived from the broader scale BCR level analyses. Table 6 shows that survival rates for 10 focal species were high (or even) compared to estimates derived from BCRs (where reported), and were low for only four species. This suggests that at least where MAPS stations were located the populations of most species were healthy.

Breeding Bird Survey and MAPS

We obtained BBS trends for 100 species over the same time period in which the MAPS data was gathered. Of these 100 species 60 showed negative trends and 32 of those (over 50%) were significant declines ($P<0.10$). Of the 40 that showed positive trends 16 were significant. No BBS trends were available for 19 SGCN species (excluding the migrant Bicknell's Thrush) including three that breed in the western portion of Virginia (Canada Warbler, Swainson's Warbler and Golden-winged Warbler). The remaining breeding species included four sporadically distributed sparrows, Brown Creeper, and four of six wren species. Veery is not listed as a SGCN species but Virginia contains part of the southern portion of the breeding range, a tongue shaped portion reaching into the southern Appalachians. We obtained survival rate estimates for the Veery from captures at 22 MAPS stations, including discontinued stations in Shenandoah.

Test for correlations revealed no relationship ($N=21$, $R=0.08$) between MAPS and BBS trends for the same period (1992-2005). Furthermore, species monitored by MAPS showed a mean annual percentage change of 1.69% and BBS trends showed a mean annual percentage change of 0.16%.

Climate and Precipitation patterns

ESPI indices for February to April were high in the El-Nino years of 1992, 1993, and 1998. However, strong La Nina type signals were apparent in 1996, 1999, 2000, and 2001. ESPI indices spatially correlate with precipitation patterns across the winter range of the Wood Thrush. El Niño winters may also influence conditions throughout the breeding habitat. The NCEP/NCAR analysis shows El Niño winter conditions (December to February) tend to be warmer across the southeast region of the United States (including Virginia), and especially throughout the stopover habitats along the Gulf Coast from Texas to Florida. The warmer conditions may translate to more invertebrate resources for birds that subsequently migrate through these areas.

Examination of NOAA seasonal climate correlations (Kalnay et al. 1996) strongly suggested that when El Nino conditions prevail between February and April more winter rainfall is experienced in the north of the Wood Thrush winter range. This relationship extends from southern Veracruz, south through the Yucatan Peninsular, Belize, Guatemala, Honduras, and Nicaragua. In the southern portion of the range, however, from Costa Rica to Panama, significantly less rainfall is likely in El Nino years. El Nino winters may also influence conditions throughout the breeding habitat The NCEP/NCAR analysis shows El Nino winter conditions (December to February) tend to be warmer across the southeast region of the United States (including Virginia), and especially throughout the stopover habitats along the Gulf Coast from Texas to Florida.

NAO indices tended to be high and positive between 1992 and 2003, especially in 1994, 2000, and 2002, bringing warmer late winter conditions to Virginia.

Precipitation data were collected from a GPCP cell centered on 38.75°N 78.75°W and incorporated approximately half of the Virginia region MAPS stations and other stations in West Virginia and Pennsylvania. Figure 5 shows that over the period 1981-2005 May to August inclusive were the wettest months where mean monthly precipitation exceeded the annual mean of ~7mm/month (center graph). Non-breeding season precipitation (October-March, top graph) showed an annual decline of 0.9mm. Therefore, on average, there was an annual decline of 0.9 x 6 months = 5.4mm in non-breeding season precipitation. Non-breeding season precipitation was higher than the annual mean of ~7mm/month (a total of ~43mm per six month period) during the period 1982-1987, and in the years 1991, 1993, 1994, 1998, 2003 and 2004. Very dry conditions were recorded in 1988, 1995, 2001 and 2002.

Breeding season precipitation levels averaged over 9mm/month (a total of ~55mm per six month period) and was particularly high (>10mm/month) in 1981, 1984, 1989, 1994, 1996, 2000, 2003 and 2004. Levels were particularly low in 1986, 1991, 1995, 1997, and 2005.

Sub-regional Analyses

Annual survival rate estimates were obtained for a total of 15 species across the three sub-regions (Table 9). Single region estimates were recorded for Veery, American Redstart, Gray Catbird, and Eastern Towhee at Shenandoah stations (6 station); Prothonotary Warbler in the SE Sub-region (7 stations); and Red-eyed Vireo, Louisiana Waterthrush, and Kentucky Warbler in the NE Sub-region (13 stations). We obtained estimates for five species in each of two sub-regions. Acadian Flycatcher and Carolina Wren survival rates in southeastern sub-region were similar to the northeastern sub-region, whereas the estimate for Northern Cardinal was slightly higher for the southeastern sub-region.

We obtained estimates for all three sub-regions for Wood Thrush and Ovenbird. The survival rate estimates for Wood Thrush were considerably lower for Shenandoah than the other two sub-regions; the estimate for northeastern sub-region was highest. For Ovenbird the three estimates were 0.5 or above with northeastern sub-region being the highest followed by the estimate for Shenandoah.

Spatial variation in body condition was considerable among each species (Table 10). The body condition of Acadian Flycatchers, as indexed by the ratio of weight to wing chord length, were similar in the northeast and southeast sub-regions for males and females but lower at Shenandoah for females (ANOVA F=7.49, df=670, P<0.0001). For females the annual rate of change in body condition (1992-2003) was negative in all three sub-regions but significantly (P<0.0005) declined in the northeast sub-region (-1.77×10^{-3} g/mm/yr).

The body condition of male Wood Thrushes was highest in the northeast sub-region, followed by Shenandoah, where female body condition was highest followed by the northeast. Although body condition was lowest for both sexes in the southeast region the annual change was positive. At Shenandoah the annual male and female body condition declined non-significantly but declined significantly in the northeast region for both males (P<0.005) and females (P<0.05), by -2.41×10^{-3} g/mm/yr and 2.17×10^{-3} g/mm/yr, respectively. In contrast, the body condition of Ovenbirds was highest in the southeast sub-region and lowest in Shenandoah for both males (ANOVA F=14.45, df=1659, P<0.0001) and females (ANOVA F=6.91, df=858, P<0.0001). We recorded declines throughout except the for male body condition in Shenandoah, which increased. In the southeast sub-region the declines in condition were significant for males (P<0.10) and females (P<0.01), by -0.78×10^{-3} g/mm/yr and 2.07×10^{-3} g/mm/yr, respectively.

Wing chord length (WCL) varied by species, gender, and sub-region, but did not vary through time (Table 11). Acadian Flycatcher WCL was longer in the northeast sub-region than in the southeast for both males (P<0.05) and females, however Shenandoah females were longer winged than any female (P<0.10). Sub-regional differences in Wood Thrush WCL were non-significant but northeastern males were the shortest-winged. Male Ovenbirds, however, were significantly longer-winged in the northeast sub-region, suggesting that they migrate farther than birds from the other populations.

DISCUSSION

Future Monitoring Requirements

Although the results of these analyses emphasize the value of demographic monitoring they also reveal many gaps in demographic monitoring with respect to species of conservation concern and habitats in Virginia and surrounding region. The Virginia region MAPS dataset realized demographic parameter estimates for 23 species, including a) apparent survival rates, b) mean adult and young population size, and c) annual trends in adult and young population size means and trends. The results showed significant annual declines in reproductive success for Wood Thrush, Gray Catbird, Prothonatory Warbler, and Common Yellowthroat. We also quantified the effects of forest fragmentation (1992-2001) on population sizes and indexed reproductive success of Acadian Flycatcher, Wood Thrush, Ovenbird, and Hooded Warbler. These relationships could be used to formulate management recommendations to protect these species. Population "performance measures" were also created to compare region-wide survival rate estimates (and indices of reproductive success) with values derived from MAPS data representing spatially extensive bird conservation regions.

Morphometric data collected as part of the MAPS protocol proved to be extremely useful in considering environmental influences upon Wood Thrushes. By combining morphometric data with climate and weather data we showed that reproductive success declined rapidly as a function of annual female body condition, juvenal body condition, and climate-induced environmental conditions affecting the wintering grounds prior to spring migration and possibly also the breeding grounds in late winter/early spring.

These and other results from different regions (e.g. Nott et al. 2002) suggest that our understanding of the stressors upon the population dynamics of Virginia's avifauna could be increased by extending the coverage of constant-effort mist-netting stations. The placement of MAPS stations in Virginia and surrounding region are considered opportunistic, and although they enable us to comment upon trends at regional or smaller spatial scales (e.g. Shenandoah National Park), do not provide sufficient coverage of some of Virginia's more sensitive and threatened habitat types and the birds of greatest conservation concern that breed there. If the predictions of an upcoming climate shift are realized, then the diversity, extent and pattern of Virginia's natural habitats are likely to change in response. In turn, the size and distribution of bird populations will track short term changes in seasonal environmental conditions and determine the new assemblages that will result from the longer-term effects of climate change on those habitats. Some researchers have already detected a northerly shift in the range of upland birds over the last 25 years in response to a warming trend across much of North America. In Virginia, that warming trend manifests itself in warmer drier winters due mainly to the influence of the warming North Atlantic Ocean.

Targeting Avifauna of Regional Habitats

Virginia has many different habitat types, some of which are rapidly declining, in which the coverage of landbird demographic monitoring is poor or non-existent. Extending demographic monitoring of landbirds throughout Virginia should consider a) reestablishing those stations that previously operated and also captured useful numbers of birds of concern (i.e., the discontinued stations that form the top half of Table 8) , and b) establishing clusters of six monitoring stations in areas where they are likely to catch useful numbers of target species. Here we discuss several physiographic regions of Virginia and the 29 Virginia Species of Greatest Conservation Need that MAPS demographic monitoring is likely to catch in sufficient numbers to facilitate demographic parameter estimation (Table 4). All of these species have reliable (coefficient of variation < 30%) survival estimates associated with them at the continent-level and MAPS regional level (http://www.birdpop.org/nbii/NBIIHome.asp)

High elevation habitats, such as those of the Northern Ridge and Valley, are often the first to respond to warming trends as the changing conditions allow altitudinal shifts in species' ranges such that species previously unable to tolerate conditions and habitats above given elevations begin to move upslope. Twelve Virginia stations were located at elevations over 475m and, considering the landscape within a one-kilometer radius of MAPS stations, were classified by the Virginia GAP coverage as predominantly Montane

Deciduous Forest. These include 10 stations in Shenandoah National Park (four only operated in 1992, two operated 1992-2003, and one operated 1993-2003) and one at Rapidan WMA (operated in 2001 and 2002) covering the counties of Madison, Page, Rappahannock, and Rockingham. MAPS habitat descriptions indicate that three of the Shenandoah stations operated in cove hardwood habitat. The remaining station was located in Augusta County and operated from 1994 to 1996. Only one of these stations is still active and located in a managed forest.

The most abundant breeding species at the six Shenandoah MAPS stations in 2003 (as determined by adults captured per 600 net-hours), in decreasing order, were American Redstart, Ovenbird, Worm-eating Warbler, Eastern Towhee, Wood Thrush, Black-and-white Warbler, Hooded Warbler, Red-eyed Vireo, and Veery. Effective monitoring of these Neotropical migrant species of concern (excluding Eastern Towhee) could be re-established at the high elevation stations to monitor landbird populations of montane deciduous habitats. Other species of concern could be effectively monitored by careful placement of additional demographic monitoring stations in specific high elevation habitats including Rose-breasted Grosbeak, Acadian Flycatcher, Ovenbird, American Redstart, Canada Warbler, Louisiana Waterthrush, and Scarlet Tanager.

The Southern Appalachian Piedmont physiographic region of Virginia is more populated than the montane regions and has been fragmented by development and agriculture. The region features many small patches of deciduous forested wetland and riparian corridors which are remnants of extensive areas of northern hardwood habitat that existed prior to European settlement. Developed land accounts for 4% of the area of the Virginia Piedmont but agriculture now covers 27% of the land, and forest covers 65%. Unfortunately, bottomland and riparian habitats were developed first for human settlement and commercial use due to their proximity to fresh water and water-based transportation. Riparian habitats, both successional and forested are also especially vulnerable to agricultural use due to the nutrient rich soils of the river banks, meanders, and adjacent floodplains. It is essential to protect the remaining forested wetland and riparian habitat because they provide breeding habitat for many declining Neotropical migrants as well as some year-round residents.

Extensive demographic landbird monitoring of Piedmont forested habitats is likely to collect useful data on the following species: Acadian Flycatcher, Red-eyed Vireo, Wood Thrush, Northern Parula, Prairie Warbler, Black-and-white Warbler, Louisiana Waterthrush, Kentucky Warbler, Hooded Warbler, Scarlet Tanager, and Eastern Towhee.

The Mid-Atlantic Coastal Plain physiographic region of Virginia is more populated than the other regions and has also been fragmented by development and agriculture, such that developed land accounts for 7% of the area, agriculture covers 26% of the land, and forest covers 48%. Because of the low elevations and coastal aspect of this region wetlands make up 14% of the total cover compared to 2% of the Piedmont. The riparian forested habitat and associated wetlands of the southern portion of this province provide breeding habitat for the richest diversity of avifauna in the state. This area is also the most populated in the state. MAPS demographic monitoring could be used to target a number of Virginia's Species of Greatest Conservation Need, especially Swainson's warbler, a Tier II species for this province. An additional 15-18 Tier IV classified species could be targeted because they are commonly captured by MAPS and provide reliable survival rate estimates at regional scales. Importantly, the MAPS program has regional estimates for Swainson's Warbler, which breeds in both the southern Virginia Coastal Plain, and the southwest corner of Virginia. We feel that this species should be targeted in this province because it will be important to monitor its response to changing environmental conditions at the northeasterly tip of its geographic range.

The southwest of Virginia is home to very diverse habitats in a highly heterogeneous pattern due to the high complexity of elevation, slope, and aspect that is typical of Appalachian ridge and valley landscapes. Southwest Virginia features habitats found in the Northern Ridge and Valley physiographic province as well as those of the Cumberland Mountain provinces. This region is more remote, less populated by humans, and thus poorly represented by MAPS. However, this region supports populations of

Swainson's Warbler and Golden-winged Warbler, both of which are high priority SGCN species. Threats to the diverse habitats are numerous including predicted changes in seasonal patterns of environmental factors such as rainfall and temperature. Introduced pests are also a problem, for example, remaining hemlock stands are being heavily damaged by the advance of Hemlock Woolly Adelgid, which has spread from eastern Virginia since the 1950's. Gypsy moth outbreaks are also advancing into southwest Virginia and have probably benefited from the warmer, drier winters that have been prevalent over the last 25 years. Another emerging problem for forest managers is the spread of Japanese Stilt grass which changes the characteristics of the forest floor by forming a dense mat of grass which impedes regeneration of trees from seedlings and affects the diversity and abundance of earthworms. Such an understory would not support the avian diversity that we currently associate with healthy forests that feature a well-developed understory, ground cover, and litter layer.

Residential development will inevitably encroach upon large contiguous patches of bottomland and affect riparian forest species. Development is advancing along higher elevation ridges of forested habitat where it will likely impact populations of mature forest-interior species such as Cerulean Warbler. Such disturbances fragment the landscape further and create more edge and smaller patches of habitat. Bruce et al. (2000) concluded that breeding bird richness was predominantly a function of forest edge such that "specialist species richness was negatively associated with forest edge and generalist richness was positively associated with forest edge". Protection and management of large publicly-owned forest patches and responsible, sustainable silviculture of commercial forests could benefit not only forest-interior species but the more diverse species that breed in the more open forest, forest-shrub ecotones, and gap habitats that result from sustainable thinning and selective logging practices (e.g. Yellow-throated Vireo).

Demographic monitoring is a method by which we can track the responses of avian demographics to a) potential threats to habitats such as development, forest defoliation or invasive plant cover, or b) the effects of implementing alternate management scenarios, such as those described above. Overall, the MAPS demographic monitoring protocol shows potential for monitoring many of Virginia's birds of conservation concern in a variety of habitats and physiographic provinces. Here we summarize potential target species that are the focal species for habitats and physiographic provinces of Virginia as defined by the Partners in Flight Bird Conservation Plans. In the Mid-Atlantic Ridge and Valley province Golden-winged Warbler and Prairie Warbler are good target species of early succession habitats. Worm-eating Warbler, Louisiana Waterthrush, and Wood Thrush are good target species to monitor in mature deciduous forest. In the Mid-Atlantic Piedmont Prairie Warbler and Field Sparrow are target species of successional habitats and Wood Thrush, Louisiana Waterthrush, and Kentucky Warbler are good target species of deciduous and mixed forests. In the Mid-Atlantic Coastal Plain the MAPS protocol could target Prairie Warbler in pine savannah habitats; Swainson's Warbler, Prothonatory Warbler, and Acadian Flycatcher in forested wetlands; and Wood Thrush, Worm-eating Warbler, and Kentucky Warbler of mixed upland forests.

Expansion of the Virginia MAPS network could be modeled on other studies conducted by The Institute for Bird Populations. For example, we developed predictive landscape-scale (1000's of hectares) demographic models for multiple species by combining land cover data from the National Land Cover Dataset with MAPS data from two networks of stations funded the Department of Defense Legacy Resource Management Office (Nott et al. 2003, Nott and Michel 2005), and the USDA Forest Service Pacific Northwest Region Six (Nott and Michel 2005). These models can be used to predict the effects of management (e.g. logging practices) on the size and productivity of multiple species (see http://www.birdpop.org/nbii/info/nbiimapsinfo.htm). The models have been used to formulate management guidelines for a suite of species in the eastern and south central states, and national forests of Washington and Oregon. In each case we constructed the species-landscape models using data from a fixed network of stations that had been operating in relatively undisturbed areas for 10-12 years. The networks were then reorganized to leave some monitoring stations in control areas (e.g. large patches of mature forest), and move others to monitor managed areas. To consider the effects of a particular thinning practice, for example, stations can be placed in stands of various ages since management, using a space-for-time substitution method that can give us an understanding of long-term effects by using shorter term monitoring.

Sub-regional Analyses

Overall, survival rates for species and sub-regions were comparable with survival estimates for the entire region, but were highest in the northeast sub-region except for Carolina Wren and Northern Cardinal. The survival rate estimate for Wood Thrush in Shenandoah was very low, indicating high winter mortality or a high rate of emigration such that birds perhaps breed one year but move to another location the next. The body condition, however, was the highest of the sub-regions and the annual rate of loss in body condition was non-significantly negative. Catastrophic events notwithstanding, good body condition is not indicative of population that suffers high mortality, in which case it is more reasonable to think that the poor survival rate is due to high rates of emigration.

The comparative analysis produced acceptable (CV<25%) survival rate estimates for eight species in Shenandoah, six species in the southeast sub-region, and 10 species in the northeast sub-region. Typically, the Institute for Bird Populations operates MAPS stations in clusters of six stations (termed a location), each of which can be operated by two trained interns with occasional supervision within the ten day cycle of the MAPS protocol. The results from this study show that such a cluster (e.g., Shenandoah) can provide survival rate estimates with acceptable precision for comparison with the results derived from other clusters. Likewise, such datasets can also provide useful information on body condition and wing chord length which other studies, including the study documented in the draft manuscript (Appendix 2), have related to seasonal climate/weather patterns and migration connectivity.

Overall, the interesting results from this study were derived from data that was collected at stations no longer in operation. We conclude that many of these stations should be reestablished to better monitor Virginia species of conservation concern and that clusters of stations should be located in threatened habitat types of Virginia in order to document changes and identify proximal causes of those changes.

References

Anderson, James R., 1971, Land use classification schemes used in selected recent geographic applications of remote sensing: Photogramm.Eng., v. 37, no. 4, p. 379-387.

Barnston, A.G. & Livezey, R.E. (1987) Classification, seasonality and persistence of low-frequency atmospheric circulation patterns. *Monthly Weather Review*, **115**, 1083-1126.

Cihlar, J. L. St-Laurent, and J.A. Dyer. 1991. Relation between the normalized vegetation index and ecological variables. Remote Sensing of Environment 35: 279-298.

Curtis, S. & R. Adler, 2000. ENSO indexes based on patterns of satellite-derived precipitation. *Journal of Climate*, **13**, 2786-2793.

DeSante, D.F., P. Pyle, and D. R. Kaschube. 2003. The 2003 Annual Report of The Monitoring Avian Productivity and Survivorship (MAPS) Program in Shenandoah National Park., May 12, 2004.

Gartshore, M. E. 1988. A summary of the breeding status of Hooded Warblers in Ontario. Ontario Birds 6: 84–99.

Hines, J.E., W.L. Kendall, and J.D. Nichols. 2003. On the use of the robust design with transient capture-recapture models. Auk 120:1151-1158

Homer, C. C. Huang, L. Yang, B. Wylie and M. Coan. 2004. *Development of a 2001 National Landcover Database for the United States. Photogrammetric Engineering and Remote Sensing*, Vol. 70, No. 7, July 2004, pp. 829-840.

Huffman, G.J., R.F. Adler, P.A. Arkin, A. Chang, R. Ferraro, A. Gruber, J. Janowiak, R.J. Joyce, A. McNab, B. Rudolf, U. Schneider, and P. Xie, 1997: The Global Precipitation Climatology Project (GPCP) Combined Precipitation Data Set. Bull. Amer. Meteor. Soc., 78, 5-20.

McGarigal, K., and B. J. Marks. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. USDA For. Serv. Gen. Tech. Rep. PNW-351.

NASA (2001) A table http://rsd.gsfc.nasa.gov/912/gpcp/ESPItable.html and summary http://rsd.gsfc.nasa.gov/912/gpcp/ESPIsummary.html of monthly ENSO Precipitation Indices (1979 onwards).

NOAA-CIRES CDC, Boulder, CO (2001) http://www.cdc.noaa.gov/Composites or http://www.cdc.noaa.gov/Correlations/

Nott M.P., and D.F. DeSante. 2002. Demographic monitoring and the identification of transients in mark-recapture models. In: Predicting Species Occurrences: Issues of Scale and Accuracy (Scott, J. M., P. J. Heglund, M. Morrison, M. Raphael, J. Haufler, B. Wall, Editors). Island Press. Covello, CA.

Pradel, R., Hines, J.E., Lebreton, J.-D., and Nichols, J.D. 1997. Capture-recapture survival models taking account of transients. Biometrics, 53, 60-72

Rew, R., Davis, G., Emmerson, S. 1993, "NetCDF User's Guide: An Interface for Data Access, Version 2.3,", UCAR.

Robbins, C. S. 1979. Effect of forest fragmentation on bird populations. Pp. 198–212 *in*Workshop proceedings: management of northcentral and northeastern forests for nongame birds (R. M. DeGraaf and K. E. Evans, eds.). U.S. Dept. Agric. Tech. Rep. no. 51.Sauer, J. R., J. E. Hines, and J. Fallon. 2005. *The North American Breeding*

Bird Survey, Results and Analysis 1966 - 2004. Version 2005.2. USGS Patuxent Wildlife Research Center, Laurel, MD

Stylinski, Cathlyn D. 2000. Effects of Resource Availability on Plant Reflectance and Physiology. Ph.D. Dissertation, San Diego State University, University of California Davis, *134 pages*.

Virginia Department of Game and Inland Fisheries. 2005. Virginia's comprehensive wildlife conservation strategy. Virginia Department of Game and Inland Fisheries, Richmond, Virginia.

TABLES 1 - 11

Table 1. List of MAPS stations in Virginia and neighboring states (within 150km of Virginia border) detailing the station code and name with the county and state. Latitudinal and longitudinal coordinates are given in degrees minute second format with the elevation (m) and NABCI Bird Conservation Region (BCR), the primary habitat and the length of operation (e.g. "01-" means operated from 2001 and was still active in 2006, "94" means operated only in 1994).

Table 1. (continued)

Station	Station Name	County	State	Latitude	Longitude	Elev. (m)	BCR	Primary Habitat	Operation
15554	Augusta Springs	Augusta	VA	38 06 40	-079 18 50	495	28	wet meadow/thicket/forest edge	94-96
16648	A.P. Hill 1	Caroline	VA	38 08 20	-077 20 20	55	27	mixed forest	95-03
16649	A.P. Hill 2	Caroline	VA	38 09 00	-077 20 20	61	27	mixed forest	95-03
16650	Fentress	Chesapeake	VA	36 41 01	-076 08 59	4	27	mixed forest	95-02
16655	Rothr Antenna	Chesapeake	VA	36 33 31	-076 16 42	6	27	mixed forest	95-02
15642	NSVAS - Blandy	Clark	VA	39 03 20	-078 03 30	200	28	mixed hardwood/farmland/riparian	02-
16644	Belvoir Upland	Fairfax	VA	38 44 10	-077 09 00	38	30	mixed upland forest	95-02
16645	Belvoir Lowland	Fairfax	VA	38 44 20	-077 08 00	9	30	deciduous bottomland forest	95-02
16646	Mason Neck 1	Fairfax	VA	38 37 34	-077 10 24	6	27	mid-successional decid. forest	95-
16647	Mason Neck 2	Fairfax	VA	38 37 35	-077 12 03	6	30	mountain-laurel thicket	95-
15643	Glendobbin	Frederick	VA	39 14 20	-078 09 45	300	28	mixed hardwood/farmland	02-
16686	Westview	Goochland	VA	37 38 40	-078 00 20	53	29	deciduous woodland/evergreen wood	98-02
16613	Dahlgren	King George	VA	38 20 40	-077 03 00	7	30	mixed deciduous forest	92-02
16721	Banshee Reeks	Loudoun	VA	39 01 41	-077 35 59	117	29	deciduous woodlands/successional fields	03,05-
15535	Thorofare Mountain	Madison	VA	38 35 00	-078 22 00	1006	28	northern red-oak forest	92
15536	Old Crescent Rock	Madison	VA	38 33 29	-078 22 47	1067	28	northern red-oak forest	92
15550	New Crescent Rock	Madison	VA	38 33 29	-078 22 47	1067	28	northern red oak forest	93-03
15534	Pinnacle Ridge	Madison	VA	38 36 30	-078 19 00	579	28	northern red-oak forest	92
15532	Pass Mountain	Page	VA	38 40 10	-078 19 40	770	28	cove hardwood forest	92
15537	Hazeltop Ridge	Page	VA	38 28 32	-078 27 42	910	28	cove hardwood forest	92-03
15549	Jeremy's Run	Page	VA	38 43 41	-078 19 29	762	28	chestnut oak forest	93-03
16711	Powhatan	Powhatan	VA	37 31 31	-078 00 20	73	29	mixed deciduous woodland/scrub/field	03-
16665	New Breckinridge Rd.	Prince William	VA	38 33 10	-077 24 40	76	29	deciduous forest	95-
15533	Pinnacle Cliff	Rappahannock	VA	38 37 40	-078 19 30	1036	28	northern red oak forest	92-03
15541	Big Run	Rockingham	VA	38 15 09	-078 41 36	762	28	chestnut oak forest	93-03
15548	Dean Mountain	Rockingham	VA	38 24 26	-078 29 46	945	28	cove hardwood forest	93-03
16664	Ammunition Storage	Stafford	VA	38 31 40	-077 23 40	76	29	deciduous forest	95-
16666	Hotpatch Road	Stafford	VA	38 32 10	-077 24 20	76	29	deciduous forest	95-96
16676	MCBQ-LOGC	Stafford	VA	38 30 40	-077 23 30	76	29	deciduous forest	97-
16601	Dismal Swamp 2	Suffolk	VA	36 43 00	-076 31 40	6	27	red maple/black gum	90-00, 02-
15639	Rapidan WMA	Madison	VA	38 25 13	-078 24 21	488	28	mesic harwood forest/riparian cor	01-02
16651	Pendleton	Virginia Beach	VA	36 48 19	-075 58 44	3	27	mixed forest	95-02
16652	Owls Creek	Virginia Beach	VA	36 49 20	-075 59 28	3	27	mixed forest	95-02
16654	Oceana Pond	Virginia Beach	VA	36 48 42	-076 00 04	6	27	mixed forest	95-02

Table 1. (continued)

Station	Station Name	County	State	Latitude	Longitude	Elev. (m)	BCR	Primary Habitat	Operation
16714	Natural Bridge	Powell	KY	37 46 37	-083 41 45	245	24	hemlock-mixed mesophytic forest	03-
16687	Pilot Knob	Powell	KY	37 54 50	-083 56 10	259	28	deciduous forest	98
16692	Sage Point	Powell	KY	37 54 19	-083 54 26	274	28	oak-hickory forest w/ utility row	99-01
15624	Adventure	Montgomery	MD	39 02 49	-077 13 12	91	29	grassland/deciduous woodland	00
16603	Jug Bay Sanctuary	Anne Arundel	MD	38 46 30	-076 41 40	30	30	mixed deciduous forest	-90
15531	Harford Glen	Harford	MD	39 29 20	-076 20 40	46	29	riparian woodland	92-00
15592	St. Timothy's School	Baltimore	MD	39 24 30	-076 41 50	130	29	mature forest/old field	90-96
16609	Patuxent	Prince Georges	MD	39 01 50	-076 47 00	12	30	swampy decid. forest/pines/scrub	92-98
16610	Patuxent Lowland	St. Mary's	MD	38 16 10	-076 26 10	30	30	mixed deciduous forest	92-
16611	Patuxent Upland 1	St. Mary's	MD	38 15 10	-076 25 20	21	30	mixed deciduous forest	92-
16612	Patuxent Upland 2	St. Mary's	MD	38 15 10	-076 25 20	30	30	mixed deciduous forest	92-
16614	Indian Head	Charles	MD	38 34 30	-077 11 50	6	30	mixed deciduous forest	92-03
16619	Stump Neck	Charles	MD	38 33 10	-077 11 50	9	30	upland deciduous forest/riparian	93-03
15644	Purchase Knob	Haywood	NC	35 35 05	-083 04 01	1451	28	northern hardwood/fraser fir tree farm	02-
16689	Cowan's Ford Wild. Ref.	Mecklenburg	NC	35 22 30	-080 58 10	221	29	mixed woodland/grassland	99-
16704	N. C Wesleyan Col.	Nash	NC	36 01 00	-077 46 50	28	27	oldfield/mixed woodland/suburbia	01
15559	Bass Lake	Watauga	NC	36 08 40	-081 41 20	1100	28	mixed hardwoods	96-01
16602	Scott King-Jordan	Durham	NC	35 52 30	-078 55 00	76	29	secondary successional forest	90-99
16638	Nags Head Woods	Dare	NC	35 59 10	-075 39 40	12	27	deciduous maritime forest/ponds	94-98
16653	Boardwalk	Currituck	NC	36 32 09	-076 15 55	5	27	swampy mixed forest	95-02
16674	Rochoc	Chowan	NC	36 12 10	-076 42 30	3	27	bottomland deciduous forest	96-03
16700	Reedy Marsh Trail	Johnston	NC	35 23 55	-078 17 24	29	27	bottomland hardwood forest	00
16667	Bear Swamp	Cumberland	NJ	39 17 40	-075 05 20	6	30	mixed deciduous forested wetland	94-
16668	Railroad	Cumberland	NJ	39 18 40	-075 05 30	15	30	mixed deciduous scrub	94
16693	Woodcock Lane	Cape May	NJ	39 05 37	-074 53 19	3	30	deciduous woodland/dec. shrubland	99-01
15514	Cumberland Valley	Bedford	PA	39 51 30	-078 36 30	760	28	deciduous forest	90-95
15564	Raystown	Huntingdon	PA	40 21 00	-078 09 00	340	28	oak-hickory forest/oldfield	95
15596	UT Arb & For Exp Sta1	Anderson	TN	36 00 10	-084 13 00	305	28	oak/hickory/pine forest/old field	1998-
15597	UT Arb & For Exp Sta2	Anderson	TN	35 59 50	-084 12 10	274	28	oak/hickory forest & shrubland	-98
15620	Great Smoky Mtns.	Blount	TN	35 38 23	-083 41 22	430	28	hardwood riparian forest	00
15562	Clinch River	Anderson	TN	36 02 40	-084 11 30	914	28	deciduous forest	92-96
15591	Holston Valley	Sullivan	TN	36 34 00	-082 07 00	520	28	decid. for./pine plant./scrub	97-01

Table 1 (continued)

Station	Station Name	County	State	Latitude	Longitude	Elev. (m)	BCR	Primary Habitat	Operation
15583	Fairmont Mall	Marion	WV	39 25 50	-080 10 50	340	28	deciduous forest/old field	97-98
15616	Beall Tract	Tucker	WV	39 04 21	-079 24 48	985	28	maple-beech-cherry forest	99
15627	S. Fork Potomac River	Pendleton	WV	38 34 44	-079 16 13	536	28	riparian corridor/mixed conif. forest	01-
15628	Beaver Creek	Pendleton	WV	38 30 40	-079 16 26	658	28	mixed coniferous-deciduous forest	01-
16682	Ivy Knob	Raleigh	WV	37 47 10	-081 29 50	1077	28	second-growth forest	96

Table 2. Table of the percentages of primary, secondary, and tertiary habitats associated with one-kilometer radii surrounding each of 34 MAPS Stations in Virginia. These were derived from classifications of the 30 meter resolution Virginia GAP dataset (http://gapanalysis.nbii.gov/). The Virginia GAP coverage was derived from Landsat TM imagery (1986-1994) and further classified with ancillary information (topography and relative phonological indices).

Table 2: Dominant Virginia GAP habitats within 1km of MAPS Stations

MAPS Station	***Primary Habitat***	***%***	***Secondary Habitat***	***%***	***Tertiary Habitat***	***%***
15532	Dry Montane Deciduous Forest	67	Mesic Montane Deciduous Forest	17	Montane Oak Dominated	10
15533	Dry Montane Deciduous Forest	58	Mesic Montane Deciduous Forest	17	Montane Yellow Pine	10
15534	Dry Montane Deciduous Forest	64	Mesic Montane Deciduous Forest	16	Montane Oak Dominated	9
15535	Dry Montane Deciduous Forest	48	Mesic Montane Deciduous Forest	19	Montane Dry Oak Dominated	14
15536	Dry Montane Deciduous Forest	33	Montane Dry Oak Dominated	25	Mesic Montane Deciduous Forest	21
15537	Dry Montane Deciduous Forest	60	Mesic Montane Deciduous Forest	19	Montane Dry Oak Dominated	15
15541	Dry Montane Deciduous Forest	69	Montane Oak Dominated	19	Mesic Montane Deciduous Forest	6
15548	Dry Montane Deciduous Forest	34	Montane Dry Oak Dominated	28	Mesic Montane Deciduous Forest	20
15549	Dry Montane Deciduous Forest	59	Mesic Montane Deciduous Forest	15	Mixed Central Hardwood Forest	12
15550	Dry Montane Deciduous Forest	33	Montane Dry Oak Dominated	25	Mesic Montane Deciduous Forest	21
15554	Montane Oak Dominated	25	Dry Montane Deciduous Forest	23	Mesic Montane Deciduous Forest	19
15639	Dry Montane Deciduous Forest	42	Mesic Montane Deciduous Forest	29	Montane Oak Dominated	22
15642	Fields	35	Mixed Herbaceous	29	Sparse Herbaceous/Row Crop	14
15643	Mixed Herbaceous	42	Montane Oak Dominated	20	Fields	20
16601	Tupelo-Red Maple Wet Forest	85	Forested Wetland	15	Virginia Deciduous Forest Complex	< 1
16613	Piedmont/Coastal Plain Forest Complex	26	Submontane Yellow Pine	14	Forested Wetland	10
16644	Piedmont/Coastal Plain Forest Complex	39	Virginia Deciduous Forest Complex	27	Submontane Yellow Pine	16
16645	Piedmont/Coastal Plain Forest Complex	37	High Density Disturbed	22	Virginia Deciduous Forest Complex	17
16646	Other (probably water)	46	Virginia Deciduous Forest Complex	22	Piedmont/Coastal Plain Forest Complex	14
16647	Virginia Deciduous Forest Complex	41	Piedmont/Coastal Plain Forest Complex	25	Other	21
16648	Montane Yellow Pine	30	Virginia Deciduous Forest Complex	26	General Non-vegetated	8
16649	Virginia Deciduous Forest Complex	35	Montane Yellow Pine	32	Piedmont/Coastal Plain Forest Complex	7
16650	Sparse Herbaceous/Row Crop	60	Tupelo-Red Maple Wet Forest	17	Virginia Deciduous Forest Complex	8
16651	Forested Wetland	43	Mixed Herbaceous	13	Unknown/Mixed pixel	12
16652	Piedmont/Coastal Plain Forest Complex	23	Submontane Yellow Pine	19	Unknown/Mixed pixel	9
16654	Forested Wetland	19	Sparse Herbaceous/Row Crop	16	High Density Disturbed	12
16655	Tupelo-Red Maple Wet Forest	25	Virginia Deciduous Forest Complex	25	Forested Wetland	16

Table 2. (continued)

MAPS Station	***Primary Habitat***	***%***	***Secondary Habitat***	***%***	***Tertiary Habitat***	***%***
16664	Virginia Deciduous Forest Complex	43	Piedmont/Coastal Plain Forest Complex	37	Submontane Yellow Pine	8
16665	Piedmont/Coastal Plain Forest Complex	48	Virginia Deciduous Forest Complex	39	Submontane Yellow Pine	13
16666	Virginia Deciduous Forest Complex	53	Piedmont/Coastal Plain Forest Complex	32	Submontane Yellow Pine	10
16676	Piedmont/Coastal Plain Forest Complex	39	Virginia Deciduous Forest Complex	29	Submontane Yellow Pine	23
16686	Virginia Deciduous Forest Complex	28	Submontane Yellow Pine	16	Open Water	13
16711	Virginia Deciduous Forest Complex	37	Sparse Herbaceous/Row Crop	13	Piedmont/Coastal Plain Forest Complex	11
16721	Pasture/Low Vegetation	44	Virginia Deciduous Forest Complex	34	Mixed Herbaceous	9

Table 3. List of species breeding in Virginia which includes landbird species recorded by the Breeding Bird Survey (BBS) for the period 1980-2005 (including trend, P-value of trend, the number of BBS routes upon which the species was observed (N)). This list also includes species of concern from national or state listings that may not be well monitored by BBS, including priority species of three PIF plans based on BBS physiographic provinces. Species that are listed as priority species in one or more provinces, or listed as Virginia Species of Greatest Conservation Need in the Virginia Wildlife Action Plan (VA_SGCN) are, for the purposes of this document, designated as Virginia Landbird Species of Concern (VASC) and marked with an "X", and appear bold if the corresponding BBS trend is significantly negative ($P<0.10$), or bold and italicized if no BBS trend data is available. Of the remaining species, those with significantly declining BBS trends and no other listing are marked with a "B". For PIF priority species, the table includes associated critical habitats for each of the PIF physiographic provinces in which the species is found. The Mid-Atlantic Coastal Plain (PIF_PA#44) features five critical habitats, pine savannah (PS), salt marsh (SM), forested wetlands (FW), mixed upland forests (MUF), and early successional habitat (ES). The Mid-Atlantic Piedmont (PIF_PA #10) features three critical habitat types, deciduous and mixed forests (DMF), shrub-scrub barrens (SSB), and agricultural grasslands (AGR). The Mid-Atlantic Ridge and Valley (PIF_PA #12) features four critical habitat types, early-succession scrub (ESS), mature deciduous forest (MDF), grasslands (GR), and northern hardwood/spruce-fir forests (NHF).

Table 3 (cont.)

Species	VASoC	SGCN Tier	Sig.	Virginia BBS 1992-2005 *Trend*	*P*	*N*	PIF_PA#44	PIF_PA #10	PIF_PA #12	MAPS-VA AHY/Station *Trend*	*P*
Rock Dove			--	-5.60	0.09	39					
Mourning Dove	B		-	-0.66	0.20	49					
Black-billed Cuckoo			-	-38.66	0.25	4					
Yellow-billed Cuckoo	X	IV	+	1.62	0.40	49					
Great Horned Owl	B		--	-13.83	0.04	6					
Barred Owl			+	0.24	0.97	10					
Chuck-will's-widow	X	IV	--	-4.87	0.05	9					
Whip-poor-will	X	IV	-	-12.90	0.25	20		SSB	ESS		
Chimney Swift	X	IV	--	-2.74	0.00	48					
Ruby-thr. Hummingbird			++	3.77	0.04	41					
Belted Kingfisher			-	-3.24	0.20	27					
Yell.-bellied Sapsucker	X	I									
Red-headed Woodpecker			-	-8.65	0.42	15					
Red-bellied Woodpecker			++	2.11	0.02	49					
Red-cockaded Woodpecker	X	I					PS				
Downy Woodpecker	B		--	-2.96	0.06	49					
Hairy Woodpecker			-	-2.41	0.52	29					
Northern Flicker	B		--	-3.41	0.08	48					
Pileated Woodpecker			--	-3.37	0.08	48					
Eastern Wood-Pewee	X	IV	-	-0.16	0.90	47				2.24	0.32
Acadian Flycatcher	X		--	-3.41	0.00	48	FW			1.66	0.21
Willow Flycatcher	X	IV	-	-0.74	0.44	44					
Eastern Phoebe			--	-2.94	0.00	48					
Great Crested Flycatcher			++	2.77	0.02	49					
Eastern Kingbird	X	IV	-	-0.07	0.95	48					
Loggerhead Shrike	X	I	--	-17.80	0.10	6					
White-eyed Vireo			+	1.86	0.19	40				2.87	0.16
Yellow-throated Vireo	X	IV	+	2.65	0.12	40					
Blue-headed Vireo			+	2.83	0.56	13					
Warbling Vireo			+	8.13	0.11	11					

Table 3 (cont.)

Species	VASoC	SGCN Tier	Sig.	Virginia BBS 1992-2005 *Trend*	*P*	*N*	PIF_PA#44	PIF_PA #10	PIF_PA #12	MAPS-VA AHY/Station *Trend*	*P*
Red-eyed Vireo			++	1.04	0.07	49				-1.71	**0.10**
Blue Jay			-	-1.44	0.17	49					
American Crow			--	-1.15	0.06	49					
Fish Crow			-	-1.45	0.61	24					
Common Raven			+	6.54	0.49	7					
Horned Lark			+	11.05	0.21	10					
Purple Martin			--	-4.60	0.08	23					
Tree Swallow			++	9.78	0.09	22					
N. Rough-winged Swallow			--	-5.03	0.05	33					
Cliff Swallow			+	7.93	0.22	6					
Barn Swallow	B		+	0.49	0.64	49					
Carolina Chickadee	B		--	-2.31	0.02	49					
Black-capped Chickadee			-	-4.30	0.78	5					
Tufted Titmouse			++	1.21	0.02	49				**-1.74**	**0.06**
White-breasted Nuthatch			+	2.97	0.12	46					
Brown-headed Nuthatch	X	IV	++	25.29	0.05	7					
Brown Creeper	X	IV									
Carolina Wren			-	-0.19	0.85	49				**4.40**	**0.03**
House Wren			--	-3.98	0.01	33					
Bewick's Wren	X	I							ESS		
Sedge Wren	X	III									
Marsh Wren	X	IV									
Winter Wren	X	II									
Blue-gray Gnatcatcher			-	-0.96	0.47	48					
Eastern Bluebird			+	0.06	0.95	49					
Veery										-1.41	0.67
Wood Thrush	X	IV	--	-2.03	0.01	49	MUF	DMF	MDF	0.35	0.81
Bicknell's Thrush (migrant)	X	IV									
American Robin			--	-1.43	0.02	49					
Gray Catbird	X	IV	--	-2.76	0.03	47				**-11.53**	**0.00**
Northern Mockingbird			++	1.16	0.08	48					

Table 3 (cont.)

Species	**VASoC**	**SGCN Tier**	**Sig.**	**Virginia BBS 1992-2005 Trend**	**P**	**N**	**PIF_PA#44**	**PIF_PA #10**	**PIF_PA #12**	**MAPS-VA AHY/Station Trend**	**P**
Brown Thrasher	X	IV	-	-1.14	0.22	47					
European Starling			-	-0.76	0.63	49					
Cedar Waxwing			--	-3.63	0.07	41					
Blue-winged Warbler			--	-5.11	0.03	4					
Northern Parula	X	IV	+	0.77	0.63	35					
Yellow Warbler	X	IV	--	-9.34	0.00	24					
Canada Warbler	X	IV									
Kirtland's Warbler (migrant)	X	IV									
Chestnut-sided Warbler			-	-4.10	0.88	4					
Black-thr. Blue Warbler	X								NHF		
Black-th. Green Warbler	X	I	--	-8.48	0.09	5					
Blackburnian Warbler	X		--	-7.35	0.05	2			NHF		
Yellow-throated Warbler			++	9.79	0.08	13					
Pine Warbler			--	-2.27	0.09	39					
Prairie Warbler	X	IV	--	-3.21	0.00	42	PS	SSB	ESS		
Cerulean Warbler	X	II	-	-1.29	0.42	4	FW	DMF	MDF		
Black-and-white Warbler	X	IV	--	-0.99	0.74	20				**6.38**	**0.00**
American Redstart			+	2.84	0.66	14				0.35	0.89
Prothonotary Warbler	X	IV	++	5.27	0.00	12	FW			-1.02	0.80
Worm-eating Warbler	X	IV	+	0.83	0.74	21	MUF		MDF	**4.59**	**0.01**
Swainson's Warbler	X	II									
Golden-winged Warbler	X	I							ESS		
Ovenbird	X	IV	++	1.51	0.06	48				**3.29**	**0.06**
Louisiana Waterthrush	X	IV	+	1.24	0.67	27		DMF	MDF	**7.03**	**0.00**
Kentucky Warbler	X	IV	--	-5.49	0.03	27	MUF	DMF		2.13	0.30
Common Yellowthroat			++	1.46	0.10	47				**-3.62**	**0.05**
Hooded Warbler			++	4.00	0.01	35				**4.03**	**0.04**
Yellow-breasted Chat	X	IV	-	-0.53	0.68	47					
Summer Tanager			-	-1.00	0.53	25					
Scarlet Tanager	X	IV	+	0.46	0.70	46				2.24	0.17
Eastern Towhee	X	IV	++	1.42	0.09	49				**2.78**	**0.01**

Table 3 (cont.)

Species	VASoC	SGCN Tier	Sig.	Virginia BBS 1992-2005 Trend	P	N	PIF_PA#44	PIF_PA #10	PIF_PA #12	MAPS-VA AHY/Station Trend	P
Henslow's sparrow	X	I					ES	AGR	GR		
Bachman's Sparrow	X	I					PS				
Sharp-tailed Sparrow	X	II					SM				
Seaside Sparrow	X	IV					SM				
Chipping Sparrow			-	-0.82	0.16	49					
Field Sparrow	X	IV	--	-5.21	0.00	49		SSB			
Vesper Sparrow			+	38.81	0.60	2					
Savannah Sparrow			+	46.17	0.38	3					
Grasshopper Sparrow	X	IV	--	-5.60	0.00	37		AGR			
Song Sparrow	B		+	0.98	0.44	41					
Dark-eyed Junco			-	-3.27	0.71	3				3.18	0.29
Northern Cardinal			++	1.22	0.01	49				1.78	0.20
Rose-breasted Grosbeak	X	IV	--	-12.51	0.06	7					
Blue Grosbeak	B		-	-1.46	0.18	44					
Indigo Bunting	B		--	-1.65	0.01	49				4.20	0.63
Red-winged Blackbird	B		+	0.14	0.96	49					
Rusty Blackbird (winter)	X	IV									
Eastern Meadowlark	X	IV	--	-3.59	0.00	49					
Common Grackle	B		-	-3.46	0.13	49					
Boat-tailed Grackle			+	2.50	0.75	3					
Brown-headed Cowbird	B		--	-3.48	0.01	49					
Orchard Oriole			++	3.00	0.03	43					
Baltimore Oriole			+	3.09	0.16	29					
House Finch			+	-3.28	0.12	44					
American Goldfinch			++	1.73	0.08	48					
Red Crossbill	X	IV									
House Sparrow	B		--	-5.04	0.00	45					

Table 4. List of Virginia Species of Greatest Conservation Need (SGCN) listed landbirds that can be effectively monitored by the MAPS demographic monitoring protocol. Species are listed in taxonomic order. The SGCN tier is indicated and an “X” denotes that the species is an SGCN for each of six physiographic provinces of Virginia as listed in the Virginia Comprehensive Wildlife Conservation Strategy. The six provinces are abbreviated to MACP (Mid-Atlantic Coastal Plain), SAP (Southern Appalachian Piedmont), BRM (Blue Ridge Mountains), NRAV (Northern Ridge and Valley), NCM (Northern Cumberland Mountains), and SCM (Southern Cumberland Mountains).

Table 4 (cont.). SGCN species that can be effectively monitored by MAPS.

Virginia SGCN Species	SGCN	MACP	SAP	BRM	NRAV	NCM	SCM
Yellow-billed Cuckoo	IV	X	X	X	X	X	X
Yell.-bellied Sapsucker	I			X	X	X	X
Eastern Wood-Pewee	IV	X	X	X	X	X	X
Willow Flycatcher	IV	X	X	X	X	X	X
Yellow-throated Vireo	IV	X	X	X	X	X	X
(Appalachian) Bewick's Wren	I				X	X	
(Appalachian) Winter Wren	II			X	X		
Wood Thrush	IV	X	X	X	X	X	X
Gray Catbird	IV	X	X	X	X	X	X
Brown Thrasher	IV	X	X	X	X	X	X
Northern Parula	IV	X	X	X	X	X	X
Yellow Warbler	IV	X	X	X	X	X	X
Canada Warbler	IV	X	X	X	X	X	
Wayne's Black-thr. Green Warbler	I	X					
Prairie Warbler	IV	X	X	X	X	X	X
Black-and-white Warbler	IV	X	X	X	X	X	X
Prothonotary Warbler	IV	X	X	X	X	X	X
Worm-eating Warbler	IV	X	X	X	X	X	X
Swainson's Warbler	II	X	X		X	X	
Golden-winged Warbler	I			X	X		
Ovenbird	IV	X	X	X	X	X	X
Louisiana Waterthrush	IV	X	X	X	X	X	X
Kentucky Warbler	IV	X	X	X	X	X	X
Yellow-breasted Chat	IV	X	X	X	X	X	X
Scarlet Tanager	IV	X	X	X	X	X	X
Eastern Towhee	IV	X	X	X	X	X	X
Field Sparrow	IV	X	X	X	X	X	X
Rose-breasted Grosbeak	IV		X	X	X	X	X
Eastern Meadowlark	IV	X	X	X	X	X	X

Table 5. Apparent annual adult survival probability, adult recapture probability, and resident proportion estimates (Est.) with according standard errors (SE) and coefficients of variation (CV). The numbers of stations (Num sta.), numbers of individuals (Num. ind.), and number of recaptures (Num. rec.) are also shown. Estimates are reported for 41 species of which 23 have low coefficients of variation for the estimates. Species names in bold represent Virginia Species of Concern (VSoc).

Table 5. Summary of apparent survival rate analyses

Species	Num. sta.	Num. ind.	Num. cap.	Num rec.	Survival Probability Est.	SE	CV	Recapture Probability Est.	SE	CV	Resident Proportion Est.	SE	CV
Low variation on estimates (<30%)													
Eastern Wood-Pewee	32	168	262	23	0.489	0.082	16.8	0.398	0.109	27.4	0.548	0.193	35.2
Acadian Flycatcher	41	1178	2132	155	0.486	0.029	6.0	0.502	0.043	8.5	0.408	0.049	12.1
White-eyed Vireo	29	404	914	60	0.462	0.046	9.9	0.428	0.066	15.4	0.599	0.117	19.5
Red-eyed Vireo	44	2087	3385	287	0.604	0.021	3.5	0.225	0.020	8.9	0.622	0.062	9.9
Tufted Titmouse	46	753	1410	121	0.542	0.028	5.2	0.432	0.037	8.6	0.737	0.082	11.2
Carolina Wren	47	892	1713	101	0.292	0.028	9.5	0.615	0.060	9.8	1.000	0.137	13.7
Veery	22	741	1487	191	0.593	0.022	3.8	0.547	0.031	5.6	0.555	0.051	9.2
Wood Thrush	46	2021	3872	217	0.426	0.023	5.5	0.470	0.037	7.9	0.413	0.044	10.5
Gray Catbird	40	802	1111	66	0.475	0.040	8.4	0.317	0.052	16.3	0.449	0.086	19.2
Black-and-white Warbler	35	298	449	30	0.568	0.067	11.8	0.257	0.068	26.4	0.593	0.177	29.8
American Redstart	28	1212	1721	150	0.591	0.028	4.8	0.248	0.028	11.3	0.543	0.070	12.9
Prothonotary Warbler	20	349	499	35	0.498	0.062	12.5	0.275	0.070	25.6	0.575	0.167	29.1
Worm-eating Warbler	36	507	868	57	0.621	0.047	7.6	0.407	0.056	13.8	0.296	0.055	18.7
Ovenbird	45	2006	3634	303	0.545	0.019	3.5	0.444	0.026	5.8	0.481	0.038	7.9
Louisiana Waterthrush	33	195	394	30	0.508	0.064	12.6	0.638	0.089	13.9	0.458	0.109	23.7
Kentucky Warbler	29	239	503	38	0.552	0.052	9.4	0.532	0.074	14.0	0.354	0.081	22.8
Common Yellowthroat	34	514	795	27	0.332	0.065	19.6	0.293	0.097	33.1	0.502	0.177	35.2
Hooded Warbler	37	842	1769	114	0.492	0.030	6.1	0.603	0.046	7.7	0.343	0.046	13.3
Scarlet Tanager	32	301	419	21	0.674	0.081	12.0	0.857	0.043	5.0	0.635	0.325	51.2
Eastern Towhee	31	423	664	62	0.517	0.047	9.0	0.345	0.057	16.5	0.639	0.127	19.8
Dark-eyed Junco	7	228	363	24	0.363	0.058	15.9	0.455	0.100	21.9	1.000	0.270	27.0
Northern Cardinal	43	1241	2329	188	0.520	0.026	5.0	0.379	0.034	8.9	0.625	0.068	11.0
Indigo Bunting	36	599	1038	76	0.447	0.042	9.4	0.480	0.064	13.4	0.468	0.084	17.9
Highly variable estimates (insufficient data)													
Red-bellied Woodpecker	29	96	128	8	0.282	0.136	48.4	0.284	0.239	84.2	1.000	0.937	93.7
Downy Woodpecker	44	309	421	14	0.450	0.095	21.1	0.265	0.111	41.8	0.385	0.182	47.2
Hairy Woodpecker	39	126	178	11	0.779	0.102	13.1	0.576	0.044	7.7	1.000	0.782	78.2
Great Crested Flycatcher	29	134	156	9	0.646	0.131	20.3	0.159	0.105	66.2	0.330	0.235	71.2
Blue Jay	39	244	312	19	0.536	0.089	16.6	0.199	0.091	45.7	0.534	0.267	49.9
Carolina Chickadee	46	412	583	20	0.558	0.072	12.9	0.216	0.069	31.8	0.380	0.133	34.9
Swainson's Thrush	33	194	237	0	0.148	0.000	0.0	0.285	0.005	1.7	0.126	0.000	0.2
American Robin	29	380	426	8	0.151	0.105	69.6	0.314	0.310	98.9	0.479	0.496	103.4
Brown Thrasher	31	127	195	12	0.734	0.108	14.7	0.102	0.061	59.4	0.574	0.340	59.2
Northern Parula	17	111	163	5	0.476	0.000	0.0	1.000	0.000	0.0	1.000	0.000	0.0
Prairie Warbler	8	114	184	8	0.206	0.111	53.9	0.522	0.309	59.2	0.701	0.522	74.5
Canada Warbler	22	170	205	5	0.200	0.165	82.3	0.125	0.251	200.9	1.000	0.000	0.0
Yellow-breasted Chat	16	224	437	16	0.405	0.089	22.0	0.275	0.108	39.3	0.528	0.219	41.5
Summer Tanager	19	100	145	5	0.400	0.195	48.8	0.165	0.174	105.5	0.541	0.579	106.9
Common Grackle	26	524	561	10	0.178	0.109	61.2	0.109	0.206	189.4	1.000	0.000	0.0
Brown-headed Cowbird	34	102	142	6	0.314	0.158	50.4	0.506	0.310	61.2	0.248	0.200	80.4
House Finch	5	95	103	1	0.220	0.000	0.0	1.000	0.000	0.0	1.000	0.000	0.0
American Goldfinch	29	272	345	6	0.247	0.052	20.9	1.000	0.000	0.0	1.000	0.000	0.0

Table 6. Species-specific apparent survival rate estimates (and CV) from the Virginia region MAPS dataset compared with estimates (and SE) from four NABCI Bird Conservation Regions (BCR): Southeastern Coastal Plain (27); Appalachian Mountains (28); Piedmont (29); and mid-Atlantic Coastal Plain (30). Estimates are for 23 species for which reliable survival rates could be calculated. Species in bold are focal species (see Table 3). Performance Measure 1 (PM1) is defined as a) low, if the Virginia estimate is lower than two or more BCR estimates, b) high, if the Virginia estimate exceeds two or more BCR estimates, or c) even, if there are as many higher estimates as there are low.

Table 6.

Species	PM1	Virginia		BCR#27		BCR#28		BCR#29		BCR#30	
		Phi	CV	Phi	CV	Phi	SE	Phi	SE	Phi	SE
Eastern Wood-Pewee	Low	0.489	16.8	0.784	0.163	0.505	0.111	0.679	0.154	0.477	0.133
Acadian Flycatcher	Low	0.486	6.0	0.547	0.045	0.479	0.128	0.521	0.086	0.517	0.029
White-eyed Vireo	High	0.462	9.9	0.414	0.054	0.455	0.060	0.449	0.068	0.490	0.029
Red-eyed Vireo	High	0.604	3.5	0.604	0.064	0.538	0.049	0.546	0.087	0.560	0.036
Tufted Titmouse	High	0.542	5.2	0.279	0.051	0.483	0.085	0.490	0.085	0.357	0.069
Carolina Wren	Low	0.292	9.5	0.324	0.030	0.431	0.064	0.392	0.060	0.365	0.050
Veery	High	0.593	3.8	0.593	0.020			0.584	0.033		
Wood Thrush	Even	0.426	5.5	0.385	0.037	0.391	0.043	0.438	0.035	0.449	0.026
Gray Catbird	Low	0.475	8.4	0.521	0.131	0.499	0.025	0.581	0.021	0.391	0.037
Black-and-white Warbler	High	0.568	11.8	0.656	0.162	0.445	0.081	0.420	0.137		
American Redstart	Even	0.591	4.8			0.555	0.028			0.593	0.122
Prothonotary Warbler	High	0.498	12.5	0.467	0.073						
Worm-eating Warbler	High	0.621	7.6	0.393	0.323	0.470	0.071			0.450	0.067
Ovenbird	Even	0.545	3.5	0.519	0.033	0.576	0.029	0.546	0.052	0.472	0.044
Louisiana Waterthrush	High	0.508	12.6	0.698	0.187			0.419	0.319	0.483	0.055
Kentucky Warbler	High	0.552	9.4	0.519	0.108	0.549	0.116	0.676	0.207	0.521	0.019
Common Yellowthroat	Low	0.332	19.6	0.363	0.042	0.465	0.040	0.435	0.039	0.445	0.027
Hooded Warbler	High	0.492	6.1	0.508	0.045	0.456	0.039	0.352	0.133	0.472	0.077
Scarlet Tanager	Even	0.674	12.0			0.714	0.116			0.539	0.146
Eastern Towhee	High	0.517	9.0	0.334	0.072	0.510	0.047	0.432	0.114	0.430	0.105
Dark-eyed Junco	Low	0.363	15.9			0.386	0.070				
Northern Cardinal	Low	0.520	5.0	0.536	0.032	0.536	0.046	0.599	0.035	0.551	0.029
Indigo Bunting	Low	0.447	9.4	0.500	0.103	0.409	0.046	0.450	0.078	0.501	0.024

Table 7. Effective MAPS monitoring of 14 focal species of conservation concern in the Virginia region. Stations are identified by the station number (Station), State abbreviation, Bird Conservation Region (BCR), and years of operation (Operation). Species are marked with an 'X' if an average of four or more captures were recorded per year of operation. Stations shown in bold are still active, and the others are inactive. Stations are ranked from high to low (top to bottom) based on the number of focal species that they effectively monitor. Also shown are the total number of stations at which each species was effectively monitored and how many of those stations were non-operational at the time of writing this report (2007). Three sub-regions were defined to encapsulate three sets of long-running MAPS stations for comparative analysis; Shenandoah National Park (SH) including 6 stations; the southeast (SE) included 7 stations; and the northeast sub-region (NE) included 13 stations.

TABLES

Table 7.

Station	State	Sub-region	BCR	Operation	Eastern Wood-Pewee	Acadian Flycatcher	Veery	Wood Thrush	Gray Catbird	Black-&-white Warbler	Prothonotory Warbler	Worm-eating Warbler	Ovenbird	Louisiana Waterthrush	Kentucky Warbler	Scarlet Tanager	Eastern Towhee	Indigo Bunting	Species Total
15541	VA	SH	28	93-03				X		X		X	X			X	X	X	7
15550	VA	SH	28	93-03			X	X	X	X			X				X	X	7
15531	MD		29	92-00		X		X	X				X	X				X	6
15548	VA	SH	28	93-03			X	X				X	X				X	X	6
15549	VA	SH	28	93-03						X		X	X			X	X	X	6
16603	MD		30	90-		X		X			X		X	X		X			6
16667	NJ		30	94-		X		X		X		X	X		X				6
16692	KY		28	99-01				X				X	X		X	X		X	6
16711	VA		29	03-		X		X		X			X	X				X	6
16721	VA		29	03,05-	X	X		X	X							X		X	6
15537	VA	SH	28	92-03			X	X					X				X	X	5
16653	NC	SE	27	95-02		X		X		X	X		X						5
16714	KY		24	03-		X		X				X	X	X					5
15533	VA	SH	28	92-03			X		X				X				X		4
15596	TN		28	98-				X					X		X			X	4
16611	MD	NE	30	92-		X		X					X		X				4
16612	MD		30	92-		X		X					X		X				4
16619	MD	NE	30	93-03		X		X				X		X					4
16648	VA	NE	27	95-03		X		X		X			X						4
16676	VA	NE	29	97-				X	X	X			X						4
15597	TN		28	98-				X				X	X						3
15620	TN		28	00-03		X				X				X					3
15624	MD		29	00-03		X		X	X										3
16601	VA	SE	27	90-00, 02-							X	X	X						3
16609	MD		30	92-98				X	X				X						3
16610	MD	NE	30	92-		X		X							X				3
16613	VA	NE	30	92-02		X		X					X						3
16647	VA	NE	30	95-		X		X			X								3
16655	VA	SE	27	95-02		X		X					X						3
16664	VA		29	95-		X		X					X						3
16665	VA	NE	29	95-		X		X					X						3
16689	NC		29	99-				X									X	X	3
15514	PA		28	90-95					X				X						2
15592	MD		29	90-96		X			X										2
15639	VA		28	39084		X		X											2
16614	MD	NE	30	92-03		X		X											2
16644	VA	NE	30	95-02		X							X						2
16646	VA	NE	27	95-		X		X											2

Station	State	Sub-region	BCR	Operation	Eastern Wood-Pewee	Acadian Flycatcher	Veery	Wood Thrush	Gray Catbird	Black-&-white Warbler	Prothonotory Warbler	Worm-eating Warbler	Ovenbird	Louisiana Waterthrush	Kentucky Warbler	Scarlet Tanager	Eastern Towhee	Indigo Bunting	Species Total
16649	VA	NE	27	95-03		X							X						2
16650	VA	SE	27	95-02				X					X						2
16638	NC		27	94-98		X					X								2
15554	VA	SE	28	94-96					X									X	2
15628	WV		28	01-								X						X	2
16666	VA		29	95-96		X		X											2
16686	VA		29	98-02									X					X	2
16693	NJ		30	99-01					X									X	2
15559	NC		28	96-01					X										1
15591	TN		28	97-01								X							1
15627	WV		28	01-					X										1
15642	VA		28	02-					X										1
15643	VA		28	02-					X										1
15644	NC		28	02-					X										1
16645	VA	NE	30	95-02		X													1
16651	VA	SE	27	95-02									X						1
16652	VA	SE	27	95-02									X						1
16654	VA	SE	27	95-02				X											1
16674	NC		27	96-03				X											1
16704	NC		27	01				X											1
16602	NC		29	90-99				X											1
15583	WV		28	97-98									X						1
Total No. of Stations					1	28	4	37	16	9	5	11	33	6	6	5	7	15	183
No. of non-operational					0	16	4	21	10	6	2	6	21	3	1	3	6	10	109

Table 8. Effective MAPS monitoring of 14 focal species of conservation concern in the state of Virginia. Thirty stations within the state of Virginia are identified by the station number (Station), State abbreviation, Bird Conservation Region (BCR), and years of operation (Operation). These stations operated for more than one year or are expected to operate for at least four years. Species are marked with an 'X' if an average of four or more captures were recorded per year of operation. Stations shown in bold are still active and all other stations are inactive. Stations are ranked from high to low based on the number of SCC species that they effectively monitor. Also shown are the total number of stations at which each species was effectively monitored and how many of those stations were non-operational at the time of writing (Fall 2007). Four Virginia MAPS stations totaled zero SCC species and are not shown.

Table 8

Station	BCR	Operation	Eastern Wood-Pewee	Acadian Flycatcher	Veery	Wood Thrush	Gray Catbird	Black-&-white Warbler	Prothonotary Warbler	Worm-eating Warbler	Ovenbird	Louisiana Waterthrush	Kentucky Warbler	Scarlet Tanager	Eastern Towhee	Indigo Bunting	Species Total
15541	28	93-03				x		x		x	x			x	x	x	7
15550	28	93-03			x	x	x	x			x				x	x	7
15548	28	93-03			x	x				x	x				x	x	6
15549	28	93-03						x		x	x			x	x	x	6
16711	**29**	**03-**		**X**		**X**		**X**			**X**	**X**				**X**	**6**
16721	**29**	**03,05-**	**X**	**X**		**X**	**X**							**X**		**X**	**6**
15537	28	92-03			x	x					x				x	x	5
15533	28	92-03			x		x				x				x		4
16648	27	95-03		x		x		x			x						4
16676	**29**	**97-**				**X**	**X**	**X**			**X**						**4**
16601	**27**	**90-00, 02-**							**X**	**X**	**X**						**3**
16613	**30**	**92-02**		**X**		**X**					**X**						**3**
16647	**30**	**95-**		**X**		**X**			**X**								**3**
16655	27	95-02		x		x					x						3
16664	**29**	**95-**		**X**		**X**					**X**						**3**
16665	**29**	**95-**		**X**		**X**					**X**						**3**
15639	28	01-02		x		x											2
16644	30	95-02		x							x						2
16646	**27**	**95-**		**X**		**X**											**2**
16649	27	95-03		x							x						2
16650	27	95-02				x					x						2
15554	28	94-96					x									x	2
16666	29	95-96		x		x											2
16686	29	98-02									x					x	2
15642	**28**	**02-**					**X**										**1**
15643	**28**	**02-**					**X**										**1**
16645	30	95-02		x													1
16651	27	95-02									x						1
16652	27	95-02									x						1
16654	27	95-02				x											1
Operational Stations			1	7	0	8	4	2	2	1	6	1	0	1	0	2	35
No. of non-operational			0	7	4	10	3	4	0	3	14	0	0	2	6	7	60

Table 9. Annual survival rate (Phi) and coefficient of variation (CV) expressed as a percentage for 15 landbirds by three sub-regions. The mean annual proportion of juveniles in the catch is given as a productivity index (PI).

Table 9.

Species	Shenandoah			Southeast Sub-region			Northeast Sub-region		
	Phi	CV	PI	Phi	CV	PI	Phi	CV	PI
Acadian Flycatcher				0.444	18.2	0.09	0.484	8.1	0.09
Red-eyed Vireo							0.600	4.8	0.04
Carolina Wren				0.276	17.1	0.51	0.236	22.4	0.41
Veery	0.604	3.8	0.12						
American Redstart	0.594	4.8	0.44						
Wood Thrush	0.291	23.4	0.11	0.456	9.8	0.00	0.494	8.5	0.18
Gray Catbird	0.546	8.5	0.15						
Prothonotary Warbler				0.461	17.5	0.47			
Worm-eating Warbler	0.501	14.6	0.53				0.615	13.9	0.12
Ovenbird	0.546	6.0	0.35	0.500	7.6	0.41	0.571	6.2	0.24
Louisiana Waterthrush							0.529	13.5	0.35
Kentucky Warbler							0.572	11.0	0.20
Hooded Warbler	0.475	9.6	0.30				0.518	8.9	0.15
Eastern Towhee	0.492	10.3	0.27						
Northern Cardinal				0.502	17.1	0.00	0.464	17.1	0.22
No. of species	8			6			10		

Table 10. Mean body condition (BC) and standard error (SE) for three Neotropical migrants by region and gender. Linear regressions of body condition (weight/wing chord length) over time (1992-2003) revealed the annual rate of change (Rate) in body condition ($x10^3$).

Table 10.

Species	Sex	Shenandoah N	Shenandoah BC g/mm	Shenandoah SE	Shenandoah Rate x10^{-3}/yr	SE Sub-region N	SE Sub-region BC g/mm	SE Sub-region SE	SE Sub-region Rate x10^{-3}/yr	NE Sub-region N	NE Sub-region BC g/mm	NE Sub-region SE	NE Sub-region Rate x10^{-3}/yr
Acadian	M					18	0.181	0.004	-0.90	40	0.179	0.003	+0.55
Flycatcher	F	20	0.169	0.004	-0.47	46	0.183	0.003	-1.41	200	0.184	0.001	**-1.77**[3]
Wood	M		0.301	0.012	-0.99		0.256	0.011	+0.34		0.331	0.009	**-2.41**[4]
Thrush	F		0.485	0.006	-1.16		0.449	0.006	+0.86		0.476	0.004	**-2.17**[5]
Ovenbird	M	427	0.247	0.001	+0.36	288	0.251	0.001	**-0.78**[2]	420	0.248	0.001	-0.53
	F	231	0.261	0.002	-0.47	166	0.271	0.002	**-2.07**[1]	173	0.268	0.002	-0.63

[1] P<0.01
[2] P<0.10
[3] P<0.0005
[4] P<0.005
[5] P<0.05

Table 11. ANOVA of Mean wing chord length (WCL) measured in millimeters and standard error (SE) for three Neotropical migrants by region and gender.

Table 11.

					Shenandoah		SE Sub-region		NE Sub-region	
Species	F	df	P	Sex	WCL mm	SE	WCL mm	SE	WCL mm	SE
Acadian Flycatcher	3.81	144	<0.05	M			72.23	0.81	74.60	0.54
	2.49	670	<0.10	F	71.40	0.73	69.28	0.48	70.50	0.23
Wood Thrush	1.98	1935	<0.11	M	106.10	0.21	106.37	0.19	105.97	0.16
	0.29	985	<0.82	F	103.44	0.34	103.75	0.37	103.50	0.21
Ovenbird	8.88	1659	<0.0001	M	74.88	0.12	74.53	0.14	74.90	0.12
	0.60	861	<0.61	F	70.97	0.14	70.85	0.16	71.15	0.16

FIGURES 1 - 5

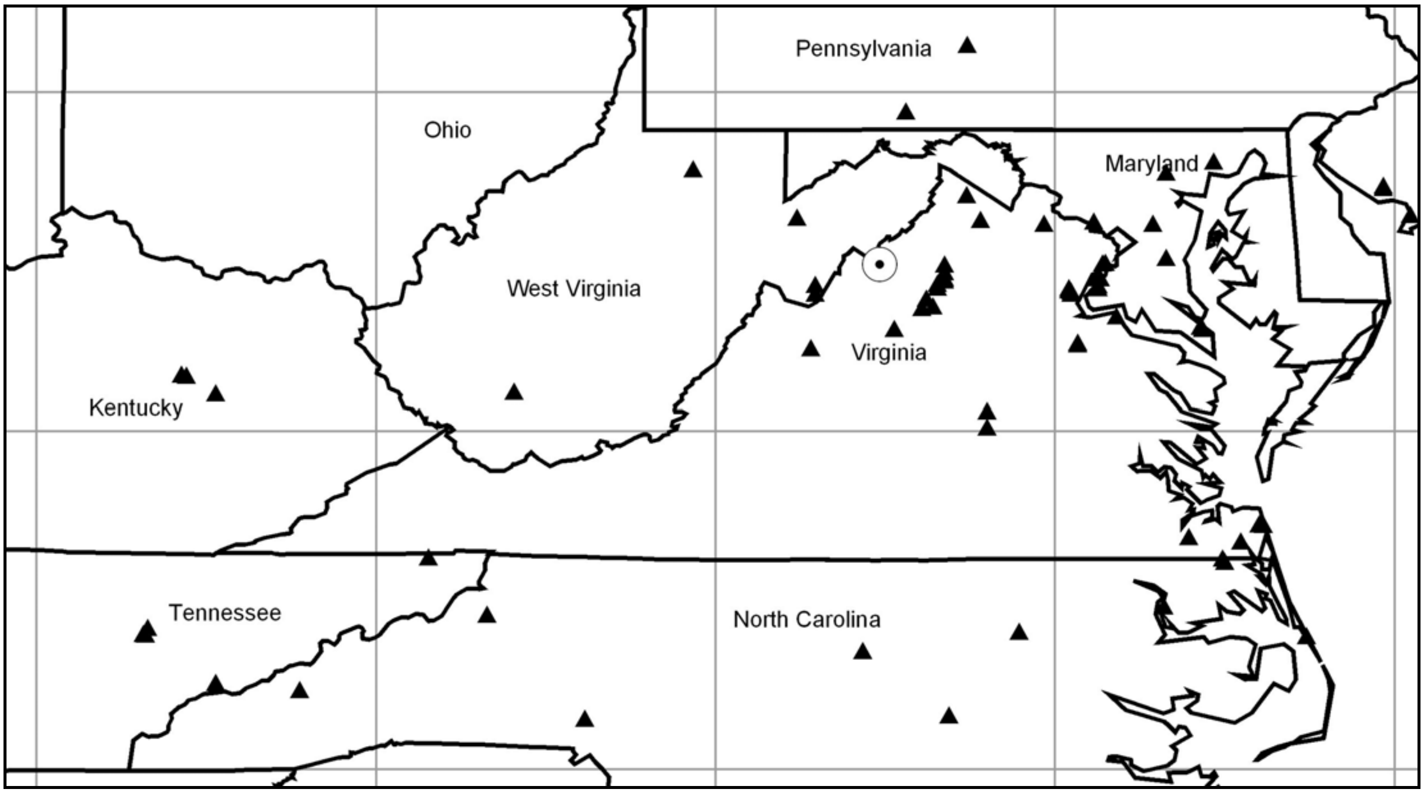


Figure 1. MAPS stations (black triangles) within Virginia and within 150km of the Virginia border. The light grey grid represents the 2.5 degree latitude-longitude resolution Global Precipitation Climatology Project grid. The bullseye located in north-central Virginia represents the center of the grid cell used in weather analyses.

FIGURES

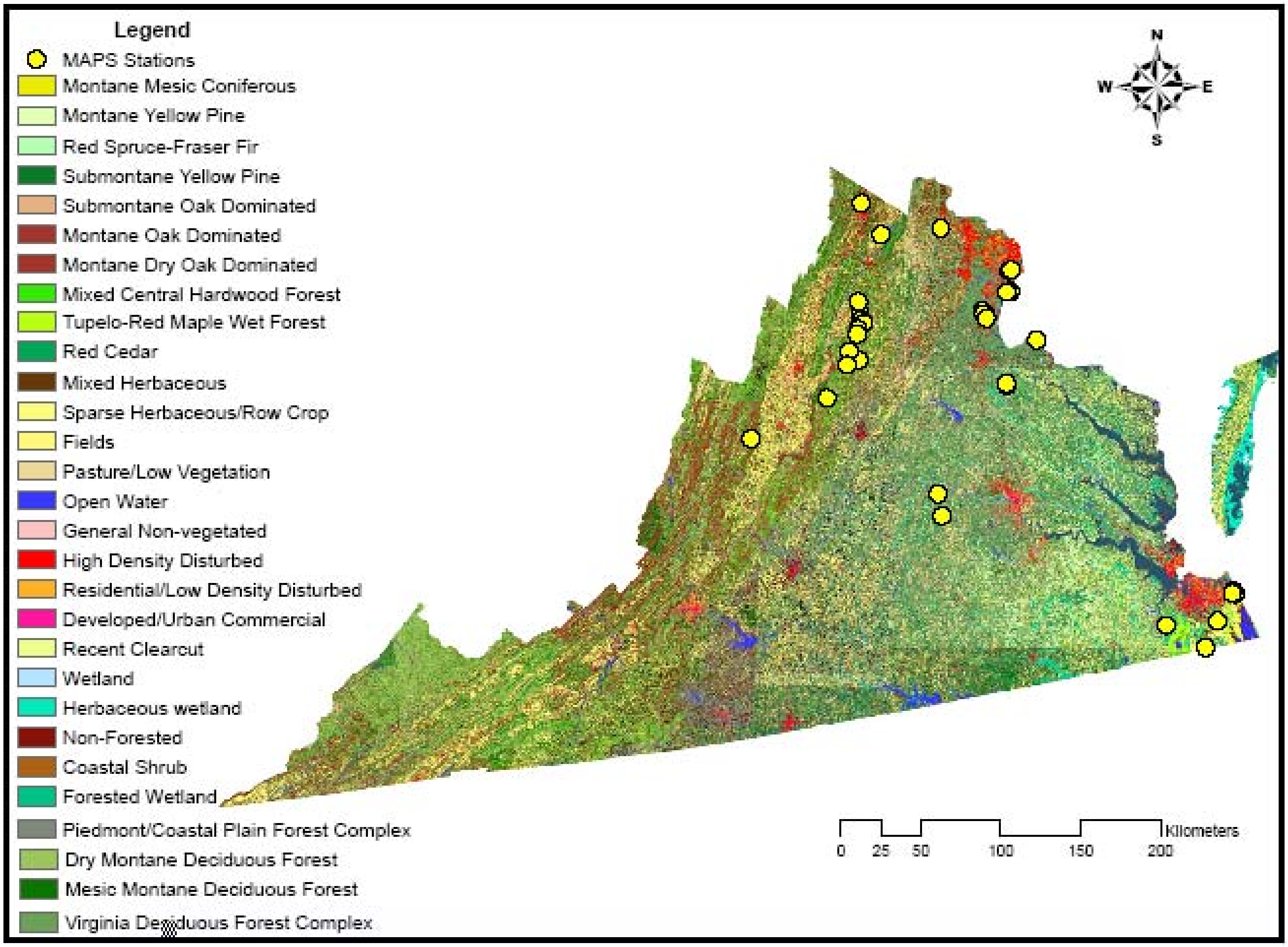


Figure 2. MAPS stations superimposed upon Virginia GAP coverage

FIGURES

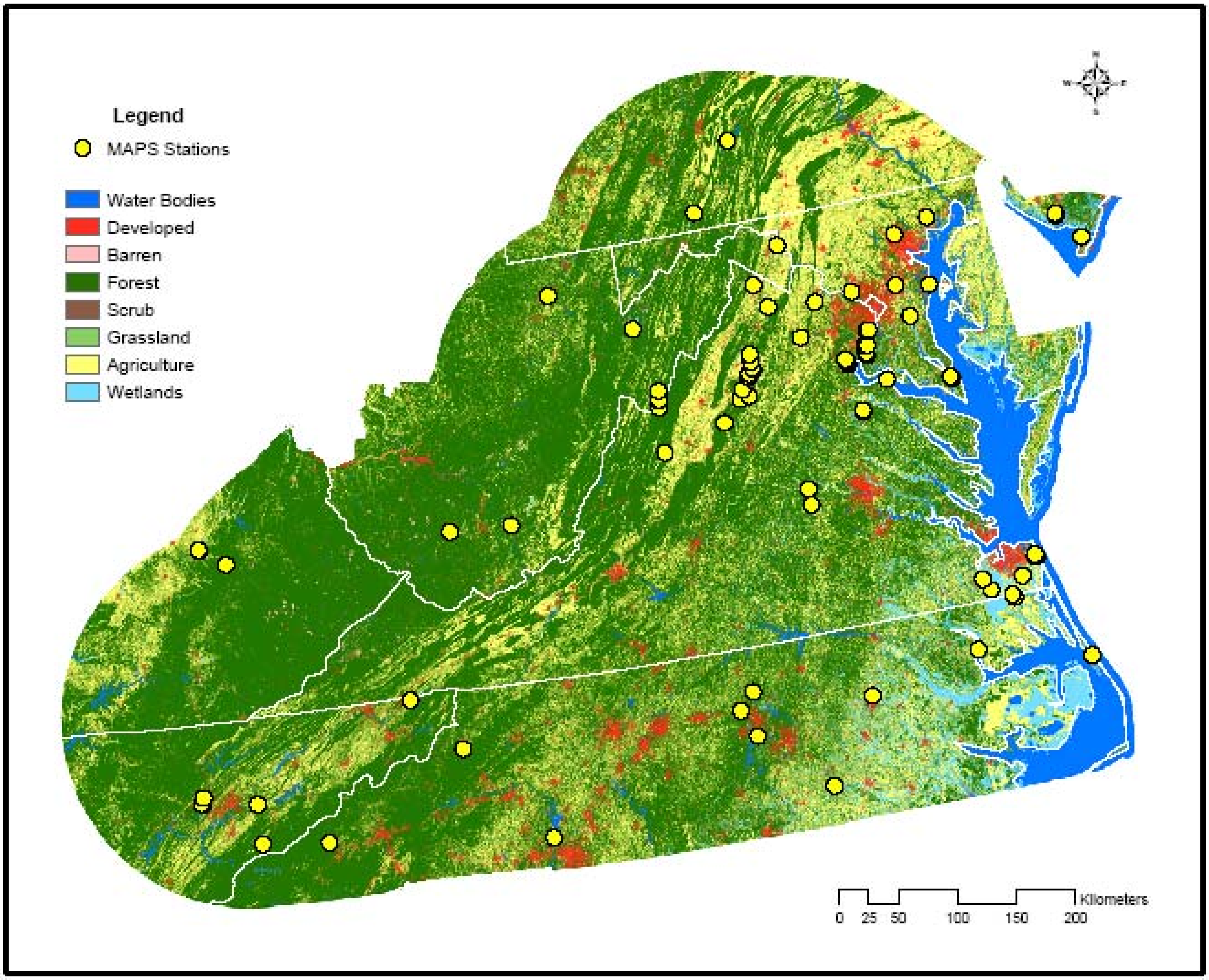


Figure 3. MAPS Stations in Virginia (+160km buffer) superimposed on NLCD 1992 Land Cover

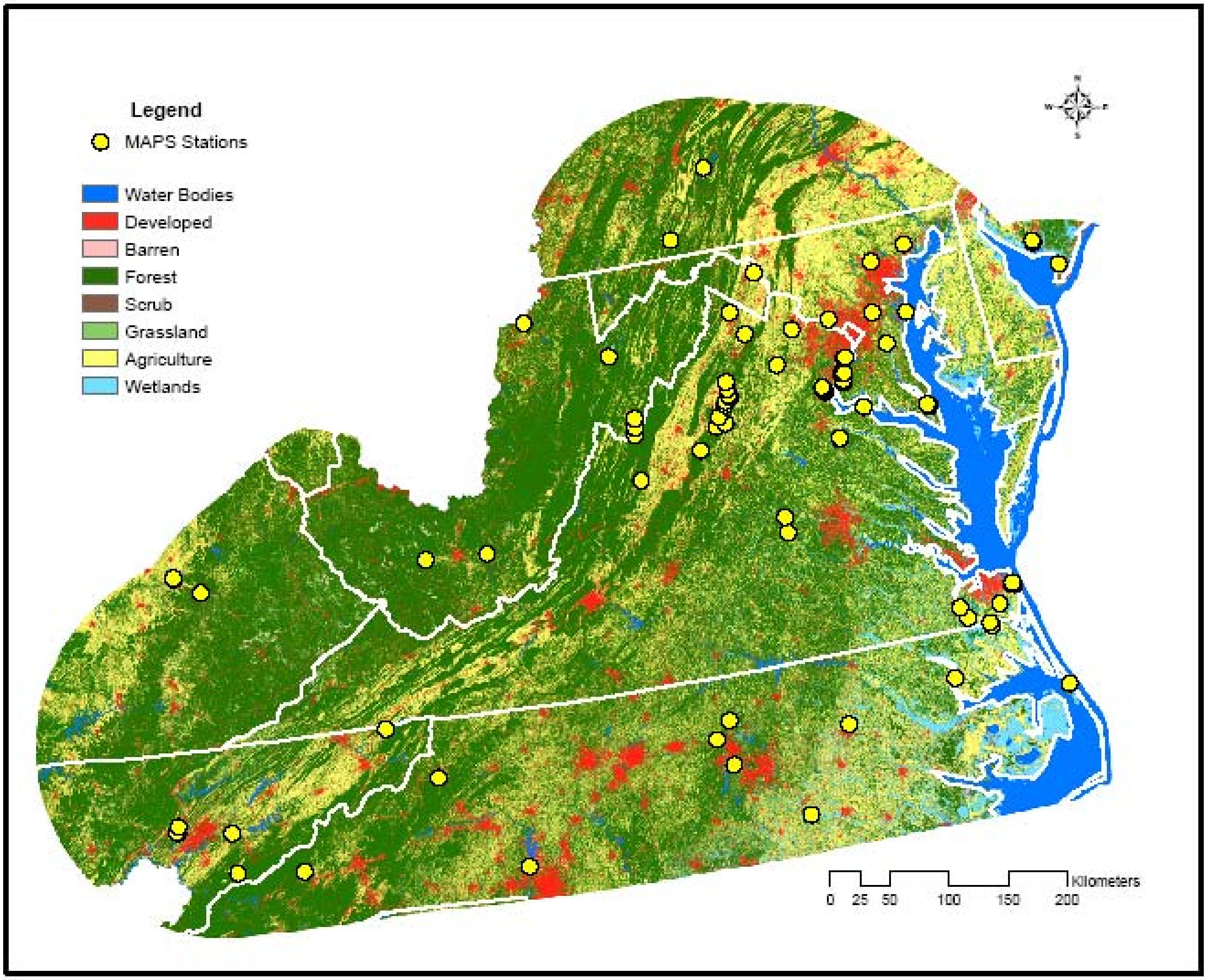


Figure 4. MAPS Stations in Virginia (+160km buffer where NLCD2001 coverage allowed) superimposed on NLCD 2001 Land Cover.

FIGURES

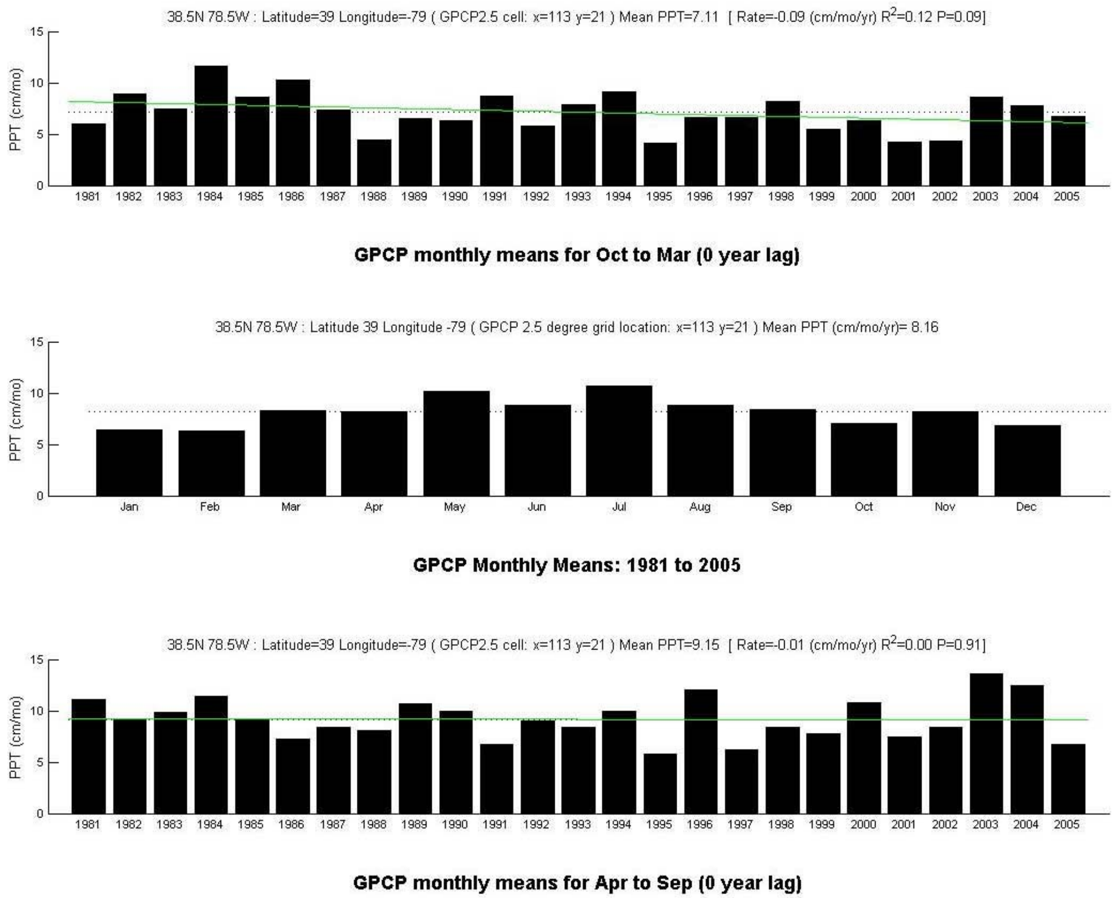


Figure 5. Visualizations of GPCP monthly data; October-March (top), monthly means (center), April-September (bottom)

APPENDIX 1

SPECIES ACCOUNTS DERIVED FROM ANALYSES TO DETERMINE SPATIO-TEMPORAL RELATIONSHIPS BETWEEN LANDSCAPE PATTERNS AND LANDBIRD DEMOGRAPHICS IN VIRGINIA AND SURROUNDING REGION

SUMMARY

We provided brief species accounts that summarize the demographics for 23 species (Table A). We selected 13 of these species (including 7 focal species) that could provide data from six or more stations that operated for more than three years, captured on average three or more adults per year, and captured at least one young over the entire period of operation. These data are necessary for the species-landscape modeling described below. For these species we provided more detailed accounts with graphs of temporal demographics and attempted to model their demographics as linear regression functions of forest cover change between 1992 and 2001 using USGS National Land Cover Datasets. Statistically significant regression models were reported for four of the 13 species. Further modeling, using a suite of landscape parameters may reveal other important relationships.

Each account outlines the regional demographics with respect to all data pooled and provides:

- mean and annual numbers of individual adults (individuals per station),
- mean and annual numbers of resident individuals. A resident adult is a marked individual that was captured more than once in a single year (seven or more days apart) or in more than one year (individuals per station),
- mean and annual numbers of young (individuals per station),
- mean and annual reproductive indices expressed as the ratio of young to adults.

We plotted these data in each extended account (a detailed figure legend can be found on page I - 6 of this appendix) and reported trends in temporal demographics, and noted extreme years.

Furthermore, we reported upon species-landscape models derived from analyses of the relationships between demographic parameters and spatial statistics for the Anderson-like Level I forest cover class (Level I forest class is equivalent to three Level II classes pooled) derived from the mean of NLCD 2001 and NLCD 1992 dataset values. This set of spatial statistics included the percentage of forest cover (Forest%), the percentage of core forest cover (Core%) using a 90m internal buffer, and forest edge density (Edge). We also reported upon species-landscape models derived from analyses of the relationships between demographic parameters and spatial statistics for the forest cover class derived from differences between the NLCD 2001 and NLCD 1992 datasets. The spatial statistics included the change in percentage of forest cover (ΔForest%), the percentage of core forest cover (ΔCore%) using a 90m internal buffer, and forest edge density (ΔEdge). The forest data were extracted for multiple radii around MAPS stations as the mean of and difference between the 1992 and 2001 National Land Cover Datasets. In each case we reported the radius of the strongest model and the mean value for each forest and demographic parameter. These models could be used in appropriately scaled GIS based management models to assess effects of proposed or ongoing management upon multiple species.

A brief account of each species follows from summaries of Table A and Table 6. In all cases the Virginia survival rates were estimated for MAPS data collected in Virginia and the surrounding 150km.

Eastern Wood-pewee *(Contopus virens)* – The Virginia survival rate (PM1) was estimated using MAPS data from 32 stations. The rate was lower than that for three of the surrounding BCRs but slightly higher than that estimated for BCR30. Both adult (PM2) and young trends (PM3) were stable.

Acadian Flycatcher (*Empidonax virescens*) – The survival rate was considerably lower than estimates from all four BCRs and estimated using data from 41 stations. The adult, resident and young populations were stable. Species-landscape models were constructed for six demographic parameters.

White-eyed Vireo (*Vireo griseus*) – The survival rate was high compared to the BCR estimates and only exceeded by the BCR30 estimate. Data were used from 44 stations. The adult population declined but resident and young populations were stable. No statistically significant landscape models were detected.

Red-eyed Vireo (*Vireo olivaceous*) – The survival rate was considerably higher than three of the BCR estimates, but equal to the BCR27 estimate. The rate was estimated using data from 29 stations. The adult population declined but resident and young populations were stable. No statistically significant landscape models were detected.

Tufted Titmouse (*Parus bicolor*) – The survival rate was estimated using data from 46 stations and was significantly higher than all the BCR estimates. The adult and young populations were highly variable and reproductive index rapidly declined. No statistically significant landscape models were detected.

Carolina Wren (*Thryothorus ludovicianus*) – The survival rate was estimated using data from 47 stations and was lower than all the BCR estimates. The adult, resident and young populations were stable. No statistically significant landscape models were detected.

Veery (*Catharus fuscescens*) – The Virginia survival rate was estimated from 22 stations and was equal to the estimate for BCR27 (same stations) but lower than the only other estimate for BCR29. The adult and young populations and reproductive index were highly variable. No statistically significant landscape models were detected.

Wood Thrush (*Hylocichla mustelina*) – The survival rate was estimated using data from 46 stations. The rate was higher than that estimated for BCR27 and BCR28 but lower than that estimated fro BCR29 and BCR30. The adult population was stable but young populations and reproductive indices rapidly declined. Species-landscape models were constructed for seven demographic parameters.

Gray Catbird (*Dumetella carolinensis*) – The survival rate was estimated using data from 40 stations and was considerably lower than three of the BCR estimates, but exceeded the estimate for BCR30. The adult population and young populations rapidly declined ($P<0.001$) and reproductive indices were highly variable. No statistically significant landscape models were detected.

Black-and-white Warbler (*Mniotilta varia*) – The survival rate was estimated using data from 35 stations. The rate exceeded that for BCR28 and BCR30 but was lower than the BCR27 estimate. The adult population significantly increased and young populations were stable. No statistically significant landscape models were detected.

American Redstart (*Setophaga ruticilla*) – The survival rate was estimated using data from 28 stations. The rate exceeded that for BCR28 but was slightly lower than the BCR30 estimate. The adult population and young populations were stable. No statistically significant landscape models were detected.

Prothonatory Warbler (*Protonotario citrea*) – The survival rate was estimated using data from 20 stations and exceeded the estimate for BCR27. The adult population was stable but numbers of young declined rapidly ($P<0.001$). No statistically significant landscape models were detected.

Worm-eating Warbler (*Protonotario citrea*) – The survival rate was estimated using data from 36 stations and was considerably higher than the estimates for BCR27, BCR28, and BCR30. The adult population significantly increased ($P=0.01$) but numbers of young were stable. No statistically significant landscape models were detected.

Ovenbird (*Seiurus aurocapillus*) – The survival rate was estimated using data from 45 stations. The rate was lower than that estimated for BCR27 and BCR28, but exceeded the other two estimates. The adult population and young populations were highly variable and reproductive indices rapidly declined. Species-landscape models were constructed for six demographic parameters.

Louisiana Waterthrush (*Seiurus motacilla*) - The survival rate was estimated using data from 33 stations and exceeded all the BCR estimates. Both adult and young populations significantly ($P<0.05$) increased by more than 7% per year. No statistically significant landscape models were detected.

Kentucky Warbler *(Oporornis formosus)* - The survival rate was estimated using data from 29 stations. The rate was only exceeded by the estimate for BCR29. Both adult and young populations were stable. No statistically significant landscape models were detected.

Common Yellowthroat *(Geothlypis trichas)* - The survival rate was estimated using data from 34 stations and was considerably lower than the estimates for the four BCRs. The adult and young populations significantly declined ($P<0.05$). No statistically significant landscape models were detected.

Hooded Warbler (*Wilsonia citrina*) – The survival rate was estimated using data from 37 stations. The rate was higher than three BCR estimates but lower than the BCR27 estimate. The adult population significantly increased ($P<0.05$) but young populations were stable. Reproductive indices were highly variable. Species-landscape models were successfully constructed.

Scarlet Tanager *(Piranga olivacea)* – The survival rate was estimated using data from 32 stations. The rate was higher than that for BCR30 but lower than the estimate forBCR28. The adult and young populations were stable. No statistically significant landscape models were detected.

Eastern Towhee (*Pipilo erythrophthalmus*) – The Virginia survival rate was considerably higher than the Northeast regional estimate. The adult populations, young populations, and reproductive indices were highly variable. No statistically significant landscape models were detected.

Dark-eyed Junco *(Junco hymenalis)* – The survival rate estimate was slightly lower than the only other estimate for BCR28. The adult and young populations were stable. No statistically significant landscape models were detected.

Northern Cardinal (*Cardinalis cardinalis*) – The Virginia survival rate was significantly lower than the Northeast regional estimate. The adult populations, young populations, and reproductive indices were highly variable. No statistically significant landscape models were detected.

Indigo Bunting (*Passerina cyanea*) – The Virginia survival rate was significantly higher than the Northeast regional estimate. The adult populations, young populations, and reproductive indices were highly variable. No statistically significant landscape models were detected.

Figure Legend for Demographic Analysis Plots in Individual Species Accounts:

The figure associated with each species account in this section features four panes showing annual variation (1992-2003) in demographic parameters. The first pane (top left) shows a bar chart of the mean number of individual adults captured per station. The black portion of each bar shows the number of resident adults captured. A resident adult is a marked individual that was captured more than once in a single year (seven or more days apart) or in more than one year. The white portion represents the number of individual adults seen (i.e. captured) only once or captured more than once in the same banding period. The numbers of stations at which sufficient numbers of adults (and young) were captured (i.e. captured on average three or more adults per year of operation, and captured at least one young over the entire period of operation) are shown above each bar.

The top right pane shows the annual mean number of individual adults captured per station as a regression plot entitled by the slope of the regression (b), the proportion of the variation described by the relationship (R^2), and the probability (P) associated with the regression. A solid line represents the regression fit which pivots about a horizontal dotted line that represents the mean number of individuals.

The bottom right pane shows a regression plot for the annual mean numbers of young individuals captured. The bottom left pane shows the regression plot of a reproductive index in which the annual mean number of individual young is expressed as a proportion of the total annual mean number of all individuals (i.e. adults plus young).

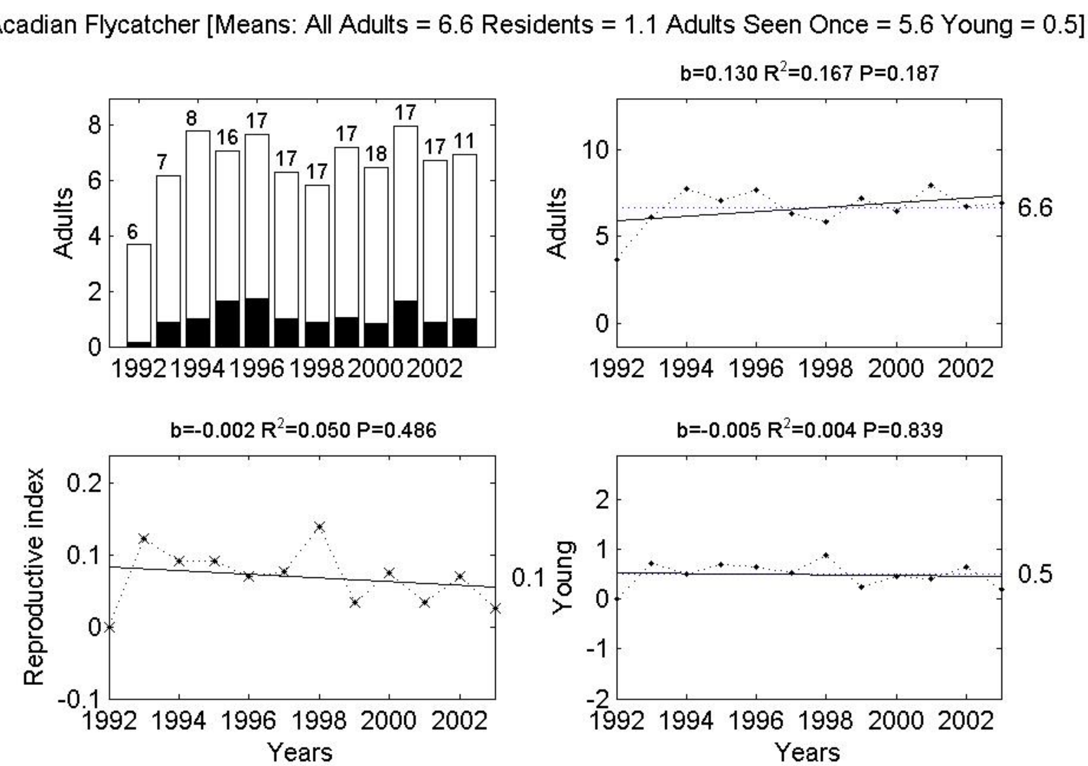
Above the plots, next to the species common name, the overall mean annual numbers are given for all adults, resident adults, adults seen once, and young.

SPECIES ACCOUNTS

ACADIAN FLYCATCHER (*EMPIDONAX VIRESCENS*)

Regional Demographics

During the period 1992 to 2003 between 6 and 18 MAPS stations contributed data to Acadian Flycatcher demographic analyses. The proportion of resident birds varied considerably around 17%. Annual variation in the number of adults showed a non-significant increase of approximately 2% per year compared to the mean of 6.6 adults per station per year. Similarly, the numbers of young remained fairly constant except for a small peak in 1998. The reproductive index also remained fairly constant (mean 0.1) except for a peak in 1998 when the numbers of adults were below average and the numbers of young were highest.



Demographic analyses of MAPS data for Acadian Flycatcher. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

Landscape Analysis

Banding data from 18 stations contributed to the Acadian Flycatcher landscape analysis. The numbers of adults were negatively correlated with the percentage of forested land within a 1km radius of those stations (Table A). The numbers of young were negatively correlated with the percentage of forested land within an 8km radius of those stations (Table A). The forested land covered a mean of 18.88% (U95 26%, L95 11%) of the area at one-kilometer radius but ~40% at 8km and 4km radii. These results suggest that at a one-kilometer radius Acadian Flycatcher adults were captured in higher numbers where the forest is more open. Likewise, more young were captured and higher reproductive indices were recorded in landscapes of four and eight kilometer radius, respectively.

Table A. Landscape parameters and regression analyses (using a period mean of NLCD 1992 and NLCD 2001 data) for chosen Acadian Flycatcher demographics using MAPS data collected from 29 stations in Virginia and surrounding region. Reproductive index is given as PI_mean.

Demographic	Landscape Parameters			Regression Analysis (period mean)				
Parameter	Class	Radius	Mean	R^2	Intercept	Slope	F	P
All Adults	Forest%	1	19	0.16	9.766	-0.0583	3.1	0.096
Young	Forest%	8	42	0.24	0.763	-0.0058	4.7	0.048
PI_mean	Forest%	4	43	0.19	0.090	-0.0007	3.5	0.081

Table B shows that the landscapes surrounding study stations lost a mean of just over 1% forest cover between 1992 and 2001. Subsequent analyses of demographics as functions of forest change revealed relationships in which the annual rate of change in the number of adults (and residents) was most positive where forest cover increased or stayed the same. Annual change in the numbers of young were most positive at those stations that gained forest cover between 1992 and 2001, however the negative regression intercept suggested that the numbers of young would decline even with no forest cover change. Not surprisingly, the region-wide reproductive index non-significantly declined between 1992 and 2003.

Table B. Landscape parameters and regression analyses (using the difference between NLCD 1992 and NLCD 2001 data) for chosen Acadian Flycatcher demographics using MAPS data collected from 29 stations in Virginia and surrounding region.

Demographic	Landscape Parameters			Regression Analysis (change)				
Parameter	Class	Radius	Mean	R^2	Intercept	Slope	F	P
All Adults	ΔForest%	10	-1.05	0.39	7.155	0.3270	10.4	0.005
Adults/yr	ΔForest%	8	-1.41	0.41	0.033	0.0410	4.8	0.043
Young/yr	ΔForest%	10	-1.05	0.21	-0.0050	0.0037	4.3	0.055

These results suggest that the numbers of adult and young Acadian Flycatchers have increased as the forest opened. This is not to suggest that clearing forest is always beneficial to Acadian Flycatchers, the slopes of the relationships are small and it is important to remember that the birds are not abundant or productive in landscapes without forested areas. These results are consistent with the fact that Acadian Flycatchers are classified as a woodland species and require forest gaps in which to forage.

Most of the Acadian Flycatcher data were derived from MAPS data collected within the mid-Atlantic Coastal Plain physiographic area in Virginia or Maryland. These stations include those on Department of Defense installations (Quantico, Fort Belvoir, U.S.Naval installations at NAS Patuxent River, NWSC Dahlgren, NWSC Indian Head, Fort A.P. Hill, and U.S. Navy installations in the vicinity of Virginia Beach), Fort Mason NWR, and Jug Bay Wildlife Sanctuary. Smaller numbers of captures were made throughout the Shenandoah stations in the Blue Ridge Mountains.

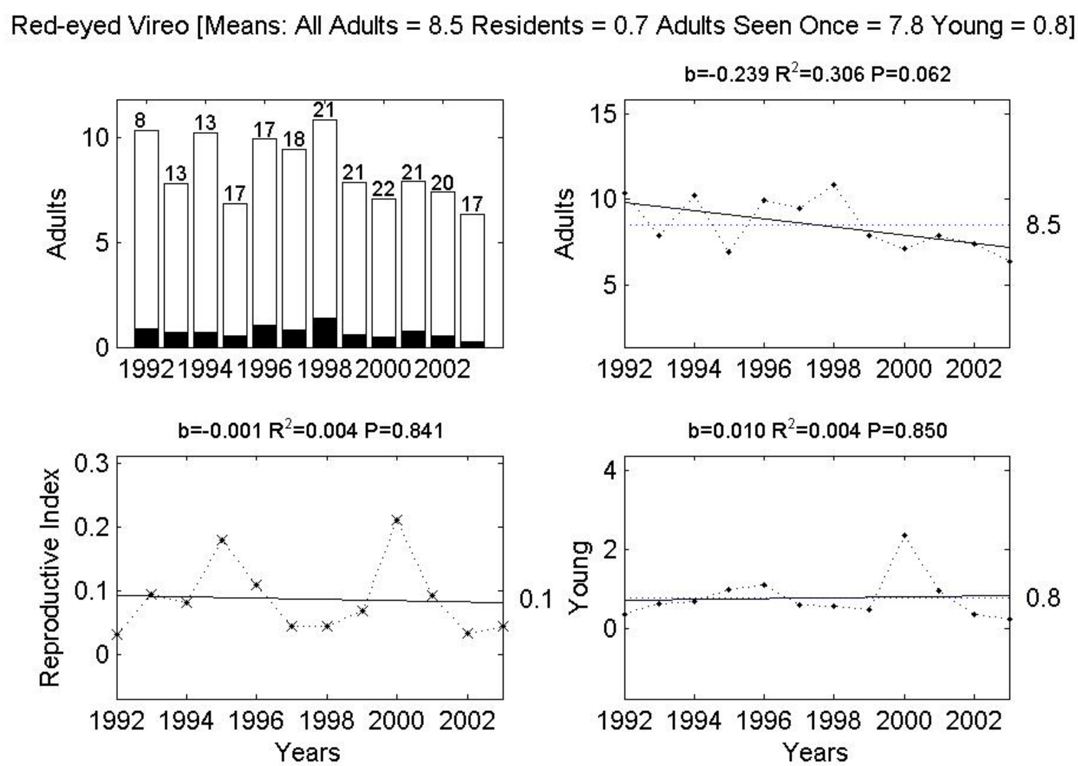
A station by station inspection of captures revealed that >4 individuals were captured per year at 28 stations, only 10 of which are still active including Jug Bay Wildlife Sanctuary, MD (16603); Quantico (2, 16664 and 16665); Mason Neck NWR (2, 16646 and 16647); and Bear Swamp, NJ (16667).

The 17 inactive stations included Patuxent (3); Stump Neck NWR; Indian Head, Dahlgren; Fort A.P. Hill (2); Fort Belvoir, MD (2); Virginia Beach naval stations (2; Fentress and Boardwalk); Harford Glen, MD (15531); Adventure, MD (15624), Timothy’s School, MD (15592), Great Smoky Mountains, TN (15620), and Rapidan WMA, VA (15639). These stations should be reactivated to monitor Acadian Flycatchers.

RED-EYED VIREO (*VIREO OLIVACEOUS*)

Regional Demographics

During the period 1992 to 2003 between 8 and 21 MAPS stations contributed data to Red-eyed Vireo demographic analyses. The proportion of resident birds remained fairly constant below 10%. Annual variation in the number of adults showed a nearly significant decline of approximately 3% per year compared to the mean of 8.5 adults per station per year, however the numbers of young remained fairly constant except for a peak in 2000. The reproductive index also remained fairly constant (mean 0.1) except for two peaks: in 1995 when the numbers of adults were lowest and the numbers of young were above average; and in 2000 when the adult population was below average and the numbers of young captured were highest.

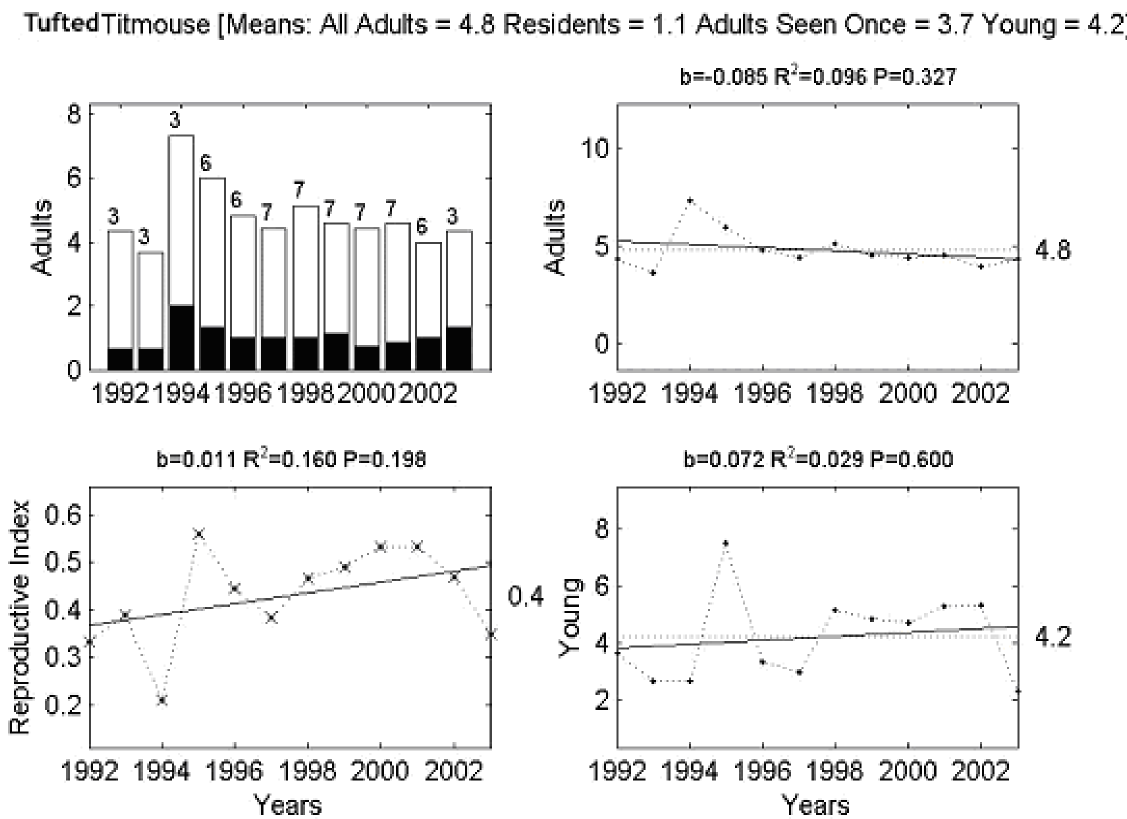


Demographic analyses of MAPS data for Red-eyed Vireo. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

TUFTED TITMOUSE (*PARUS BICOLOR*)

Regional Demographics

During the period 1995 to 2002 six or seven MAPS stations contributed data to Tufted Titmouse demographic analyses. The proportion of resident birds remained fairly constant at approximately 20%. Annual variation in the number of adults remained constant with mean of 4.8 adults per station per year. The numbers of young also remained fairly constant except for a peak in 1995. The reproductive index also remained fairly constant (mean 0.43) except for a peak in 1995 when the numbers of young captured were highest, and a trough in 1994 when the numbers of adults were highest.

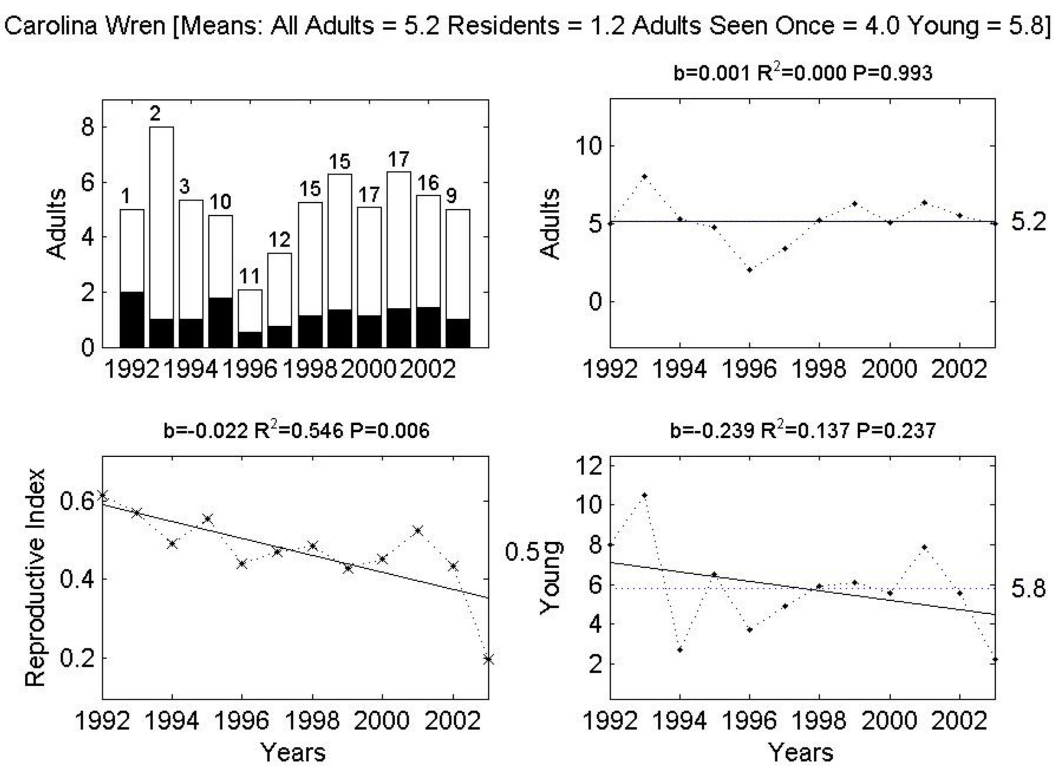


Demographic analyses of MAPS data for Tufted Titmouse. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

CAROLINA WREN (*THRYOTHORUS LUDOVICIANUS*)

Regional Demographics

During the period 1995 to 2003 between nine and 17 MAPS stations contributed data to Carolina Wren demographic analyses. The proportion of resident birds remained fairly constant at approximately 23%. Annual variation in the number of adults remained constant with a peak in 1993 and a low in 1996 and a mean of 5.2 adults per station per year. The numbers of young declined non-significantly with a peak in 1993 and lows in 1994 and 2003, with a mean of 5.8 young per station per year. These patterns resulted in a highly significantly (P<0.01) declining reproductive index of approximately 4% per year (mean 0.5) ranging from a high of 0.6 in 1992 to 0.2 in 2003. Overall, the reproductive index declined by over 40%.

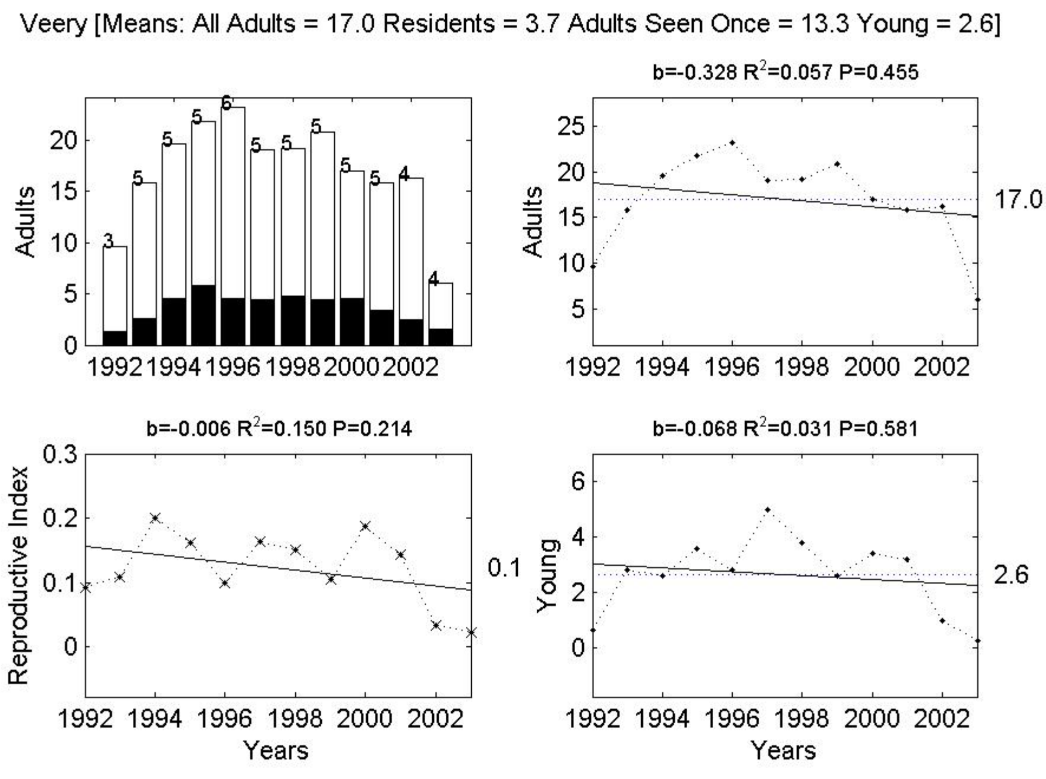


Demographic analyses of MAPS data for Tufted Titmouse. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

VEERY (*CATHARUS FUSCESCENS*)

Regional Demographics

During the period 1992 to 2003 between three and six MAPS stations, located in Shenandoah National Park, contributed data to the Veery demographic analysis. The proportion of resident birds remained fairly constant at approximately 20%. The number of adults increased from ~10 in 1992 to peak at ~23 in 1996, followed by a decline to a low of ~5 in 2003 compared to a mean of 17.0 adults per station per year. The numbers of young also remained fairly constant except for a peak in 1997 and lows of near zero in 1992 and 2003. The reproductive index declined non-significantly (mean 0.12) with lows close to zero in 2002 and 2003.

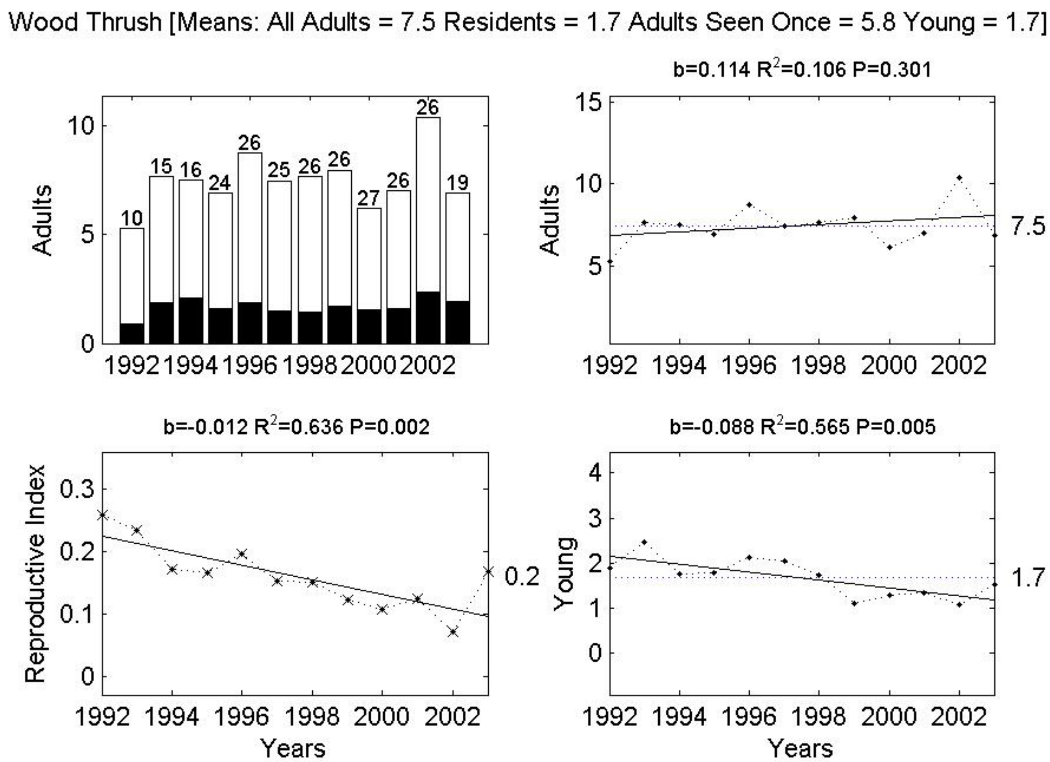


Demographic analyses of MAPS data for Veery. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

WOOD THRUSH (*HYLOCICHLA MUSTELINA*)

Regional Demographics

During the period 1992 to 2003 between 10 and 26 MAPS stations contributed data to Wood Thrush demographic analyses. The proportion of resident birds remained fairly constant at approximately 20%. The number of adults increased non-significantly with a prominent peak of ~10 in 2002 compared to a mean of 7.5 adults per station per year. The numbers of young, however, significantly (P=0.005) declined at a rate of ~5% per year which resulted in a significant (P<0.005) decline in the reproductive index of ~7% per year.



Demographic analyses of MAPS data for Wood Thrush. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

Landscape Analysis

Banding data from 29 stations contributed to the Wood Thrush analysis. The numbers of adults and the numbers of young were significantly and negatively correlated with the percentage of forested land within a 1km radius of those stations (Table A). Because the slope of the relationship between the numbers of young and forest cover was more negative than that of the adults, the reproductive success also declined with increasing forest cover. The forested land covered a mean of 64% (U95 73%, L95 54%) of the area. Only 3 of the stations featured less than 30% forest cover but captured the highest numbers of adults and young.

Table A. Landscape parameters and regression analyses (using a period mean of NLCD 1992 and NLCD 2001 data) for chosen Wood Thrush demographics using MAPS data collected from 29 stations in Virginia and surrounding region.

Demographic	Landscape Parameters			Regression Analysis (period mean)				
Parameter	Class	Radius	Mean	R^2	Intercept	Slope	F	P
All Adults	Forest%	1	64	0.30	14.23	-0.1021	11.5	0.002
Young	Forest%	1	64	0.33	4.208	-0.3296	13.3	0.001
PI_mean	Forest%	1	64	0.17	0.243	-0.0018	5.3	0.028

Analyses of Wood Thrush demographics as functions of forest change (below) revealed positive relationships between total numbers of adults, the annual rate of change in the number of adults (and residents), and forest change. Numbers of adults increased where forest cover had increased or stayed the same (Table B). Conversely, the reproductive index increased at those stations that lost the most forest cover and the negative regression intercept suggested that productivity would decline even without forest cover change. In fact, the region-wide reproductive indices did significantly decline between 1992 and 2003. The Wood Thrush case study suggested that the decline may be climate-related.

Table B. Landscape parameters and regression analyses (using the difference between NLCD 1992 and NLCD 2001 data) for chosen Wood Thrush demographics using MAPS data collected from 29 stations in Virginia and surrounding region.

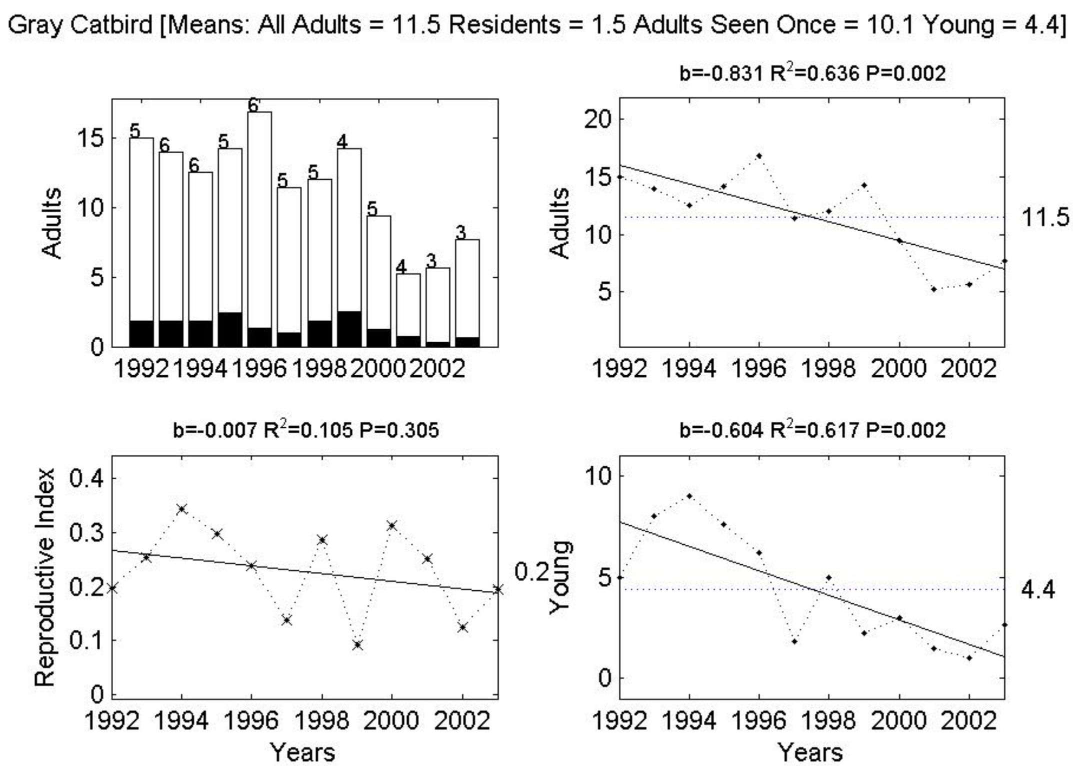
Demographic	Landscape Parameters			Regression Analysis (change)				
Parameter	Class	Radius	Mean	R^2	Intercept	Slope	F	P
All Adults	ΔForest%	6	-2.26	0.37	8.247	0.3612	14.6	0.001
Adults/yr	ΔForest%	1	-2.24	0.16	0.288	0.0444	4.7	0.040
Resident/yr	ΔForest%	1	-2.24	0.35	0.0008	0.0022	13.6	0.001
PI/yr	ΔForest%	10	-2.75	0.25	-0.014	-0.0025	8.2	0.008

Thus, the results suggest that overall the adult populations of Wood Thrush are fairly stable but productivity is declining annually. At the station level the highest populations are found in areas where the mean forest cover was 50-60% but fewer individuals were found above 70% forest cover. Overall, between radii of one and ten kilometers, a mean 2-3% of forest cover was lost. Most forest was lost from stations with high forest cover and that is where the percentage population gains were highest.

GRAY CATBIRD (*DUMETELLA CAROLINENSIS*)

Regional Demographics

During the period 1992 to 2003 between three and six MAPS stations contributed data to Gray Catbird demographic analyses. The proportion of resident birds remained fairly constant at approximately 13%. The number of adults significantly ($P<0.005$) decreased from ~15 in 1992 to ~7 in 2003 at a rate of ~7% per year, compared to a mean of 11.5. The number of young significantly ($P<0.005$) decreased from ~9 in 1994 to ~2 in 2003 at a rate of ~13% per year, compared to a mean of 4.4 young per year. The reproductive index was highly variable from year to year with lows close to 0.1 in 2002 and 2003, but overall declined non-significantly (mean 0.2).

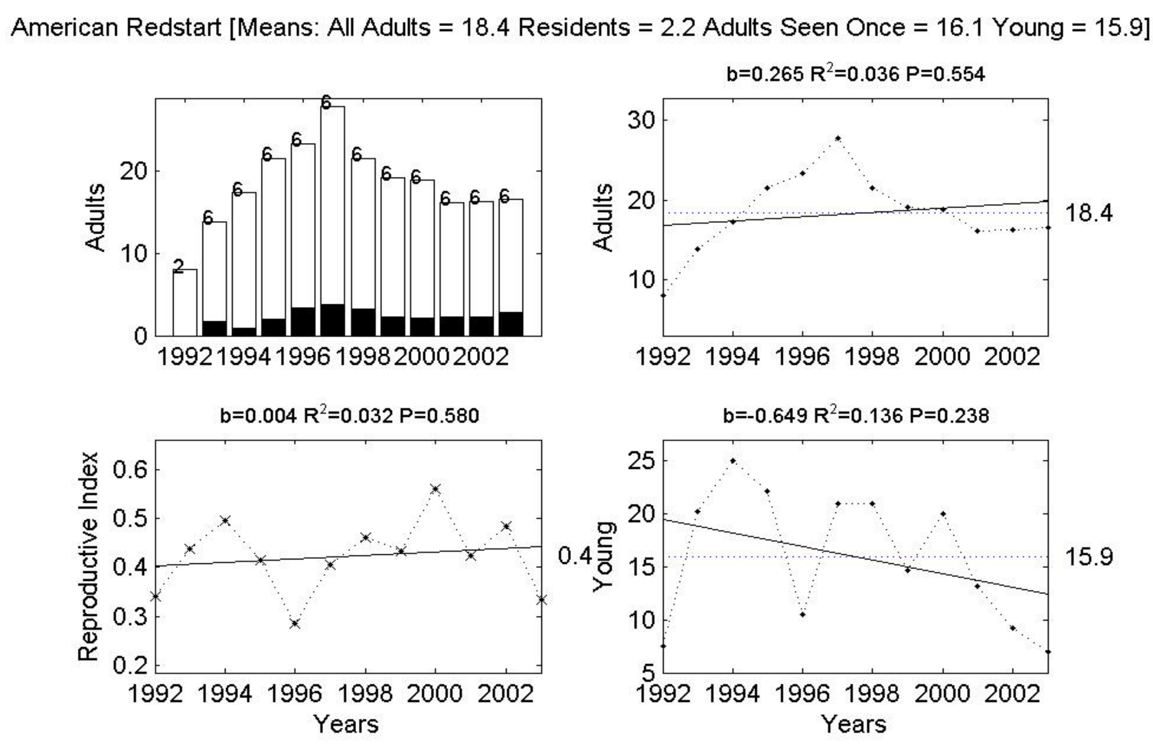


Demographic analyses of MAPS data for Gray Catbird. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

AMERICAN REDSTART (*SETOPHAGA RUTICILLA*)

Regional Demographics

During the period 1993 to 2003 six MAPS stations contributed data to American Redstart demographic analyses. The proportion of resident birds remained fairly constant at approximately 12%. Annual variation in the number of adults showed an initial increase from below 10 individuals in 1992 to over 25 by 1997 after which the numbers declined to just below the average of 18.4 by 2003. The numbers of young varied greatly from ~7 in 1992 to 25 in 1994 and then declined precipitously to ~10 individuals by 1996. The reproductive index also remained fairly constant (mean 0.42) except for two peaks: in 1994 when the numbers of adults were average and the numbers of young were highest; and in 2000 when the adult population was below average and the numbers of young captured were relatively high. In 1996, however, the numbers of adults were high and the numbers of young were low.

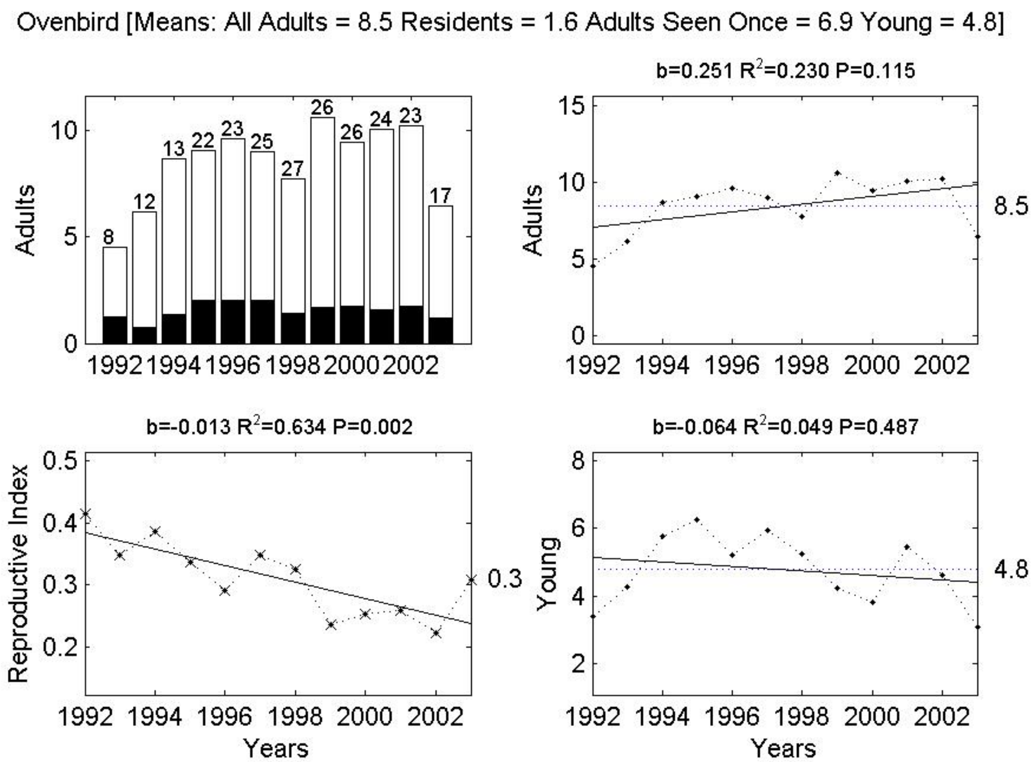


Demographic analyses of MAPS data for American Redstart. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

OVENBIRD (*SEIURUS AUROCAPILLUS*)

Regional Demographics

During the period 1992 to 2003 between 8 and 26 MAPS stations contributed data to Acadian Flycatcher demographic analyses. The proportion of resident birds remained fairly constant at approximately 18%. The number of adults increased non-significantly from 5 adults to 10 during the period 1992 to 2002 to a mean of 8.5 adults per station per year. The numbers of young remained fairly stable with a mean of 4.8, however this resulted in a significant (P<0.005) decline in the reproductive index of ~4% per year, compared to a mean of 0.3.



Demographic analyses of MAPS data for Ovenbird. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

Landscape Analysis

Banding data from 26 stations contributed to the Ovenbird analysis. The numbers of adults and young were significantly and negatively correlated with the amount of forested edge within a 1km radius of those stations (Table A). The forested land covered a mean of 59% (U95 71%, L95 46%) of the area.

Table A. Landscape parameters and regression analyses (using a period mean of NLCD 1992 and NLCD 2001 data) for chosen Ovenbird demographics using MAPS data collected from 27 stations in Virginia and surrounding region.

Demographic	Landscape Parameters			Regression Analysis (period mean)				
Parameter	Class	Radius	Mean	R^2	Intercept	Slope	F	P
All Adults	Edge (m/ha)	4	59*	0.14	11.50	-0.0524	4.0	0.058

* % of forest cover

Analyzing demographics as functions of forest change revealed relationships whereby the mean number of adults and young increased as a function of forest change such that the highest numbers were found in large contiguous tracts that result from high forest cover (>60%). High numbers of resident adults were detected where the percentage of forest core area had increased or stayed the same, and low where forest core had decreased. The proportion of residents increased with increasing forest edge. The negative regression intercept suggested that productivity would remain stable (-0.009 residents annually) if forest cover remained stable. Annual rates of change in reproductive indices decreased with increasing forest cover and the negative regression intercept suggested that productivity would decline even without forest cover change. Accordingly, the region-wide reproductive indices did significantly (P<0.005) decline between 1992 and 2003.

Table B. Landscape parameters and regression analyses (using the difference between NLCD 1992 and NLCD 2001 data) for chosen Ovenbird demographics using MAPS data collected from 26 stations in Virginia and surrounding region.

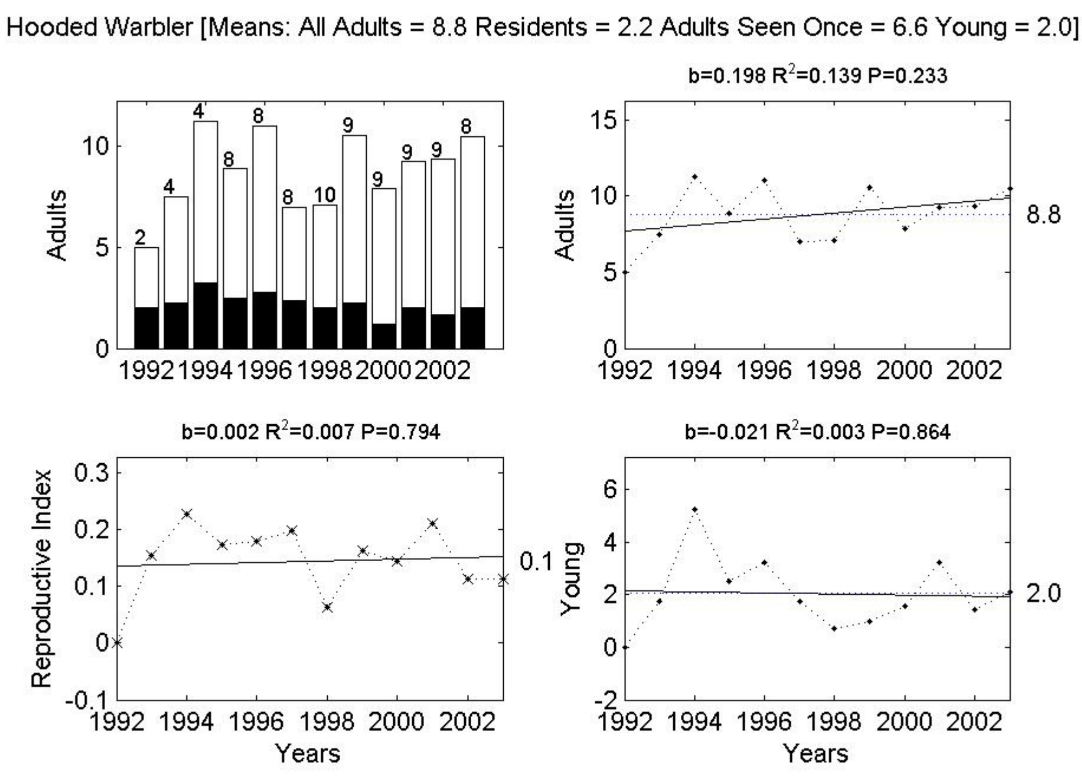
Demographic	Landscape Parameters			Regression Analysis (change)				
Parameter	Class	Radius	Mean	R^2	Intercept	Slope	F	P
All Adults	ΔForest%	4	-1.62	0.26	9.003	0.2165	8.8	0.007
Residents	ΔCore%	4	-2.57	0.19	0.182	0.0063	6.0	0.022
Young	ΔForest%	6	-1.40	0.43	5.219	0.3038	19.2	0.0002
Residents/yr	ΔEdge%	8	0.04	0.19	-0.009	0.0006	6.0	0.022
PI/yr	ΔForest%	4	-1.62	0.29	-0.0105	-0.0018	9.0	0.007

Ovenbirds are recognized as an “area dependent” species, requiring large tracts of contiguous forest and interior woodland for successful breeding (Robbins et al. 1989) Our results are consistent with an area dependency effect in that all demographic measures increased with forest cover or core (interior) forest at the scale of the “best” models (4-8 kilometers). The numbers of young have increased at sites where forest cover increased but, overall, forested habitat declined slightly which may explain why reproductive success declined slightly.

HOODED WARBLER (*WILSONIA CITRINA*)

Regional Demographics

During the period 1992 to 2003 between two and ten MAPS stations contributed data to Hooded Warbler demographic analyses. The proportion of resident birds seemed to vary considerably around 25%. Annual variation in the number of adults showed a non-significant increase of 2% per year compared to an average of 8.8 adult per station per year. The numbers of young showed no trend but varied greatly from 5 in 1994 to ~1 per station in 1998. The reproductive index was variable but overall constant (mean ~0.13) except for two peaks: in 1994 when the numbers of young were highest; and in 2001 when the numbers of young captured were relatively high. In 1998, however, the numbers of adults and young were low.



Demographic analyses of MAPS data for Hooded Warbler. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

Landscape Analysis

Banding data from 10 stations contributed to the Hooded Warbler analysis. The numbers of adults and the numbers of young were significantly and positively correlated with the percentage of core forested land within a 10km and 4km radius, respectively (Table A). Because the slope of the relationship between the numbers of young and forest cover was more negative than that of the adults, the reproductive success also declined with increasing forest cover. The core area forested land (using a 90m buffer within each forest patch) covered a mean of 43% (U95 65%, L95 21%) of the area within 4km radii of stations.

Table A. Landscape parameters and regression analyses (using a period mean of NLCD 1992 and NLCD 2001 data) for chosen Wood Thrush demographics using MAPS data collected from 29 stations in Virginia and surrounding region.

Demographic Parameter	Landscape Parameters			Regression Analysis (period mean)				
	Class	Radius	Mean	R^2	Intercept	Slope	F	P
All Adults	Core%	10	36	0.39	4.283	0.1223	5.0	0.055
Young	Core%	4	43	0.54	0.0398	0.0418	9.6	0.015

Analyzing demographics as functions of forest change revealed inverse relationships whereby the annual rate of change in the number of adults, residents and young were more positive where forest cover had decreased, and rates were negative where forest cover increased. The strongest relationships were with the edge density (which increases with forest loss) for adult rates of change, and core area of forest (% cover) for residents, young and reproductive index. The rate of change intercepts suggested that productivity would remain stable or slightly decrease if forest cover remained stable. Annual rates of change in reproductive indices also decreased with increasing forest cover.

Table B. Landscape parameters and regression analyses (using the difference between NLCD 1992 and NLCD 2001 data) for chosen Hooded Warbler demographics using MAPS data collected from 10 stations in Virginia and surrounding region.

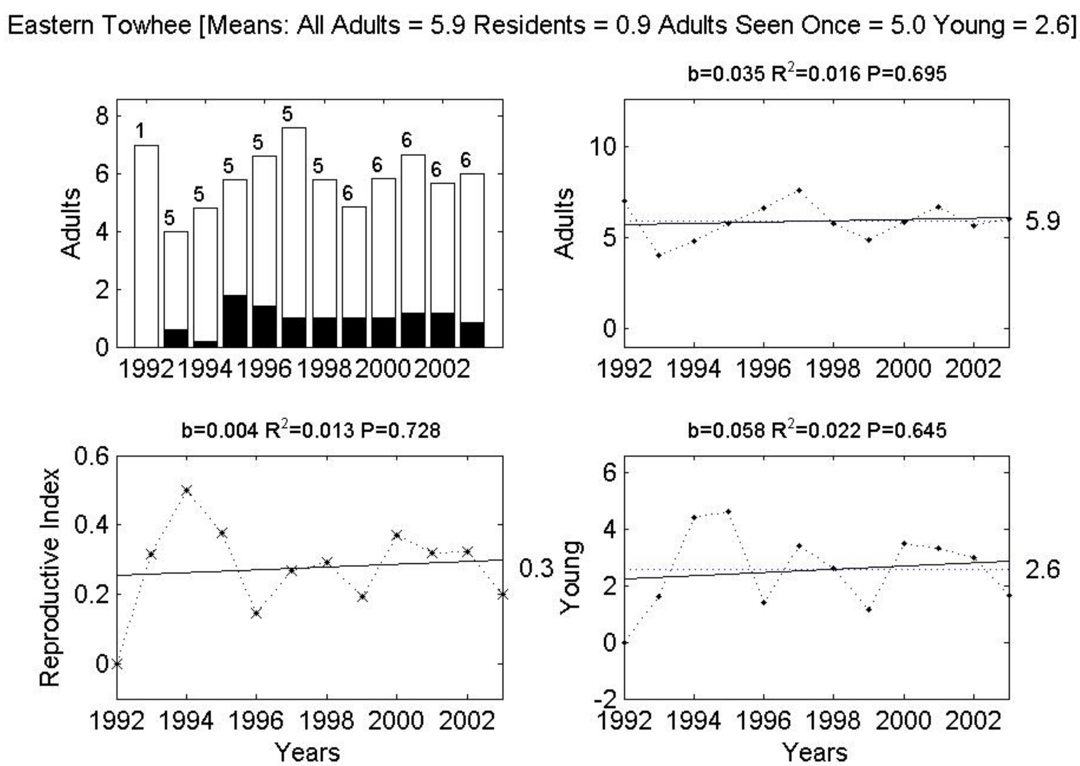
Demographic Parameter	Landscape Parameters			Regression Analysis (change)				
	Class	Radius	Mean	R^2	Intercept	Slope	F	P
Adults/yr	ΔEdge%	1	12.75	0.59	0.0254	0.0086	11.7	0.009
Residents/yr	ΔCore%	1	-7.65	0.48	-0.0095	-0.0009	7.5	0.026
Young/yr	ΔCore%	6	-1.10	0.39	-0.0342	-0.0208	5.2	0.052
PI/yr	ΔCore%	6	-1.10	0.41	0.0035	-0.0012	5.5	0.048

Hooded Warblers, like Ovenbirds, are recognized as an “area dependent” species, requiring large tracts of contiguous forest and interior woodland for successful breeding (Robbins et al. 1989)   Our results are consistent with an area dependency effect in that the mean demographic measures increased with the percentage cover of forested core (interior forest) at the scale of the “best” models (i.e. 4-10 kilometers). However, the results of the forest change analysis suggest that Hooded Warblers have benefited slightly from forest loss. Gartshore (1988) reported that selective logging in less mature forests can create or enhance breeding by creating a thick shrub understory for birds to nest in, which may be partially responsible for the phenomenon observed here.

EASTERN TOWHEE (*PIPILO ERYTHROPHTHALMUS*)

Regional Demographics

During the period 1993 to 2003, five or six MAPS stations contributed data to Eastern Towhee demographic analyses. The proportion of resident birds remained fairly constant at approximately 15%. Annual variation in the number of adults remained constant with mean of 5.9 adults per station per year. The numbers of young varied considerably with peaks in 1994 and 1995. The reproductive index was highly variable (mean 0.28) except for a peak in 1994 when the numbers of young captured were very high, and a trough in 1996 when the numbers of young were low and the numbers of adults were high.

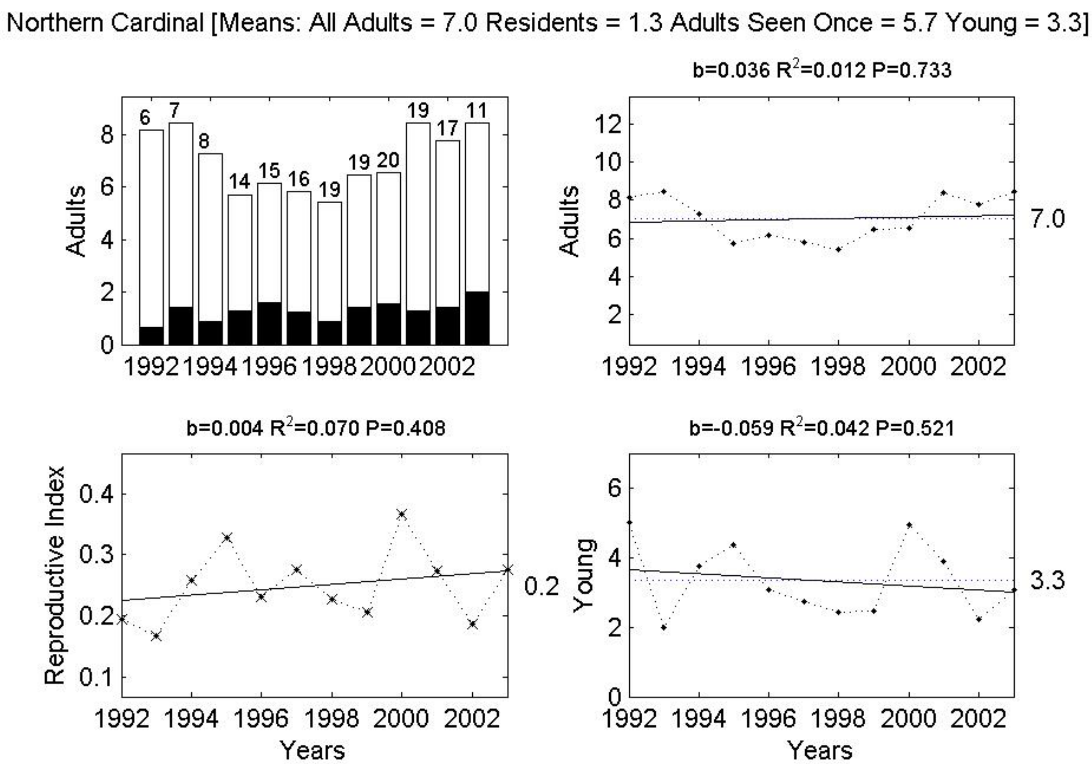


Demographic analyses of MAPS data for Eastern Towhee. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

NORTHERN CARDINAL (*CARDINALIS CARDINALIS*)

Regional Demographics

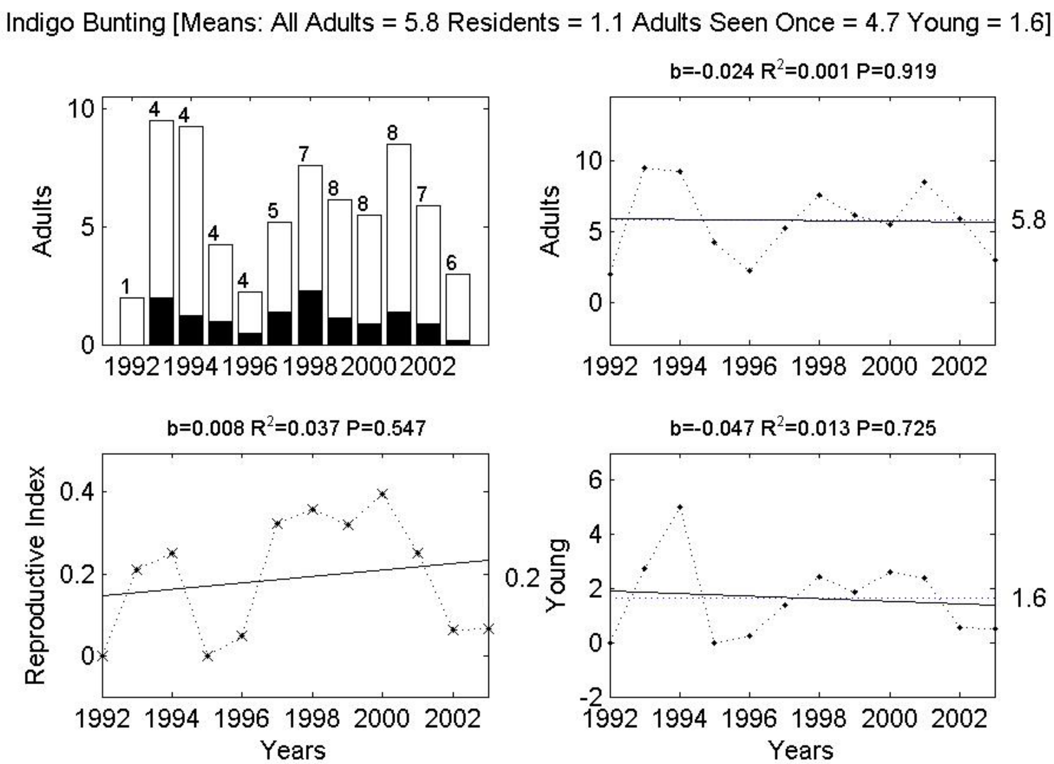
During the period 1992 to 2003 between 6 and 20 MAPS stations contributed data to Northern Cardinal demographic analyses. The proportion of resident birds varied considerably around 18%. Annual variation in the number of adults remained constant with mean of 7.0 adults per station per year and such that all the below average years covered the period 1995-2000. The numbers of young varied considerably with peaks in 1995 and 2000. Consequently, the reproductive index was highly variable (mean 0.25) with peaks in 1995 and 2000 when the numbers of young captured were very high and the numbers of adults were below average.



Demographic analyses of MAPS data for Northern Cardinal. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

INDIGO BUNTING (*PASSERINA CYANEA*)

Regional Demographics



Demographic analyses of MAPS data for Indigo Bunting. Top left pane shows annual numbers of adults (complete bar), residents (black) and the number of stations that contributed data (numeric). Also shown are regression plots and associated statistics for adults (top right), young (bottom right), and reproductive index (bottom left). Mean annual numbers are given on the right hand side of the plots.

These data were considered too sporadic to comment on.