

THE 2003 ANNUAL REPORT OF THE
MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP
(MAPS) PROGRAM
IN SHENANDOAH NATIONAL PARK

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May 12, 2004

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EXECUTIVE SUMMARY

Since 1989, The Institute for Bird Populations has been coordinating the Monitoring Avian Productivity and Survivorship (MAPS) Program, a cooperative effort among public and private agencies and individual bird banders in North America, to operate a continent-wide network of some 500 constant-effort mist-netting and banding stations. The purpose of the MAPS program is to provide annual indices of adult population size and post-fledging productivity, as well as estimates of adult survivorship and recruitment into the adult population, for various landbird species. Broad-scale data on productivity and survivorship are not obtained from any other avian monitoring program in North America and are needed to provide crucial information upon which to initiate research and management actions to reverse the documented declines in North American landbird populations. A second objective of the MAPS program is to provide standardized population and demographic data for the landbirds found in local areas or on federally managed public lands, such as national parks, national forests, and military installations. In this light, the MAPS program is being operated in Shenandoah National Park as part of the Park's Long-Term Ecological Monitoring (LTEM) program. It is expected that information from MAPS will be capable of aiding research and management efforts within the park to protect and enhance the park's avifauna and ecological integrity.

We operated six MAPS stations in Shenandoah National Park in 2003 at the same locations at which they were operated from 1993 to 2002. With few exceptions, the 16 net sites per station were operated for six morning hours per day on one day per 10-day period for seven consecutive 10-day periods between May 31 and August 5. A total of 584 birds was banded at the six stations during the summer of 2003, various individuals were recaptured a total of 196 times, and 57 birds were captured and released unhanded. Thus, a total of 837 captures of 41 species was recorded. As in previous years, the capture rate of adult birds (the index of adult population size) tended to be higher at higher elevation stations and those dominated by northern red oak than at stations dominated by chestnut oak or at lower elevation stations. In addition, stations dominated by northern red oak have tended to show higher productivity indices than other stations, with chestnut oak stations having slightly higher productivity than cove hardwood stations.

At the Pinnacle Cliff station, where the Pinnacles Fire of November 2000 reduced the cover of mountain laurel, the dominant shrub species at Pinnacle Cliff, both population sizes and productivity decreased disproportionately between 2000 and 2001 (i.e., as compared with other stations). In 2002, breeding populations of all species pooled again declined to a greater degree at Pinnacle Cliff than at any other station, whereas productivity increased by a greater degree at Pinnacle Cliff than at any other station. In 2003, breeding population sizes, number of young captured, and productivity all showed substantially larger increases at Pinnacle Cliff than at any other station, indicating that the bird community and likely the entire ecosystem is rebounding at this station. It will be interesting to see if populations and productivity at Pinnacle Cliff eventually surpass pre-fire levels, which would indicate the long-term benefits of occasional fire to breeding populations, and support the concept that controlled burns could be of value to the breeding birds of Shenandoah.

Although the overall trend in bird populations at Shenandoah National Park over the past 11 years has been stable, closer examination of the data indicates that the stable overall population trend actually reflects a slight but rather steady decrease after a substantial increase early in the study as species rebounded from the effects of a massive gypsy-moth defoliation. The non-significant decreases in population size between 2002 and 2003 for all stations combined may have been significantly negative were it not for a large increase in population size seen at the Pinnacle Cliff station (see above). Productivity trends showed 11-year declining tendencies in 12 of 17 species, with substantial and significant or near-significant declines noted for four species, vs. no such increases, and a near-substantial decline for all species pooled. Again, an overall productivity increase between 2002 and 2003 would likely have been a substantial decrease were it not for a dramatic increase in productivity at the Pinnacle Cliff station. These patterns indicate general declines in both population sizes and productivity indices at Shenandoah during the greater part of the study.

With 11 years of data, survival rate estimates could be obtained for 17 species, while the precision of the estimates of survival continues to improve. Annual adult apparent survival rates at Shenandoah during 1993-2003 compared reasonably well with that for the eastern regions of North America in 1992-1998, indicating that the declining tendencies at Shenandoah in recent years likely cannot be explained by poor survival. Continued monitoring may show that the long-term decreases in productivity are negatively impacting adult population sizes of species breeding in the Park. With appropriate future funding, we hope to address these questions by comparing productivity values at Shenandoah with those from surrounding areas and by analyzing productivity and population size as a function of landscape-level and climate-related variables.

Previous extensive analyses conducted on 1992-1996 MAPS data indicated that the indices and estimates of primary demographic parameters (productivity and survivorship) of common landbird species produced by the MAPS Programs in Shenandoah National Park could adequately predict the short-term population trends of those species. Subsequent broad-scale analyses of MAPS data have confirmed these results for many other regions. As a result, the indices and estimates of primary demographic parameters produced by MAPS will be extremely useful for the management and conservation of landbirds, both at Shenandoah National Park, and, in combination with similar data from other areas, across all of North America.

We have continued to undertake broad-scale analyses of MAPS data at regional levels to help understand the population dynamics of landbirds and to enhance the formulation of potential management actions to reverse population declines. The aim of these analyses is to enhance the understanding of the broad-scale dynamics of bird populations in national parks and other public lands and to help formulate recommendations for management strategies for these bird species. Indeed, the ultimate objective of the MAPS Program is to identify generalized management guidelines and formulate specific management actions that can be implemented on National Parks and elsewhere to reverse the population declines of target landbird species and to maintain the populations of stable or increasing species. Management strategies for species for which low productivity (or survival) appears to be driving the population decline will involve efforts to

modify the habitat from characteristics associated with low productivity (or survival) to characteristics associated with high productivity (or survival).

As an example of this approach, by means of funding from the DoD Legacy Resources Management Program, we have described relationships between landscape-level habitat characteristics and four demographic variables (adult population size, population trends, numbers of young, and productivity) from MAPS data, and have formulated of management strategies based on these relationships for a number of target Species of Conservation Concern (Nott et al. 2003). We are currently implementing these guidelines and actions on DoD installations in conjunction with efforts to increase military Readiness and Range Sustainment. The strategy for implementation includes the establishment of new MAPS stations to monitor the effectiveness of the guidelines, the discontinuing of an equal number of old stations, and the continued operation of other old stations to serve as controls for the new management stations. The ultimate goal is to evaluate the efficiency of these management practices and to modify them in an adaptive management process. If appropriate funding can be secured, we hope to be able to undertake similar analyses using data from Shenandoah National Park and the surrounding region.

Based upon all of the above information, we conclude that the MAPS protocol is extremely well-suited to provide a component of Shenandoah's Long-term Ecological Monitoring Program (LTEM). We recommend, therefore, that the MAPS Program be included as an integral part of Shenandoah's LTEM, and that operation at the six currently active stations be sustained well into the future.

INTRODUCTION

The National Park Service (NPS) has been charged with the responsibility of managing natural resources on lands under its jurisdiction in a manner that conserves them unimpaired for future generations. In order to carry out this charge, the NPS is implementing integrated long-term programs for inventorying and monitoring the natural resources in national parks and other NPS units. A pilot study to develop and evaluate field and analytical techniques to accomplish these objectives was first implemented in four national parks across the United States. The goals of this pilot program were to develop: (1) quantitative sampling and analytical methods that can provide relatively complete inventories and long-term trends for many components of biological diversity; and (2) effective means of monitoring the ecological processes driving the trends. An additional goal was that the methods evaluated be useful in other national parks and seashores across the United States. These programs are referred to as Long-term Ecological Monitoring (LTEM) Programs.

The development of an effective long-term ecological monitoring program in the national parks can be of even wider importance than aiding the NPS in managing its resources. Because lands managed by the NPS provide large areas of relatively pristine ecosystems that promise to be maintained in a relatively undisturbed manner indefinitely into the future, studies conducted in national parks can provide invaluable information for monitoring natural ecological processes and for evaluating the effects of large-scale, even global, environmental changes. The national parks and other NPS units can also serve as critical control areas for monitoring the effects of relatively local land-use practices. Thus, long-term monitoring data from the national parks can provide information that is crucial for efforts to preserve natural resources and biodiversity on multiple spatial scales, ranging from the local scale to the regional or even continental scale.

Landbirds

Landbirds, because of their high body temperature, rapid metabolism, and high ecological position on most food webs, may be excellent indicators of the effects of local, regional, and global environmental change in terrestrial ecosystems. Furthermore, their abundance and diversity in virtually all terrestrial habitats, diurnal nature, discrete reproductive seasonally, and intermediate longevity facilitate the monitoring of their population and demographic parameters. It is not surprising, therefore, that landbirds have been selected by the NPS to receive high priority for monitoring. Nor is it surprising that several large-scale monitoring programs that provide annual population estimates and long-term population trends for landbirds are already in place on this continent. They include the North American Breeding Bird Survey (BBS), the Breeding Bird Census, the Winter Bird Population Study, and the Christmas Bird Count.

Recent analyses of data from several of these programs, particularly the BBS, suggest that populations of many landbirds, including forest-, scrubland-, and grassland-inhabiting species, appear to be in serious decline (Peterjohn et al. 1995). Indeed, populations of most landbird species appear to be declining on a global basis. Nearctic-Neotropical migratory landbirds (species that breed in North America and winter in Central and South America and the West Indies; hereafter, Neotropical migratory birds) constitute one group for which pronounced

population declines have been documented (Robbins et al. 1989, Terborgh 1989). In response to these declines, the Neotropical Migratory Bird Conservation Program, "Partners In Flight - Aves de las Americas," was initiated in 1991 (Finch and Stangel 1993). The major goal of Partners in Flight (PIF) is to reverse the declines in Neotropical migratory birds through a coordinated program of monitoring, research, management, education, and international cooperation. As one of the major cooperating agencies in PIF, the NPS has defined its role in the program to include the establishment of long-term monitoring programs at NPS units using protocols developed by the Monitoring Working Group of PIF. Clearly, the long-term ecological monitoring goals of the NPS and the monitoring and research goals of PIF share many common elements.

The goals of these programs differ, however, in at least one important respect. A major goal of PIF is to reverse population declines, especially in rare or uncommon (although not threatened or endangered) "priority" species, while a major objective of the NPS' LTEM program is to understand the ecological processes driving population changes. This latter goal often necessitates concentrating on relatively common or even abundant species that are undergoing population changes, rather than rare or uncommon ones. Thus, appropriate target species might be expected to differ somewhat between PIF and LTEM efforts.

Primary Demographic Parameters

Existing population-trend data on Neotropical migrants, while suggesting severe and sometimes accelerating declines, provide no information on primary demographic parameters (productivity and survivorship) of these birds. Thus, population-trend data alone provide no means for determining at what point(s) in the life cycles problems are occurring, or to what extent the observed population trends are being driven by causal factors that affect birth rates, death rates, or both (DeSante 1995). In particular, large-scale North American avian monitoring programs that provide only population-trend data have been unable to determine to what extent forest fragmentation and deforestation on the temperate breeding grounds, versus that on the tropical wintering grounds, are causes for declining populations of Neotropical migrants. Without critical data on productivity and survivorship, it will be extremely difficult to identify effective management and conservation actions to reverse current population declines (DeSante 1992).

The ability to monitor primary demographic parameters of target species must also be an important component of any successful long-term inventory and monitoring program that aims to monitor the ecological processes leading from environmental stressors to population responses (DeSante and Rosenberg 1998). This is because environmental factors and management actions generally affect primary demographic parameters directly and these effects usually can be observed over a short time period (Temple and Wiens 1989). Because of the buffering effects of floater individuals and density-dependent responses of populations, there may be substantial timelags between changes in primary parameters and resulting changes in population size or density as measured by census or survey methods (DeSante and George 1994). Thus, a population could be in trouble long before this becomes evident from survey data. Moreover, because of the vagility of many animal species, especially birds, local variations in secondary parameters (e.g., population size or density) may be masked by recruitment from a wider region (George et al. 1992) or accentuated by lack of recruitment from a wider area (DeSante 1990). A

successful monitoring program should be able to account for these factors.

Finally, a successful monitoring program should be able to detect significant differences in productivity as a function of such local variables as landscape-level habitat characteristics or degree of habitat disturbance. The detection of such differences can lead to immediate management implementation within a national park, especially for species where long-term demographic monitoring suggests that declines are related to local (e.g., productivity) rather than remote (e.g., overwinter survival in Neotropical migrants) factors.

MAPS

In 1989, The Institute for Bird Populations (IBP) established the Monitoring Avian Productivity and Survivorship (MAPS) program, a cooperative effort among public agencies, private organizations, and individual bird banders in North America to operate a continent-wide network of constant-effort mist-netting and banding stations to provide long-term demographic data on landbirds (DeSante et al. 1995). The design of the MAPS program was patterned after the very successful British Constant Effort Sites (CES) Scheme that has been operated by the British Trust for Ornithology since 1981 (Peach et al. 1996). The MAPS program was endorsed in 1991 by both the Monitoring Working Group of PIP and the USDI Bird Banding Laboratory, and a four-year pilot project (1992-1995) was approved by the USDI Fish and Wildlife Service and National Biological Service (now the Biological Resources Division [BRD] of the U.S. Geological Survey [USGS]) to evaluate its utility and effectiveness for monitoring demographic parameters of landbirds. A peer review of the program and of the evaluation of the pilot project was completed by a panel assembled by USGS/BRD (Geissler 1996). The review concluded that: (1) MAPS is technically sound and is based on the best available biological and statistical methods; and (2) it complements other landbird monitoring programs such as the BBS by providing useful information on landbird demographics that is not available elsewhere.

Now in its 15th year (12th year of standardized protocol and extensive distribution of stations), the MAPS program has expanded greatly from 178 stations in 1992 to nearly 500 stations in 1999-2003. The substantial growth of the Program since 1992 was caused by its endorsement by PIF and the subsequent involvement of various federal agencies in PIF, including the NPS, USDA Forest Service, US Fish and Wildlife Service, Department of Defense, Department of the Navy, and Texas Army National Guard. Within the past ten years, for example, IBP has been contracted to operate up to six MAPS stations in Shenandoah National Park, as well as six in Denali, five in Yosemite, and two in Kings Canyon national parks, and six on Cape Cod National Seashore. MAPS stations were established in these NPS units in order to evaluate the usefulness of the MAPS methodology as a major component of the NPS's Long-Term Ecological Monitoring Program and, subsequently, to implement its use as part of that program.

Goals and Objectives of MAPS

MAPS is organized to fulfill three tiers of goals and objectives: monitoring, research, and management.

- The specific monitoring goals of MAPS are to provide, for over 100 target species, including Neotropical-wintering migrants, temperate-wintering migrants, and permanent residents:
 - (A) annual indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured; and
 - (B) annual estimates of adult population size, adult survival rates, proportions of residents among newly captured adults, recruitment rates into the adult population, and population growth rates from modified Cormack-Jolly-Seber analyses of mark-recapture data on adult birds.
- The specific research goals of MAPS are to identify and describe:
 - (1) temporal and spatial patterns in these demographic indices and estimates at a variety of spatial scales ranging from the local landscape to the entire continent; and
 - (2) relationships between these patterns and ecological characteristics of the target species, population trends of the target species, station-specific and landscape-level habitat characteristics, and spatially-explicit weather variables.
- The specific management goals of MAPS are to use these patterns and relationship, at the appropriate spatial scales, to:
 - (a) identify thresholds and trigger points to notify appropriate agencies and organizations of the need for further research and/or management actions;
 - (b) determine the proximate demographic cause(s) of population change;
 - (c) suggest management actions and conservation strategies to reverse population declines and maintain stable or increasing populations; and
 - (d) evaluate the effectiveness of the management actions and conservation strategies actually implemented through an adaptive management framework.

The overall objectives of MAPS are to achieve the above-outlined goals by means of long-term monitoring at two major spatial scales. The first is a very large scale — effectively the entire North American continent divided into eight geographic regions. It is envisioned that the national parks, along with national forests, military installations, and other publically owned lands, will provide a major subset of sites for this large-scale objective.

The second, smaller-scale but still long-term objective is to fulfill the above-outlined goals for specific geographic areas (perhaps based on BBS physiographic strata, such as the Northern Piedmont, Ridge and Valley, or Allegheny Plateau, or the newly described Bird Conservation Regions) or specific locations (such as individual national parks, national forests, or military

installations). The objective for MAPS at these smaller scales is to aid research and management efforts within the areas, parks, forests, or installations to protect and enhance their avifauna and ecological integrity. The sampling strategy utilized at these smaller scales should be hypothesis-driven and should be integrated with other research and monitoring efforts.

Both long-term objectives are in agreement with objectives laid out for the NPS's Long-Term Ecological Monitoring Program. Accordingly, the MAPS program was established in Shenandoah National Park as part of the development of Shenandoah's LTEM Program. It is expected that information from the MAPS program will be capable of aiding research and management efforts within the park to protect and enhance the park's avifauna and ecological integrity.

Recent Important Results from MAPS

Recent important results from MAPS reported in the peer-reviewed literature include the following. (1) Age ratios obtained during late summer, population-wide mist netting provided a good index to actual productivity in the Kirtland's Warbler (Bart et al. 1999). (2) Measures of productivity and survival derived from MAPS data were consistent with observed population changes at multiple spatial scales (DeSante et al. 1999). (3) Patterns of productivity from MAPS at two large spatial scales (eastern North America and the Sierra Nevada) not only agreed with those found by direct nest monitoring and those predicted from theoretical considerations, but were in general agreement with current life-history theory and were robust with respect to both time and space (DeSante 2000). (4) Modeling spatial variation in MAPS productivity indices and survival-rate estimates as a function of spatial variation in population trends provides a successful means for identifying the proximate demographic cause(s) of population change at multiple spatial scales (DeSante et al. 2001). (5) Productivity of landbirds breeding in Pacific Northwest national forests is affected by global climate cycles including the El Nino Southern Oscillation and the North Atlantic Oscillation, in such a manner that productivity of Neotropical migratory species is determined more by late winter and early spring weather conditions on their wintering grounds than by late spring and summer weather conditions on their breeding grounds (Nott et al. 2002). These results indicate that MAPS is capable of achieving, and in some cases is already achieving, its objectives and goals.

SPECIFICS OF THE SHENANDOAH MAPS PROGRAM

Goals

The specific goals for the initial operation of the MAPS Program in Shenandoah National Park were to:

- (1) evaluate the ability and effectiveness of MAPS to provide a useful component of the long-term inventory and monitoring program in Shenandoah National Park; and
- (2) determine the effectiveness of various MAPS stations in Shenandoah National Park to provide reliable demographic information on the landbirds of the Eastern deciduous forest environment.

The current goal for the Shenandoah MAPS program is to continue to monitor the primary demographic parameters of Shenandoah's landbirds as part of Shenandoah's LTEM program in order to provide critical information that can be used to aid our understanding of the ecological processes leading from environmental stressors to populations responses. To achieve this goal, we will first need to analyze spatial patterns in productivity indices and survival rate estimates as a function of spatial patterns in population trends for target species, in order to determine the proximate demographic factor (i.e., productivity or survivorship) causing the observed population trends (DeSante et al. 2001). We will then need to link MAPS data with landscape-level habitat data and spatially explicit weather data in a geographical information system (GIS) to identify relationships between landscape-level habitat and/or weather characteristics and the primary demographic responses (productivity and survival rates) of the target species. This will allow hypotheses to be generated regarding the ultimate environmental causes of the population trends. Successful completion of this approach will necessitate analyses of MAPS stations from areas larger than just Shenandoah National Park. For example, Shenandoah data will need to be compared to data from relatively pristine ecosystems (e.g., other national parks) at other locations, and from data in more heavily managed or disturbed ecosystems in eastern North America. It should be noted that funding for such analyses does not currently exist and sources of future funding have not yet been identified. We suggest that such analyses should be implemented after 12 consecutive years of data have been collected, that is, after the 2004 breeding season.

Establishment and Operation of Stations

Six MAPS stations were re-established and operated in Shenandoah National Park in 2003 in exactly the same locations where they were operated in 2002. Two stations (Pinnacle Cliff and Hazeltop Ridge) have been operated for twelve years (1992-2003); both of these stations, however, were modified considerably in 1993, and data from 1992 is not included in this report. The remaining four stations (Big Run, Dean Mountain, Jeremy's Run, and Crescent Rock) have been operated for eleven years (1993-2003). The six stations are located (from highest to lowest elevation) as follows: (1) the Crescent Rock station in red oak habitat at about 1067 m elevation on the east side of Skyline Drive opposite the Crescent Rock parking area between mileposts 44

and 45; (2) the Pinnacle Cliff station in red oak habitat at about 1036 m elevation on the west side of Skyline Drive between mileposts 35 and 36; (3) the Dean Mountain station in cove hardwood habitat at about 945 m elevation on the west side of Skyline Drive approximately 1/8 mile south of milepost 61; (4) the Hazeltop Ridge station in cove hardwood habitat at about 910 m elevation on the west side of Skyline Drive south of the Hazeltop Ridge parking area between mileposts 54 and 55; (5) the Big Run station in chestnut oak habitat at about 762 m elevation on the west side of Skyline Drive between mileposts 81 and 82; and (6) the Jeremy's Run station in chestnut oak habitat at about 762 m elevation on the west side of Skyline Drive between mileposts 25 and 26. A summary of the 2003 Shenandoah MAPS operation and the major habitats represented at each of the six stations is presented in Table 1.

The 2003 Shenandoah MAPS Program

The 2003 Shenandoah field biologist interns, Leah Gibbons, Lauren Hoffstetter, and Derek Robertson received two weeks of intensive training in a comprehensive course in mist netting and bird-banding techniques given by IBP biologist Amy McAndrews during the first two weeks of May, 2003, at the Jug Bay Wetland Sanctuary near Chesapeake Bay, Maryland. Amy and the three interns arrived at Shenandoah National Park on May 14 to re-establish the stations; data collection began on May 29. Amy McAndrews then provided part-time supervision of the 2003 interns for the duration of their field work at Shenandoah.

All 16 net sites at each station were re-established without difficulty in the exact same locations as in 1993-2002. One 12m, 30mm-mesh, 4-tier, nylon mist net was erected at each of the 16 net sites on each day of operation. Each station was operated for six morning hours per day (beginning at local sunrise) on one day in each of seven consecutive 10-day periods between Period 4 (beginning May 31 [or up to five days earlier for logistical considerations]) and Period 10 (beginning July 30). With very few exceptions, the operation of all stations occurred on schedule in each of the seven 10-day periods. A summary of the 2003 operation of the MAPS Program at Shenandoah and the major habitats at each of the six stations is presented in Table 1.

METHODS

The operation of each of the six stations during 2003 and during each of the preceding years followed MAPS protocol, as established for use by the MAPS Program throughout North America and spelled out in the MAPS Manual (DeSante et al. 2003). A brief overview of both the field and analytical techniques applied in 2003 is presented here.

Data Collection

With few exceptions, all birds captured during the course of the study were identified to species, age, and sex and, if unbanded, were banded with USGS/BRD numbered aluminum bands. Birds were released immediately upon capture and before being banded or processed if situations arose where bird safety would be compromised. Such situations involved exceptionally large numbers of birds being captured at once, or the sudden onset of adverse weather conditions such as high winds or sudden rainfall. The following data were taken on all birds captured, including recaptures, according to MAPS guidelines using standardized codes and forms:

- (1) capture code (newly banded, recaptured, band changed, unbanded);
- (2) band number;
- (3) species;
- (4) age and how aged;
- (5) sex (if possible) and how sexed (if applicable);
- (6) extent of skull pneumaticization;
- (7) breeding condition of adults (i.e., presence or absence of a cloacal protuberance or brood patch);
- (8) extent of Juvenal plumage in young birds;
- (9) extent of body and flight-feather molt;
- (10) extent of primary-feather wear;
- (11) fat class;
- (12) wing chord and body mass;
- (13) date and time of capture (net-run time); and
- (14) station and net site where captured.

Effort data (i.e., the number of hours of operation for each net on each day) were also collected in a standardized manner. In order to allow constant-effort comparisons of data to be made, the times of opening and closing the array of mist nets and of beginning each net check were recorded to the nearest ten minutes. The breeding status (confirmed breeder, likely breeder, non-breeder) of each species seen, heard, or captured at each MAPS station on each day of operation was recorded using techniques similar to those employed for breeding bird atlas projects.

For each of the six stations operated, simple habitat maps were prepared on which up to four major habitat types, as well as the locations of all structures, roads, trails, and streams, were identified and delineated; when suitable maps from previous years were available, these were used. The pattern and extent of cover of each major habitat type identified at each station, as

well as the pattern and extent of cover of each of four major vertical layers of vegetation (upperstory, midstory, understory, and ground cover) in each major habitat type were classified into one of twelve pattern types and eleven cover categories according to guidelines spelled out in the MAPS Habitat Structure Assessment Protocol (Nott et al. 2003a).

Computer Data Entry and Verification

The computer entry of all banding data was completed by John W. Shipman of Zoological Data Processing, Socorro, NM. The critical data for each banding record (capture code, band number, species, age, sex, date, capture time, station, and net number) were proofed by hand against the raw data and any computer-entry errors were corrected. Computer entry of effort and vegetation data was completed by IBP biologists using specially designed data entry programs. All banding data were then run through a series of verification programs as follows:

- (1) Clean-up programs to check the validity of all codes entered and the ranges of all numerical data;
- (2) Cross-check programs to compare station, date, and net fields from the banding data with those from the summary of mist netting effort data;
- (3) Cross-check programs to compare species, age, and sex determinations against degree of skull pneumaticization, breeding condition (extent of cloacal protuberance and brood patch), and extent of body and flight-feather molt, primary-feather wear, and juvenal plumage;
- (4) Screening programs which allow identification of unusual or duplicate band numbers or unusual band sizes for each species; and
- (5) Verification programs to screen banding and recapture data from all years of operation for inconsistent species, age, or sex determinations for each band number.

Any discrepancies or suspicious data identified by any of these programs were examined manually and corrected if necessary. Wing chord, weight, station of capture, date, and any pertinent notes were used as supplementary information for the correct determination of species, age, and sex in all of these verification processes.

Data Analysis

To facilitate analyses, we first classified the landbird species captured in mist nets into five groups based upon their breeding or summer residency status. Each species was classified as one of the following: a regular breeder (B) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS station *during all years* that the station was operated; a usual breeder (U) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS station *during more than half but not all of the years* that the station was operated; an occasional breeder (O) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS station *during half or fewer of the years* that the station was operated; a transient (T) if the species was *never* a breeder or summer resident at the station, but the station was within the overall breeding range of the species; and a migrant (M) if the station was not located within the overall breeding range of the species. Data for a given species from a given station were included in productivity analyses

if the station was within the breeding range of the species; that is, data were included from stations where the species was a breeder (B, U, or O) or transient (T), but not where the species was a migrant (M). Data for a given species from a given station were included in survivorship analyses and in analyses of population and productivity trends only if the species was classified as a regular (B) or usual (U) breeder at the station.

A. Population-size and productivity analyses — The proofed, verified, and corrected banding data from 2003 were run through a series of analysis programs that calculated for each species and for all species combined at each station and for all stations pooled:

- (1) the numbers of newly banded birds, recaptured birds, and birds released unhanded;
- (2) the numbers and capture rates (per 600 net-hours) of first captures (in 2003) of individual adult and young birds; and
- (3) the proportion of young in the catch.

Following the procedures pioneered by the British Trust for Ornithology (BTO) in their CES Scheme (Peach et al. 1996), the number of adult birds captured was used as an index of adult population size and the proportion of young in the catch was used as an index of productivity.

For each of the six stations, we calculated changes between 2002 and 2003 in the indices of adult population size and post-fledging productivity, and determined the statistical significance of any changes that occurred according to methods developed by the BTO in their CES scheme (Peach et al. 1996). These year-to-year comparisons were made in a "constant-effort" manner by means of a specially designed analysis program that used actual net-run (capture) times and net-opening and -closing times on a net-by-net and period-by-period basis to exclude captures that occurred in a given net in a given period in one year during the time when that net was not operated in that period in the other year. For species captured at several stations in Shenandoah National Park, the significance of park-wide annual changes in the indices of adult population size and post-fledging productivity was inferred statistically using confidence intervals derived from the standard errors of the mean percentage changes. The statistical significance of the overall change at a given station was inferred from a one-sided binomial test on the proportion of species at that station that increased (or decreased). Throughout this report, we use an alpha level of 0.05 for statistical significance and we use the term "near-significant" or "nearly significant" for differences for which $0.05 \leq P < 0.10$.

B. Analyses of trends in adult population size and productivity — We examined 11-year trends in indices of adult population size and productivity for target species for which an average of at least six individual adult birds were captured per year at all stations combined at which the species was a regular or usual breeder during the 11 years, 1993-2003. For trends in adult population size, we first calculated adult population indices for each species for each of the 11 years based on an arbitrary starting index of 1.0 in 1993. Constant-effort changes (as defined above) were used to calculate these "chain" indices in each subsequent year by multiplying the proportional change (percent change divided by 100) between the two years times the index of the previous year and adding that figure to the index of the previous year, or simply:

$$PSI_{i+1} = PSI_i + PSI_i * (d_i/100)$$

where PSI_i is the population size index for year i and d_i is the percentage change in constant-effort numbers from year i to year $i+1$. A regression analysis was then run to determine the slope (PT) of these indices over the ten year period. Because the indices for adult population size are based on percentage changes, we further calculated the annual percent change (APC), defined as the average change per year over the ten year period, to provide an estimate of the population trend for the species; APC was calculated as:

$$(\text{actual 1993 value of } PSI / \text{predicted 1993 value of } PSI \text{ based on the regression}) * PT.$$

We present the APC , the standard error of the slope (SE), the correlation coefficient (r), and the significance of the correlation (P) to describe each trend. Species for which $r > 0.5$ are considered to have a substantially increasing trend, those for which $r < -0.5$ are considered to have a substantially decreasing trend, those for which $-0.5 < r < 0.5$ and $SE < 0.029$ are considered to have a stable trend, and those for which $-0.5 < r < 0.5$ and $SE > 0.029$ are considered to have widely fluctuating values but no substantial trend.

Trends in productivity, PrT , were calculated in an analogous manner by starting with actual productivity values in 1993 and calculating each successive year's value based on the actual constant-effort changes in productivity between each pair of consecutive years. For trends in productivity, the slope (PrT) and its standard error (SE) are presented, along with the correlation coefficient (r), and the significance of the correlation (P). Productivity trends are characterized in a manner analogous to that for population trends, except that productivity trends are considered to be highly fluctuating if the SE of the slope > 0.017 .

C. Survivorship analyses — Modified Cormack-Jolly-Seber (CJS) mark-recapture analyses (Pollock et al. 1990, Lebreton et al. 1992) were conducted using the computer program SURVTV (White 1983) on 11 years of banding data (1993-2003) pooled from all of the six stations at which the species was a regular or usual breeders at the station, and for which, on average, at least six individual adults per year were captured at all appropriate stations combined over the 11 years (1993-2003).

Using SURVTV, we estimated survivorship parameters for each of the target species using both a between- and within-year transient model which accounts for the presence of transient adults (migrant and floater individuals which are only captured once) in the sample of newly captured birds (Pradel et al. 1997, Nott and DeSante 2002). The transient model permits calculation of maximum-likelihood estimates and standard errors (SE) for adult survival probability (f), adult recapture probability (p), and proportion of residents among newly-captured adults (t). Recapture probability is defined as the conditional probability of recapturing a bird in a subsequent year that was banded in a previous year, given that it survived and returned to the place it was originally banded. These estimates were derived from the capture histories of all adult birds for each target species captured at all stations at which they were classified as regular (B) or usual (U) breeders (see above). Here we report the results of time-constant models.

RESULTS

A total of 3304.2 net-hours was accumulated at the six MAPS stations operated in Shenandoah National Park in 2003 (Table 1). Data from 2971.0 of these net-hours could be compared directly to 2002 data in a constant-effort manner.

Indices of Adult Population Size and Post-fledging Productivity

A. 2003 values — For each individual species and for all species pooled, the numbers of individual birds newly banded, released unbanded, and recaptured, are presented for each station in Table 2, and for all stations combined in Table 4. A total of 837 captures of 41 species occurred at Shenandoah during the summer of 2003 (Table 4). Newly banded birds comprised 69.8% of the total captures. The greatest number of total captures (229) was recorded at the Jeremy's Run station and the smallest number of total captures (90) was recorded at the Big Run station. The highest species richness occurred at Crescent Rock (25 species) and the lowest species richness occurred at Big Run (14 species).

The capture rates (per 600 net-hours) of individual adult and young birds and the proportion of young in the catch are presented for each species and for all species pooled at each station in Table 3, and for all stations combined in Table 4. We present capture rates (captures per 600 net-hours) of adults and young in these tables so that the data can be compared among stations which, because of the vagaries of weather and accidental net damage, can differ from one another in effort expended (Table 1). Adult population size (for all species pooled) was highest at Jeremy's Run (131.8 birds/600 net-hours), followed in descending order by Crescent Rock (95.9), Dean Mountain (92.8), Pinnacle Cliff (69.8), Hazeltop Ridge (64.6), and Big Run (49.3).

Captures of young (Table 3) of all species pooled at each station in 2003 followed a different sequence, being highest at Pinnacle Cliff, followed by Jeremy's Run, Big Run, Crescent Rock, Dean Mountain, and Hazeltop Ridge. Productivity (Table 3), as determined by the proportion of young in the catch, followed sequence rather similar to that of numbers of young captured, being highest at Pinnacle Cliff (0.57), followed in descending order by Big Run (0.37), Jeremy's Run (0.29), Crescent Rock (0.19), Dean Mountain (0.17), and Hazeltop Ridge (0.13).

Among individual species, American Redstart was the most frequently captured, followed by Dark-eyed Junco, Ovenbird, Worm-eating Warbler, Hooded Warbler, Black-and-white Warbler and Eastern Towhee, Wood Thrush, Veery, and Red-eyed Vireo. 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. The following is a list of the common breeding species (captured at a rate of at least 4.0 adults per 600 net-hours), in decreasing order, at each station in 2003 (see Table 3):

Crescent Rock

American Redstart
Ovenbird
Red-eyed Vireo
Veery
Black-and-white Warbler

Pinnacle Cliff

American Redstart
Gray Catbird
Dark-eyed Junco
Eastern Towhee
Veery

Dean Mountain

Wood Thrush
Veery
American Redstart
Ovenbird

Hazeltop Ridge

American Redstart
Wood Thrush
Ovenbird
Scarlet Tanager

Big Run

Worm-eating Warbler
Ovenbird
Black-and-white Warbler
Hooded Warbler

Jeremy's Run

American Redstart
Worm-eating Warbler
Hooded Warbler
Eastern Towhee
Black-and-white Warbler
Red-eyed Vireo
Ovenbird

B. Comparisons between 2002 and 2003 — Constant-effort comparisons between 2002 and 2003 were undertaken at all six Shenandoah MAPS stations for numbers of adult birds captured (adult population size; Table 5), numbers of young birds captured (Table 6), and proportion of young in the catch (productivity; Table 7).

Adult population size for all species pooled at all six stations combined decreased non-significantly between 2002 and 2003 by -15.3% (Table 5). Decreases were recorded for 25 of 40 species, a proportion that was near-significantly greater than 0.50 ($P = 0.077$). The number of adults captured of all species pooled decreased at three of the six stations by amounts ranging from -23.7% at Big Run to -44.0% at Dean Mountain, and increased at three stations by amounts ranging from +2.5% at Jeremy's Run to +41.3% at Pinnacle Cliff. The proportion of decreasing species at Hazeltop Ridge was nearly significantly greater than 0.50. Six species (Red-eyed Vireo, Tufted Titmouse, Veery, Ovenbird, Dark-eyed Junco, and Indigo Bunting) showed significant or near-significant decreases in adult population size across stations, whereas only one species (Worm-eating Warbler) showed such an increase.

The number of young birds captured of all species pooled for all stations combined decreased by -5.3%, a slight and non-significant change (Table 6). Decreases between 2002 and 2003 were recorded for 16 of 29 species, a proportion not significantly greater than 0.50. The overall change in number of young captured for all species pooled decreased at four of the stations, by amounts ranging from -26.7% at Big Run to -72.1% at Dean Mountain, and increased by +1.9% at Jeremy's Run and +131.6% at Pinnacle Cliff. The proportion of increasing or decreasing species was not significantly greater than 0.50 at any station. At all stations pooled, significant or near-significant decreases were noted for four species (Downy Woodpecker, Tufted Titmouse, Worm-eating Warbler, and Eastern Towhee) whereas no species showed such an increase.

Productivity (the proportion of young in the catch) showed a non-significant increase of +0.024 from 0.291 in 2002 to 0.315 in 2003 for all species pooled and all stations combined (Table 7). Despite the small overall increase, decreases in productivity were recorded for a majority of

species (15 of 29 vs. 9 increases), a proportion, however, that was not significantly greater than 0.50. This indicates that some of the more common species (such as Ovenbird, Hooded Warbler, and Dark-eyed Junco) showed increases in productivity. Decreases in productivity for all species pooled were also noted for five of the six stations, by amounts ranging from -0.001 at Jeremy's Run to -0.115 at Dean Mountain, whereas these were apparently more than offset by the increase of +0.123 at Pinnacle Cliff. The proportion of increasing or decreasing species was not significantly greater than 0.50 at any stations. One species, Gray Catbird, showed a near-significant increase in productivity across all stations, and one species, Worm-eating Warbler, showed a significant decrease across stations.

Thus, in general, adult population sizes, numbers of young, and productivity all tended to decline between 2002 and 2003 at most Shenandoah stations except Pinnacle Cliff, where adult population sizes showed their largest increase, numbers of young showed by far its very largest increase, and productivity showed its only increase. These patterns appeared not to be species-wide (some of the more common species showed increases in productivity whereas many less-common species showed decreases) but this non-species-wide pattern could have been caused by the marked differences between Pinnacle Cliff (which has a somewhat different species composition from the other stations) and the other five stations. Changes in numbers of young and productivity also tended to be slightly more positive at Jeremy's Run between 2002 and 2003 than they were at the remaining four stations.

C. Eleven-year Mean Population Size and Productivity Values — Table 8 gives mean annual numbers of individual adults captured per 600 net-hours (an index of adult population size), numbers of young captured per 600 net-hours, and proportion of young in catch (an index of productivity) during the 11-year period 1993-2003 for all species at each of the six stations and for all stations pooled. Over the 11-year period, breeding population size was highest at Dean Mountain, followed by Crescent Rock, Pinnacle Cliff, Jeremy's Run, Big Run, and Hazeltop Ridge, whereas productivity was highest at Pinnacle Cliff, followed by Crescent Rock, Jeremy's Run, Big Run, Dean Mountain, and Hazeltop Ridge. Species richness followed yet a different order, being highest at Big Run, followed by Pinnacle Cliff and Jeremy's Run, Crescent Rock, Dean Mountain, and Hazeltop Ridge.

Higher-elevation stations (Crescent Rock, Pinnacle Cliff, and Dean Mountain) had higher adult population sizes (mean 114.6) than lower-elevation stations (Hazeltop Ridge, Big Run, Jeremy's Run; mean 80.9). Red-oak stations (Crescent Rock and Pinnacle Cliff; mean 104.7) and cove-hardwood stations (Dean Mountain and Hazeltop Ridge; mean 103.9) had higher adult population sizes than chestnut-oak stations (Big Run and Jeremy's Run; mean of 84.7). Numbers of young captured followed a similar pattern, with more at higher-elevation stations (mean 71.5) than at lower-elevation stations (mean 43.9); although the mean for red oak stations (74.9) was substantially higher than that for chestnut-oak stations (49.2) and cove-hardwood stations (49.0). Thus, productivity for the eleven-year period was greater at higher elevation stations (0.38) than at lower elevation stations (0.34) and was highest at the two red-oak stations (0.41), followed by the two cove hardwood stations (0.36), and finally by the two chestnut-oak stations (0.31).

D. Eleven-year Trends in Adult Population Size and Productivity — "Chain" indices of adult population size for each of the 11 years (1993-2003) are presented for 17 target species and for all species pooled in Figure 1. See Methods for an explanation of the calculations used to obtain these indices. The annual percentage change (*APC*) and its standard error (*SE*, in parentheses), the correlation coefficient (*r*), and the significance of the correlation (*P*) for each of the 17 target species and all species pooled are also presented in Figure 1. Note that, for Tufted Titmouse, we began the analysis in 1994 rather than 1993 because no adults were captured in 1993. Trends for four of the 17 species (Tufted Titmouse, Wood Thrush, Black-and-white Warbler, and Eastern Towhee) showed substantial increases ($r > 0.5$), with the trend for Tufted Titmouse being nearly significant, that for Eastern Towhee being significant, and those for Wood Thrush and Black-and-white Warbler being highly significant. Trends for five species (Blue-headed Vireo, Veery, Gray Catbird, Chestnut-sided Warbler, and Indigo Bunting) showed substantial declines ($r < -0.5$), with that of Veery being nearly significant and those of Gray Catbird, Chestnut-sided Warbler, and Indigo Bunting being significant. Trends for two species (Dark-eyed Junco and Rose-breasted Grosbeak) as well as all species pooled were fairly stable, with absolute $r < 0.5$ and $SE < 0.029$; all species pooled and Dark-eyed Junco were virtually flat while Rose-breasted Grosbeak showed a nearly substantial decrease. The remaining six species (Red-eyed Vireo, American Redstart, Worm-eating Warbler, Ovenbird, Hooded Warbler, and Scarlet Tanager) showed erratic fluctuations ($SE > 0.029$), but no definite trend (absolute $r < 0.5$). Five of these species (all but American Redstart), however, showed increasing tendencies. Thus, overall, nine species showed increases and eight species showed decreases. The annual percentage change (*APC*) in adult population size between 1993 and 2003 varied from -7.1% for Chestnut-sided Warbler to +22.5% for Tufted Titmouse, and was +0.1% for all species pooled.

Figure 2 shows 11-year trends in productivity for all 17 target species and all species pooled. No species had a substantial increasing productivity trend ($r > 0.5$), whereas four species (Veery, Wood Thrush, American Redstart, and Ovenbird) showed substantial decreasing trends ($r < -0.5$), all of which were significant. Productivity trends for two species, Rose-breasted Grosbeak and Indigo Bunting showed erratic fluctuations ($SE > 0.017$), but no definite trend (absolute $r < 0.5$), although both showed an increasing tendency. Productivity trends for the remaining 11 species and for all species pooled were relatively stable (absolute $r < 0.5$, $SE < 0.017$), although eight of these 11 trends (and 12 of 17 overall) were negative. The trend for all species pooled was near-substantially negative ($r = -0.480$).

Many species showed opposite temporal patterns of population size and productivity, reflecting a situation seen at many MAPS stations and indicating that increased breeding success leads to higher recruitment, which in turn results in lower reproductive success, and vice versa. At many MAPS stations this pattern shows a two-year cycle, sometimes disrupted (or compounded) by meteorological or phenological conditions. At Shenandoah, these patterns likely were disrupted by the gypsy-moth defoliation of the early 1990's, with recent data perhaps suggesting a return to a more stable two-year cycle, although both population size and productivity declined between 2002 and 2003. Veery showed an unusual pattern in which both productivity and population trend were significantly negative, suggesting that the species could be in trouble and should be watched closely. Blue-headed Vireo, Gray Catbird, and American Redstart also showed

decreases in both productivity and population size, although for none of the three species were both parameters significantly negative.

Estimates of Adult Survivorship

Estimates of adult survival and recapture probabilities, using transient models, could be obtained for all 17 target species breeding at Shenandoah National Park using 11 years of data (Table 9). The time-constant estimates for survival probability ranged from a low of 0.297 for Dark-eyed Junco to a high of 0.728 for Scarlet Tanager, and averaged 0.474. Recapture probabilities ranged from a low of 0.048 for Scarlet Tanager to a high of 0.729 for Chestnut-sided Warbler, and averaged 0.392. Proportion of residents varied from a low of 0.265 for Rose-breasted Grosbeak to a high of 1.000 for Tufted Titmouse and Scarlet Tanager, and averaged 0.526. The CV(f) for these 17 species ranged from 3.9% for Veery to 56.9% for Rose-breasted Grosbeak, and averaged 19.7%. This compares with a mean CV of 22.4% based on ten years of data.

DISCUSSION

Stations at higher elevations (Crescent Rock, Pinnacle Cliff, and Dean Mountain) and those dominated by northern red oak (Crescent Rock and Pinnacle Cliff) support larger populations of adult birds than lower-elevation stations (Hazeltop Ridge, Big Run, and Jeremy's Run) and those dominated by chestnut oak (Big Run and Jeremy's Run). Stations dominated by northern red oak show higher productivity indices than all other stations. Except for effects of the 2000 fire at the high-elevation, red-oak Pinnacle Cliff station (see below), these elevational and habitat type patterns have generally been consistent throughout the 11-year period.

At the Pinnacle Cliff station, where the Pinnacles Fire of November 2000 reduced the cover of mountain laurel, the dominant shrub species at Pinnacle Cliff, by approximately 80%, both population sizes and productivity decreased disproportionately between 2000 and 2001 (i.e., as compared with other stations). In 2002, breeding populations of all species pooled again declined to a greater degree at Pinnacle Cliff (-37.8%) than at any other station, whereas productivity increased by a greater degree (absolute change of +0.138) than at any other station. In 2003, breeding population sizes, number of young captured, and productivity showed substantially larger increases at Pinnacle Cliff (+41%, +131.6%, and an absolute increase of 0.123, respectively) than at any other station, indicating that the ecosystem is rebounding at this station. It will be interesting to see if populations and productivity at Pinnacle Cliff eventually surpass pre-fire levels, which would indicate the long-term benefits of occasional fire to breeding populations, and support the concept that controlled burns could be of value to the breeding birds of Shenandoah.

Although the overall trend in bird populations at Shenandoah National Park over the past 11 years, as indicated by the MAPS Program, has been relatively stable (adult population size for all species pooled has increased by 0.1% per year), closer examination of the data indicates that the flat overall population trend actually reflects a small but relatively steady decrease after the substantial increase between the first two years of the study, 1993 and 1994, when species rebounded strongly from the effects of the gypsy-moth defoliation. The non-significant decreases in population size between 2002 and 2003 (following similar decreases between 2001 and 2002) likely would have been significant, were it not for a large increase at the Pinnacle Cliff station (see above). Productivity trends showed 11-year declining tendencies in 12 of 17 species, with substantial and significant or near-significant declines noted for four species (Veery, Wood Thrush, American Redstart, and Rose-breasted Grosbeak; vs. no such increases), and a near-substantial decline ($r = -0.480$) for all species pooled. Again, the slight overall increase in productivity noted between 2002 and 2003 would likely have been a decrease were it not for a dramatic increase in productivity at the Pinnacle Cliff station. Overall, therefore, these patterns indicate general declines in both population sizes and productivity at Shenandoah during the greater part of the study.

With 10 and 11 years of data, respectively, survival estimates could be obtained for 17 species in both 2002 and 2003, up from 14 species in 2001. Moreover, the precision of the estimates of

survival rate continues to improve with a mean CV(f) of 19.7% with 11 years of data compared to 22.4% with ten years of data. This is in agreement with Rosenberg et al.'s (1996, 1999) predictions that maximum precision would not be reached until at least 12 years of data were accumulated. With additional years of data we should also be able to model temporal effects on survival probabilities, although it is likely that up to twenty years of data will be necessary to determine actual temporal trends in survivorship.

Time-constant annual apparent adult survival rates at Shenandoah during 1993-2003 compare reasonably well with those for the eastern regions of North America as a whole during 1992-1998 (DeSante and O'Grady 2000). Nine species with CV(f) less than 30% had a mean survival of 0.510 at Shenandoah vs. 0.523 in the Southeast Region as a whole, and 12 species had a mean survival of 0.492 at Shenandoah vs. 0.495 in the Northeast Region as a whole. Thus, the declining tendencies at Shenandoah in recent years are cannot be explained by poor survival.

At present we have no explanation for declining tendencies in productivity at Shenandoah. Continued monitoring may show that long-term decreases in productivity are negatively impacting adult population sizes of species breeding in the Park. In future years, we hope to be address these questions by comparing productivity levels at Shenandoah with those from the surrounding areas and initiating with landscape-level and climate-related analyses.

Previous analyses conducted on 1992-1996 MAPS data from Shenandoah National Park (DeSante et al. 1997) indicated that the indices and estimates of primary demographic parameters (productivity and survivorship) of common landbird species produced by the MAPS Programs could adequately predict the short-term population trends of those species. These results have now been extended more broadly by analyses of data from other national parks and national forests (DeSante et al. 1999). As a result, we have shown that the indices and estimates of primary demographic parameters produced by MAPS are extremely useful for the management and conservation of landbirds, both at Shenandoah National Park, and, in combination with similar data from other areas, across all of North America. We conclude that the MAPS protocol is very well-suited to provide one component of Shenandoah's long-term ecological monitoring program.

As mentioned in last years report, we have continued to undertake broad-scale analyses of MAPS data at regional levels to further understand the population dynamics of landbirds and to identify potential management actions to reverse population declines. These analyses include the modeling of spatial variation in vital rates as a function of spatial variation in population trends (DeSante et al. 2001), the modeling of population sizes, population trends, and productivity as a function of landscape-scale habitat characteristics within a two- to four-kilometer radius area of each station (Nott 2000, Nott et al. 2003b), and the modeling of productivity indices and survival rate estimates as a function of spatially explicit weather variables (Nott 2002) and global climate cycles (Nott et al. 2002). All of these analyses are designed to enhance our understanding of the broad-scale dynamics of bird populations, and to allow the formulation of management strategies for the conservation of landbirds.

Indeed, the ultimate objective of the MAPS Program is to identify generalized management guidelines and formulate specific management actions that can be implemented on National Parks and other public lands to reverse the population declines of target landbird species and to maintain the populations of stable or increasing species. Our aim is to facilitate the identification and formulation of these management guidelines and actions by modeling landbird vital rates as a function of landscape-level habitat characteristics and spatially explicit weather variables. These management strategies will then involve efforts to modify the habitat from characteristics associated with low productivity to characteristics associated with high productivity (for species for which low productivity is driving the population decline).

The funding necessary to explore these analyses and formulate management strategies based on MAPS data collected on DoD Installations was obtained from the Legacy Resource Management Program during 2000-2003. Analyses that have described relationships between landscape-level habitat characteristics and four demographic variables (adult population size, population trends, numbers of young, and productivity) and have led to the formulation of management strategies have now been completed for a number of target species of Conservation Concern (Nott et al. 2003b). We are currently implementing these guidelines and actions on DoD installations in conjunction with efforts to increase military Readiness and Range Sustainment. The implementation strategy for these guidelines includes the establishment of new MAPS stations to monitor their effectiveness, the discontinuing of an equal number of old stations, and the continued operation of others of the old stations to serve as controls for the new management stations. The ultimate goal of this project is to evaluate the efficiency of these on-going management practices and to modify them in an adaptive management process, in order to reverse declining populations, and to maintain stable or increasing populations of target landbird species. If appropriate funding can be secured, we hope to be able to undertake such analyses using data from Shenandoah National Park and the surrounding region when 12 years of data have been obtained, that is, after the 2004 field season.

CONCLUSIONS AND RECOMMENDATIONS

(1) Adult population sizes of all species pooled in Shenandoah National Park have tended to be higher at northern red oak stations and at higher-elevation stations than they at chestnut oak and lower-elevation stations. In addition, stations dominated by northern red oak have tended to show higher productivity indices than other stations. These habitat and elevational patterns have generally been consistent throughout the 11 years (1993-2003) of the study.

(2) At the Pinnacle Cliff station, where the Pinnacles Fire of November 2000 reduced the cover of mountain laurel, the dominant shrub species at Pinnacle Cliff, both population sizes and productivity decreased disproportionately between 2000 and 2001 (i.e., as compared with other stations). In 2002, breeding populations of all species pooled again declined to a greater degree at Pinnacle Cliff than at any other station, whereas productivity increased by a greater degree at Pinnacle Cliff than at any other station. In 2003, breeding population sizes, number of young captured, and productivity all showed substantially larger increases at Pinnacle Cliff than at any other station, indicating that the bird community and likely the entire ecosystem is rebounding at this station. It will be interesting to see if populations and productivity at Pinnacle Cliff eventually surpass pre-fire levels, which would indicate the long-term benefits of occasional fire to breeding populations, and support the concept that controlled burns could be of value to the breeding birds of Shenandoah.

(3) Although the overall trend in bird populations at Shenandoah National Park over the past 11 years has been stable, closer examination of the data indicates that the stable overall population trend actually reflects a slight but rather steady decrease after a substantial increase early in the study as species rebounded from the effects of a massive gypsy-moth defoliation. The non-significant decreases in population size between 2002 and 2003 for all stations combined may have been significantly negative were it not for a large increase in population size seen at the Pinnacle Cliff station (see above). Productivity trends showed 11-year declining tendencies in 12 of 17 species, with substantial and significant or near-significant declines noted for four species, vs. no such increases, and a near-substantial decline for all species pooled. Again, an overall productivity increase between 2002 and 2003 would likely have been a substantial decrease were it not for a dramatic increase in productivity at the Pinnacle Cliff station. These patterns indicate general declines in both population sizes and productivity indices at Shenandoah during the greater part of the study.

(4) With 11 years of data, survival rate estimates could be obtained for 17 species, while the precision of the estimates of survival continues to improve. Annual adult apparent survival rates at Shenandoah during 1993-2003 compared reasonably well with that for the eastern regions of North America in 1992-1998, indicating that the declining tendencies at Shenandoah in recent years likely cannot be explained by poor survival.

(5) Continued monitoring may show that the long-term decreases in productivity are negatively impacting adult population sizes of species breeding in the Park. With appropriate future

funding, we hope to address these questions by comparing productivity values at Shenandoah with those from surrounding areas and by analyzing productivity and population size as a function of landscape-level and climate-related variables.

(6) Previous extensive analyses conducted on 1992-1996 MAPS data indicated that the indices and estimates of primary demographic parameters (productivity and survivorship) of common landbird species produced by the MAPS Programs in Shenandoah National Park could adequately predict the short-term population trends of those species. Subsequent broad-scale analyses of MAPS data have confirmed these results for many other regions. As a result, the indices and estimates of primary demographic parameters produced by MAPS can be extremely useful for the management and conservation of landbirds, both at Shenandoah National Park, and, in combination with similar data from other areas, across all of North America.

(7) We have continued to undertake broad-scale analyses of MAPS data at regional levels to help understand the population dynamics of landbirds and to enhance the formulation of potential management actions to reverse population declines. The aim of these analyses is to enhance the understanding of the broad-scale dynamics of bird populations in national parks and other public lands and to help formulate recommendations for management strategies for these bird species. Indeed, the ultimate objective of the MAPS Program is to identify generalized management guidelines and formulate specific management actions that can be implemented on National Parks and elsewhere to reverse the population declines of target landbird species and to maintain the populations of stable or increasing species. Management strategies for species for which low productivity (or survival) appears to be driving the population decline will involve efforts to modify the habitat from characteristics associated with low productivity (or survival) to characteristics associated with high productivity (or survival).

(8) As an example of this approach, by means of funding from the DoD Legacy Resources Management Program, we have described relationships between landscape-level habitat characteristics and four demographic variables (adult population size, population trends, numbers of young, and productivity) from MAPS data, and have formulated management strategies based on these relationships for a number of target Species of Conservation Concern (Nott et al. 2003b). We are currently implementing these guidelines and actions on DoD installations in conjunction with efforts to increase military Readiness and Range Sustainment. The strategy for implementation includes the establishment of new MAPS stations to monitor the effectiveness of the guidelines, the discontinuing of an equal number of old stations, and the continued operation of other old stations to serve as controls for the new management stations. The ultimate goal is to evaluate the efficiency of these management practices and to modify them in an adaptive management process. If appropriate funding can be secured, we hope to be able to undertake similar analyses using data from Shenandoah National Park and the surrounding region.

(9) We conclude that the MAPS protocol is extremely well-suited to provide a component of Shenandoah's Long-term Ecological Monitoring Program (LTEM). We recommend, therefore, that the MAPS Program be included as an integral part of Shenandoah's LTEM, and that operation at the six currently active stations be sustained well into the future.

ACKNOWLEDGMENTS

All data collected for the MAPS Program in Shenandoah National Park in 2003 were gathered by Leah Gibbons, Lauren Hoffstetter, and Derek Robertson, field biologist interns of The Institute for Bird Populations. We thank the interns for their excellent work in re-establishing and operating the Shenandoah MAPS stations. We thank Amy McAndrews for training the interns and providing part-time supervision of the Shenandoah interns over the field season. We also thank Rolf Gubler and Jim Atkinson of Shenandoah National Park for their kind assistance with all of the logistical and administrative aspects of this work. Financial support for the MAPS Program and housing for the field biologist interns, for which we are very grateful, were provided by Shenandoah National Park. This is Contribution Number 223 of The Institute for Bird Populations.

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Table 1. Summary of the 2003 MAPS program in Shenandoah National Park.

Station					Avg Elev. (m)	2003 operation		
						Total number of net-hours	No. of periods	Inclusive dates
Name	Code	No.	Major Habitat Type	Latitude-longitude				
Crescent Rock	CRRO	15550	Red oak, moderately dense understory	38°33'40"N,-78°22'40"W	1067	506.8(426.8)	7	6/06-7/30
Pinnacle Cliff	PICL	15533	Red oak, dense understory	38°37'40"N,-78°19'40"W	1036	584.7(542.7)	7	6/08-8/04
Dean Mountain	DEMO	15548	Cove hardwood, moderately dense understory	38°24'20"N,-78°29'50"W	945	458.8(403.8)	7	6/02-8/01
Hazeltop Ridge	HARI	15537	Cove hardwood, open understory	38°28'30"N,-78°27'40"W	910	566.8(556.8)	7	6/05-7/31
Big Run	BIRU	15541	Chestnut oak, moderately dense understory	38°15'10"N,-78°41'30"W	762	572.5(485.0)	7	5/29-8/03
Jeremy's Run	JERU	15549	Chestnut oak, dense understory	38°43'40"N,-78°19'30"W	762	614.5(555.8)	7	5/30-8/02
ALL STATIONS COMBINED						3304.2(2971.0)	7	5/29-8/04

¹ Total net-hours in 2003. Net-hours in 2003 that could be compared in a constant-effort manner to 2002 are shown in parentheses.

Table 2. Capture summary for the six individual MAPS stations operated in Shenandoah National Park in 2003.
N = Newly Banded, U = Unbanded, R = Recaptures of banded birds.

Species	Crescent Rock			Pinnacle Cliff			Dean Mountain			Hazeltop Ridge			Big Run			Jeremy's Run		
	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Sharp-shinned Hawk		1																
Cooper's Hawk		1																
Broad-winged Hawk		1																
Ruffed Grouse													1					
Whip-poor-will																	1	
Ruby-throated Hummingbird		3			2			7			2		1				4	
Downy Woodpecker	1			2						3		1				2		
Hairy Woodpecker				1		1	3			1								
Eastern Wood-Pewee							2			1								
Acadian Flycatcher	2						1					2	1					
Great Crested Flycatcher	1		1													1		
Blue-headed Vireo	1			3														
Red-eyed Vireo	8	2	3				2		1	3						11		2
Blue Jay				3														
Carolina Chickadee																	1	
Black-capped Chickadee				1														
Tufted Titmouse	1			1						1			4		2	3		
White-breasted Nuthatch	1			2			1											
Brown Creeper				1														
Veery	6		3	2		3	8		6	1	1	2				1		
Wood Thrush	3		1	1			13	2	11	10		5	1			2		
Gray Catbird	3		1	15		3	3		1	1		1						
Brown Thrasher													1					
Chestnut-sided Warbler	4		2	1			3					1						
Black-throated Green Warbler				1														
Blackburnian Warbler											1							
Black-and-white Warbler	5			8		2				2		1	10		5	15		2
American Redstart	28	1	5	32	2	6	9	2	5	13	1	11	7		1	36	5	15

Table 2. (cont.) Capture summary for the six individual MAPS stations operated in Shenandoah National Park in 2003.
N = Newly Banded, U = Unbanded, R = Recaptures of banded birds.

Species	Crescent Rock			Pinnacle Cliff			Dean Mountain			Hazeltop Ridge			Big Run			Jeremy's Run		
	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Worm-eating Warbler	1	1		1			2			1		1	15		9	22	1	9
Ovenbird	14	1	5	5	1		7		4	6		6	10	1	5	15		2
Louisiana Waterthrush										1								
Kentucky Warbler																1		
Hooded Warbler	3			1									7		2	27	1	11
Canada Warbler	1			2					1	1								
Scarlet Tanager				2			2			3		2				5		
Eastern Towhee	4		2	4	1	2	2		1	1	2	1	3		1	18		8
Dark-eyed Junco	3		1	59	2	15	6	1	1				1					
Rose-breasted Grosbeak	2						2											
Indigo Bunting	1									2			1			1		1
Brown-headed Cowbird							1									3	2	
American Goldfinch																1		
Unidentified Bird													1					
ALL SPECIES POOLED	93	11	24	148	8	32	67	12	31	51	7	34	61	4	25	164	15	50
Total Number of Captures		128			188			110			92			90			229	
Number of Species	21	8	10	22	5	7	17	4	9	17	5	12	12	3	7	17	7	8
Total Number of Species		25			23			19			21			14			20	

Table 3. Numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated in Shenandoah National Park in 2003.

Species	Crescent Rock			Pinnacle Cliff			Dean Mountain			Hazeltop Ridge			Big Run			Jeremy's Run		
	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.
Downy Woodpecker	0.0	1.2	1.00	2.1	0.0	0.00				1.1	2.1	0.67				0.0	2.0	1.00
Hairy Woodpecker				1.0	1.0	0.50	2.6	1.3	0.33	1.1	0.0	0.00						
Eastern Wood-Pewee							2.6	0.0	0.00	1.1	0.0	0.00						
Acadian Flycatcher	2.4	0.0	0.00				1.3	0.0	0.00	2.1	0.0	0.00	1.0	0.0	0.00			
Great Crested Flycatcher	2.4	0.0	0.00													1.0	0.0	0.00
Blue-headed Vireo	1.2	0.0	0.00	3.1	0.0	0.00												
Red-eyed Vireo	10.7	0.0	0.00				3.9	0.0	0.00	3.2	0.0	0.00				10.7	1.0	0.08
Blue Jay				2.1	1.0	0.33												
Carolina Chickadee																0.0	1.0	1.00
Black-capped Chickadee				0.0	1.0	1.00												
Tufted Titmouse	1.2	0.0	0.00	0.0	1.0	1.00				1.1	0.0	0.00	2.1	3.1	0.60	0.0	2.9	1.00
White-breasted Nuthatch	0.0	1.2	1.00	2.1	0.0	0.00	0.0	1.3	1.00									
Brown Creeper				0.0	1.0	1.00												
Veery	7.1	0.0	0.00	4.1	0.0	0.00	15.7	0.0	0.00	3.2	0.0	0.00				1.0	0.0	0.00
Wood Thrush	3.6	0.0	0.00	1.0	0.0	0.00	19.6	3.9	0.17	11.6	1.1	0.08	1.0	0.0	0.00	1.0	1.0	0.50
Gray Catbird	3.6	0.0	0.00	12.3	4.1	0.25	3.9	0.0	0.00	1.1	0.0	0.00						
Brown Thrasher													0.0	1.0	1.00			
Chestnut-sided Warbler	3.6	1.2	0.25	1.0	0.0	0.00	3.9	0.0	0.00	1.1	0.0	0.00						
Black-throated Green Warbler				1.0	0.0	0.00												
Black-and-white Warbler	5.9	0.0	0.00	3.1	6.2	0.67				1.1	1.1	0.50	9.4	4.2	0.31	11.7	4.9	0.29
American Redstart	28.4	7.1	0.20	18.5	16.4	0.47	15.7	1.3	0.08	19.1	0.0	0.00	1.0	6.3	0.86	29.3	9.8	0.25
Worm-eating Warbler	0.0	1.2	1.00	0.0	1.0	1.00	2.6	0.0	0.00	0.0	1.1	1.00	12.6	6.3	0.33	20.5	3.9	0.16
Ovenbird	15.4	3.6	0.19	3.1	2.1	0.40	7.8	3.9	0.33	8.5	2.1	0.20	10.5	3.1	0.23	8.8	7.8	0.47

Table 3. (cont.) Numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated in Shenandoah National Park in 2003.

Species	Crescent Rock			Pinnacle Cliff			Dean Mountain			Hazeltop Ridge			Big Run			Jeremy's Run		
	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.
Louisiana Waterthrush										0.0	1.1	1.00						
Kentucky Warbler																1.0	0.0	0.00
Hooded Warbler	2.4	1.2	0.33	1.0	0.0	0.00							7.3	2.1	0.22	19.5	11.7	0.38
Canada Warbler	0.0	1.2	1.00	1.0	1.0	0.50	1.3	0.0	0.00	0.0	1.1	1.00						
Scarlet Tanager				2.1	0.0	0.00	2.6	0.0	0.00	5.3	0.0	0.00				3.9	1.0	0.20
Eastern Towhee	3.6	2.4	0.40	5.1	1.0	0.17	2.6	0.0	0.00	2.1	0.0	0.00	3.1	1.0	0.25	17.6	4.9	0.22
Dark-eyed Junco	1.2	2.4	0.67	6.2	56.4	0.90	2.6	6.5	0.71				0.0	1.0	1.00			
Rose-breasted Grosbeak	2.4	0.0	0.00				2.6	0.0	0.00									
Indigo Bunting	1.2	0.0	0.00							2.1	0.0	0.00	1.0	0.0	0.00	2.0	0.0	0.00
Brown-headed Cowbird							1.3	0.0	0.00							2.9	1.0	0.25
American Goldfinch																1.0	0.0	0.00
ALL SPECIES POOLED	95.9	22.5	0.19	69.8	93.4	0.57	92.8	18.3	0.17	64.6	9.5	0.13	49.3	28.3	0.37	131.8	52.7	0.29
Number of Species	17	10		18	13		17	6		16	7		10	9		15	13	
Total Number of Species		21			22			18			19			12			18	

Table 4. Summary of results for all six Shenandoah National Park MAPS stations combined in 2003.

Species	Birds captured			Birds/600 net hours		
	Newly banded	Un-banded	Recap-tured	Adults	Young	Prop. Young
Sharp-shinned Hawk		1				
Cooper's Hawk		1				
Broad-winged Hawk		1				
Ruffed Grouse		1				
Whip-poor-will		1				
Ruby-throated Hummingbird		19				
Downy Woodpecker	8		1	0.5	0.9	0.63
Hairy Woodpecker	5		1	0.7	0.4	0.33
Eastern Wood-Pewee	3		0	0.5	0.0	0.00
Acadian Flycatcher	4		2	1.1	0.0	0.00
Great Crested Flycatcher	2		1	0.5	0.0	0.00
Blue-headed Vireo	4		0	0.7	0.0	0.00
Red-eyed Vireo	24	2	6	4.7	0.2	0.04
Blue Jay	3		0	0.4	0.2	0.33
Carolina Chickadee		1		0.0	0.2	1.00
Black-capped Chickadee	1		0	0.0	0.2	1.00
Tufted Titmouse	10		2	0.7	1.3	0.64
White-breasted Nuthatch	4		0	0.4	0.4	0.50
Brown Creeper	1		0	0.0	0.2	1.00
Veery	18	1	14	4.7	0.0	0.00
Wood Thrush	30	2	17	5.8	0.9	0.14
Gray Catbird	22		6	3.5	0.7	0.17
Brown Thrasher	1		0	0.0	0.2	1.00
Chestnut-sided Warbler	8		3	1.5	0.2	0.11
Black-throated Green Warbler	1		0	0.2	0.0	0.00
Blackburnian Warbler		1				
Black-and-white Warbler	40		10	5.4	2.9	0.35
American Redstart	125	11	43	18.7	7.1	0.28
Worm-eating Warbler	42	2	19	6.4	2.4	0.27
Ovenbird	57	3	22	8.9	3.8	0.30
Louisiana Waterthrush	1		0	0.0	0.2	1.00
Kentucky Warbler	1		0	0.2	0.0	0.00
Hooded Warbler	38	1	13	5.4	2.7	0.33
Canada Warbler	4		1	0.4	0.5	0.60
Scarlet Tanager	12		2	2.4	0.2	0.07
Eastern Towhee	32	3	15	6.0	1.6	0.21
Dark-eyed Junco	69	3	17	1.6	11.4	0.88
Rose-breasted Grosbeak	4		0	0.7	0.0	0.00

Table 4. (cont.) Summary of results for all six Shenandoah National Park MAPS stations combined in 2003.

Species	Birds captured			Birds/600 net hours		Prop. Young
	Newly banded	Un- banded	Recap- tured	Adults	Young	
Indigo Bunting	5		1	1.1	0.0	0.00
Brown-headed Cowbird	4	2		0.7	0.2	0.20
American Goldfinch	1		0	0.2	0.0	0.00
Unidentified Bird		1				
ALL SPECIES POOLED	584	57	196	84.1	38.9	0.32
Total Number of Captures		837				
Number of Species	33	18	20	29	24	
Total Number of Species		41			34	

Table 5. Percentage changes between 2002 and 2003 in the numbers of individual ADULT birds captured at six constant-effort MAPS stations in Shenandoah National Park.

Species								All six stations combined			
	Crescent Rock	Pinnacle Cliff	Dean Mount.	Hazeltop Ridge	Big Run	Jeremy's Run	n ¹	Number of adults		Percent change	SE ²
								2002	2003		
Yellow-billed Cuckoo						-100.0	1	1	0	-100.0	
Downy Woodpecker		++++ ³	-100.0	++++ ³	-100.0	-100.0	5	7	3	-57.1	47.5
Hairy Woodpecker		0.0	100.0	++++			3	2	4	100.0	86.6
Northern Flicker	-100.0	-100.0					2	3	0	-100.0	88.9
Eastern Wood-Pewee			0.0	++++	-100.0		3	3	2	-33.3	69.4
Acadian Flycatcher	++++ ³		-50.0	-33.3	++++ ³	-100.0	5	7	6	-14.3	47.3
Least Flycatcher		-100.0					1	1	0	-100.0	
Great Crested Flycatcher	-50.0					++++ ³	2	2	2	0.0	100.0
Blue-headed Vireo	-100.0	++++	-100.0				3	6	3	-50.0	76.4
Red-eyed Vireo	66.7		-50.0	-70.0	-100.0	-21.4	5	36	22	-38.9	16.9 *
Blue Jay		100.0					1	1	2	100.0	
Carolina Chickadee			-100.0		-100.0	-100.0	3	5	0	-100.0	88.9
Black-capped Chickadee							0	0	0		
Tufted Titmouse	0.0		-100.0	-50.0	-60.0	-100.0	5	12	4	-66.7	11.6 ***
White-breasted Nuthatch							0	0	0		
Brown Creeper							0	0	0		
Blue-gray Gnatcatcher						-100.0	1	1	0	-100.0	
Veery	-53.8	-20.0	-47.6	-75.0		-50.0	5	53	25	-52.8	7.0 ***
Wood Thrush	0.0	-50.0	55.6	0.0	-50.0	-85.7	6	34	31	-8.8	26.0
American Robin	-100.0						1	1	0	-100.0	
Gray Catbird	-50.0	140.0	++++ ³	++++			4	11	19	72.7	91.2
Brown Thrasher				-100.0			1	1	0	-100.0	
Cedar Waxwing	-100.0					-100.0	2	3	0	-100.0	88.9
Chestnut-sided Warbler	++++	++++	0.0	-50.0		-100.0	5	6	8	33.3	73.5
Black-throated Green Warb		++++					1	0	1	++++ ³	
Blackburnian Warbler				-100.0			1	3	0	-100.0	
Pine Warbler						-100.0	1	1	0	-100.0	
Cerulean Warbler			-100.0				1	2	0	-100.0	

Table 5. (cont.) Percentage changes between 2002 and 2003 in the numbers of individual ADULT birds captured at six constant-effort MAPS stations in Shenandoah National Park.

Species								All six stations combined			
	Crescent Rock	Pinnacle Cliff	Dean Mount.	Hazeltop Ridge	Big Run	Jeremy's Run	n ¹	Number of adults		Percent change	SE ²
								2002	2003		
Black-and-white Warbler	150.0	50.0	-100.0	++++	80.0	-7.7	6	23	30	30.4	29.9
American Redstart	475.0	125.0	-67.6	-18.2	++++	20.8	6	92	100	8.7	40.4
Worm-eating Warbler	-100.0		100.0	-100.0	83.3	100.0	5	17	29	70.6	22.8 **
Ovenbird	0.0	-25.0	-58.3	-61.9	-23.1	28.6	6	67	45	-32.8	14.4 *
Louisiana Waterthrush							0	0	0		
Kentucky Warbler						++++	1	0	1	++++	
Hooded Warbler	++++	0.0	-100.0		0.0	13.3	5	24	27	12.5	11.5
Canada Warbler	-100.0	++++	-75.0				3	5	2	-60.0	30.2
Scarlet Tanager	-100.0	++++	0.0	25.0	-100.0	33.3	6	13	13	0.0	31.5
Eastern Towhee	-60.0	-16.7	-50.0	-33.3	-25.0	80.0	6	30	31	3.3	31.4
Dark-eyed Junco	0.0	-28.6	-33.3	-100.0			4	13	8	-38.5	13.1 *
Northern Cardinal	-100.0						1	1	0	-100.0	
Rose-breasted Grosbeak	100.0		100.0	-100.0	-100.0		4	5	4	-20.0	56.9
Indigo Bunting	0.0	-100.0		-60.0	-100.0	-66.7	5	16	5	-68.8	90 ***
Brown-headed Cowbird			++++			++++	2	0	3	++++	
American Goldfinch						0.0	1	1	1	0.0	
ALL SPECIES POOLED	12.9	41.3	-44.0	-41.3	-23.7	2.5	6	509	431	-15.3	12.4
No. species that increased ⁴	7(3)	10(6)	6(2)	6(5)	4(2)	9(3)				12(3)	
No. species that decreased ⁵	12(8)	8(3)	15(7)	14(5)	11(7)	14(9)				25(12)	
No. species remained same	5	2	3	1	1	1				3	
Total Number of Species	24	20	24	21	16	24				40	
Proportion of increasing (decreasing) species	0.292	0.500	(0.625)	(0.667)	(0.688)	0.375				(0.625)	
Sig. of increase (decrease) ⁶	0.987	0.588	(0.154)	(0.095) *	(0.105)	0.927				(0.077) *	

Table 5. (cont.) Percentage changes between 2002 and 2003 in the numbers of individual ADULT birds captured at six constant-effort MAPS stations in Shenandoah National Park.

¹ Number of stations at which at least one adult bird was captured in either year.

² Standard error of the % change in the number of adult birds captured.

³ Increase indeterminate (infinite) because no adult was captured during 2002.

⁴ No. of species for which adults were captured in 2003 but not in 2002 are in parentheses.

⁵ No. of species for which adults were captured in 2002 but not in 2003 are in parentheses.

⁶ Statistical significance of the one-sided binomial test that the proportion of increasing (decreasing) species is not greater than 0.50.

*** $P < 0.01$; ** $0.01 < P < 0.05$; * $0.05 < P < 0.10$.

Table 6. Percentage changes between 2002 and 2003 in the numbers of individual YOUNG birds captured at six constant-effort MAPS stations in Shenandoah National Park.

Species	All six stations combined										
	Crescent Rock	Pinnacle Cliff	Dean Mount.	Hazeltop Ridge	Big Run	Jeremy's Run	Number of young			Percent change	SE ²
							n ¹	2002	2003		
Yellow-billed Cuckoo							0	0	0		
Downy Woodpecker	-50.0	-100.0	-100.0	-33.3	-100.0	100.0	6	12	5	-58.3	21.5 **
Hairy Woodpecker	-100.0	0.0	++++				3	2	2	0.0	86.6
Northern Flicker							0	0	0		
Eastern Wood-Pewee							0	0	0		
Acadian Flycatcher				-100.0			1	1	0	-100.0	
Least Flycatcher							0	0	0		
Great Crested Flycatcher							0	0	0		
Blue-headed Vireo						-100.0	1	1	0	-100.0	
Red-eyed Vireo					-100.0	-50.0	2	3	1	-66.7	22.2
Blue Jay		++++					1	0	1	++++	
Carolina Chickadee						-66.7	1	3	1	-66.7	
Black-capped Chickadee		++++					1	0	1	++++	
Tufted Titmouse	-100.0	0.0	-100.0		++++	-70.0	5	14	6	-57.1	21.0 *
White-breasted Nuthatch			++++		-100.0		2	2	1	-50.0	100.0
Brown Creeper		++++					1	0	1	++++	
Blue-gray Gnatcatcher							0	0	0		
Veery			-100.0				1	1	0	-100.0	
Wood Thrush	-100.0		++++	-75.0		++++	4	5	4	-20.0	74.8
American Robin							0	0	0		
Gray Catbird		++++					1	0	4	++++	
Brown Thrasher					++++		1	0	1	++++	
Cedar Waxwing							0	0	0		
Chestnut-sided Warbler							0	0	0		
Black-throated Green Warb		-100.0			-100.0		2	3	0	-100.0	88.9
Blackburnian Warbler							0	0	0		
Pine Warbler							0	0	0		
Cerulean Warbler							0	0	0		

Table 6. (cont.) Percentage changes between 2002 and 2003 in the numbers of individual YOUNG birds captured at six constant-effort MAPS stations in Shenandoah National Park.

Species								All six stations combined			
	Crescent Rock	Pinnacle Cliff	Dean Mount.	Hazeltop Ridge	Big Run	Jeremy's Run	n ¹	Number of young		Percent change	SE ²
								2002	2003		
Black-and-white Warbler	-100.0	500.0	-100.0	++++	0.0	25.0	6	13	15	15.4	54.7
American Redstart	-42.9	60.0	-87.5	-100.0	-25.0	11.1	6	39	34	-12.8	27.9
Worm-eating Warbler	++++	0.0	-100.0	-50.0	-40.0	-33.3	6	23	13	-43.5	12.4 **
Ovenbird	100.0	++++	100.0	-80.0	-40.0	300.0	6	19	19	0.0	60.5
Louisiana Waterthrush				++++			1	0	1	++++	
Kentucky Warbler							0	0	0		
Hooded Warbler	-50.0			-100.0	++++	71.4	4	10	15	50.0	40.8
Canada Warbler	++++	-50.0	-100.0	++++			4	3	3	0.0	77.0
Scarlet Tanager		-100.0				++++	2	5	1	-80.0	40.0
Eastern Towhee	-50.0	-50.0			0.0	-16.7	4	13	9	-30.8	11.1 *
Dark-eyed Junco	0.0	372.7	-77.3		++++		4	34	59	73.5	158.8
Northern Cardinal							0	0	0		
Rose-breasted Grosbeak				-100.0			1	1	0	-100.0	
Indigo Bunting						-100.0	1	2	0	-100.0	
Brown-headed Cowbird						++++	1	0	1	++++	
American Goldfinch							0	0	0		
ALL SPECIES POOLED	-40.9	131.6	-72.1	-60.9	-26.7	1.9	6	209	198	-5.3	32.4
No. species that increased ⁴	3(2)	8(5)	4(3)	3(3)	4(4)	8(3)				10(7)	
No. species that decreased ⁵	8(4)	5(3)	8(6)	8(4)	7(4)	7(2)				16(6)	
No. species remained same	1	3	0	0	2	0				3	
Total Number of Species	12	16	12	11	13	15				29	
Proportion of increasing (decreasing) species	(0.667)	0.500	(0.667)	(0.727)	(0.538)	0.533				(0.552)	
Sig. of increase (decrease) ⁶	(0.194)	0.988	(0.194)	(0.113)	(0.500)	0.500				(0.356)	

Table 6. (cont.) Percentage changes between 2002 and 2003 in the numbers of individual YOUNG birds captured at six constant-effort MAPS stations in Shenandoah National Park.

¹ Number of stations at which at least one young bird was captured in either year.

² Standard error of the % change in the number of young birds captured.

³ Increase indeterminate (infinite) because no young bird was captured during 2002.

⁴ No. of species for which young birds were captured in 2003 but not in 2002 are in parentheses.

⁵ No. of species for which young birds were captured in 2002 but not in 2003 are in parentheses.

⁶ Statistical significance of the one-sided binomial test that the proportion of increasing (decreasing) species is not greater than 0.50.

*** $P < 0.01$; ** $0.01 < P < 0.05$; * $0.05 < P < 0.10$.

Table 7. Percentage changes between 2002 and 2003 in the PROPORTION OF YOUNG in the catch at six constant-effort MAPS stations in Shenandoah National Park.

Species	Crescent Rock	Pinnacle Cliff	Dean Mount.	Hazeltop Ridge	Big Run	Jeremy's Run	n ¹	All six stations combined			
								Proportion young		Absol. change	SE ²
								2002	2003		
Yellow-billed Cuckoo						+--+ ³	1	0.000	— ⁴	+--+ ³	
Downy Woodpecker	0.000	-1.000	+--+ ³	-0.333	+--+ ³	0.500	6	0.632	0.625	-0.007	0.257
Hairy Woodpecker	+--+ ³	0.000	0.333	+--+ ³			4	0.500	0.333	-0.167	0.223
Northern Flicker	+--+	+--+ ³					2	0.000		+--+	
Eastern Wood-Pewee			0.000	+--+	+--+		3	0.000	0.000	0.000	0.000
Acadian Flycatcher	+--+		0.000	-0.250	+--+	+--+	5	0.125	0.000	-0.125	0.086
Least Flycatcher		+--+					1	0.000		+--+	
Great Crested Flycatcher	0.000					+--+	2	0.000	0.000	0.000	0.000
Blue-headed Vireo	+--+	+--+	+--+			+--+	4	0.143	0.000	-0.143	0.176
Red-eyed Vireo	0.000		0.000	0.000	+--+	-0.042	5	0.077	0.044	-0.033	0.048
Blue Jay		0.333					1	0.000	0.333	0.333	
Carolina Chickadee			+--+		+--+	0.250	3	0.375	1.000	0.625	0.281
Black-capped Chickadee		+--+					1	— ⁴	1.000	+--+	
Tufted Titmouse	-0.500	0.000	+--+	0.000	0.500	0.167	6	0.539	0.600	0.062	0.260
White-breasted Nuthatch			+--+		+--+		2	1.000	1.000	0.000	0.000
Brown Creeper		+--+					1	-----	1.000	+--+	
Blue-gray Gnatcatcher						+--+	1	0.000		+--+	
Veery	0.000	0.000	-0.046	0.000		0.000	5	0.019	0.000	-0.019	0.014
Wood Thrush	-0.250	0.000	0.125	-0.183	0.000	0.500	6	0.128	0.114	-0.014	0.079
American Robin	+--+						1	0.000		+--+	
Gray Catbird	0.000	0.250	+--+	+--+			4	0.000	0.174	0.174	0.072 *
Brown Thrasher				+--+	+--+		2	0.000	1.000	1.000	0.000
Cedar Waxwing	+--+					+--+	2	0.000	-----	+--+	
Chestnut-sided Warbler	+--+	+--+	0.000	0.000		+--+	5	0.000	0.000	0.000	0.000
Black-throated Green Warb		-1.000			+--+		2	1.000	0.000	-1.000	0.000
Blackburnian Warbler				+--+			1	0.000		+--+	
Pine Warbler						+--+	1	0.000	-----	+--+	
Cerulean Warbler			+--+				1	0.000	-----	+--+	

Table 7. (cont.) Percentage changes between 2002 and 2003 in the PROPORTION OF YOUNG in the catch at six constant-effort MAPS stations in Shenandoah National Park.

Species	Crescent Rock	Pinnacle Cliff	Dean Mount.	Hazeltop Ridge	Big Run	Jeremy's Run	n ¹	All six stations combined			
								Proportion young		Absol. change	SE ²
								2002	2003		
Black-and-white Warbler	-0.500	0.333	+--+	+--+	-0.125	0.059	6	0.361	0.333	-0.028	0.121
American Redstart	-0.488	-0.085	-0.107	-0.044	-0.250	-0.016	6	0.298	0.254	-0.044	0.114
Worm-eating Warbler	1.000	0.000	-0.800	0.333	-0.272	-0.229	6	0.575	0.310	-0.266	0.099 **
Ovenbird	0.076	0.400	0.209	-0.123	-0.047	0.248	6	0.221	0.297	0.076	0.082
Louisiana Waterthrush				+--+			1		1.000	+--+	
Kentucky Warbler						+--+	1		0.000	+--+	
Hooded Warbler	-0.667	0.000	+--+	+--+	0.222	0.096	6	0.294	0.357	0.063	0.102
Canada Warbler	1.000	-0.500	-0.200	+--+			4	0.375	0.600	0.225	0.300
Scarlet Tanager	+--+	-1.000	0.000	0.000	+--+	0.200	6	0.278	0.071	-0.206	0.250
Eastern Towhee	0.056	-0.083	0.000	0.000	0.050	-0.158	6	0.302	0.225	-0.077	0.065
Dark-eyed Junco	0.000	0.301	-0.166	+--+	+--+		5	0.723	0.881	0.157	0.117
Northern Cardinal	+--+						1	0.000		+--+	
Rose-breasted Grosbeak	0.000		0.000	+--+	+--+		4	0.167	0.000	-0.167	0.111
Indigo Bunting	0.000	+--+		0.000	+--+	-0.250	5	0.111	0.000	-0.111	v0.080
Brown-headed Cowbird			+--+			+--+	2		0.250	+--+	
American Goldfinch						0.000	1	0.000	0.000	0.000	
ALL SPECIES POOLED	-0.105	0.123	-0.115	-0.053	-0.009	-0.001	6	0.291	0.315	0.024	0.085
No. species that increased	4	5	3	1	3	8				9	
No. species that decreased	5	6	5	5	4	5				15	
No. species remained same	8	6	7	7	1	2				5	
Total Number of Species ⁵	17	17	15	13	8	15				29	
Proportion of increasing (decreasing) species	(0.294)	0.294	(0.333)	(0.385)	(0.500)	(0.333)				0.310	
Sig. of increase (decrease) ⁶	(0.975)	0.975	(0.941)	(0.867)	(0.637)	(0.941)				0.988	

Table 7. (cont.) Percentage changes between 2002 and 2003 in the PROPORTION OF YOUNG in the catch at six constant-effort MAPS stations in Shenandoah National Park.

¹ Number of stations at which at least one aged bird was captured in either year.

² Standard error of the change in the proportion of young.

³ The change in the proportion of young is undefined at this station because no aged individual of the species was captured in one of the two years.

⁴ Proportion of young not given because no aged individual of the species was captured in the year shown.

⁵ Species for which the change in the proportion of young is undefined are not included.

⁶ Statistical significance of the one-sided binomial test that the proportion of increasing (decreasing) species is not greater than 0.50.

*** $P < 0.01$; ** $0.01 < P < 0.05$; * $0.05 \leq P < 0.10$

Table 8. Mean numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated in Shenandoah National Park averaged over the 11 years, 1993-2003. Data for each species are included only from stations that lie within the breeding range of the species.

Species	Crescent Rock			Pinnacle Cliff			Dean Mountain			Hazeltop Ridge			Big Run			Jeremy's Run			All stations pooled		
	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹
American Woodcock																					
Black-billed Cuckoo	0.2	0.0	0.00	0.2	0.0	0.00							0.1	0.1	0.50	0.3	0.0	0.00	0.1	0.0	0.20
Yellow-billed Cuckoo	0.1	0.0	0.00	0.2	0.0	0.00							0.1	0.0	0.00	0.4	0.0	0.00	0.1	0.0	0.00
Red-bellied Woodpecker										0.0	0.1	1.00							0.0	0.0	1.00
Downy Woodpecker	0.9	1.1	0.70	0.9	0.8	0.64	0.9	0.8	0.39	1.1	2.0	0.71	1.1	0.9	0.54	0.6	0.7	0.69	0.9	1.1	0.55
Hairy Woodpecker	0.6	0.3	0.38	0.3	0.3	0.60	0.9	0.5	0.29	0.4	0.3	0.47	1.1	0.2	0.28	0.5	0.1	0.06	0.6	0.3	0.39
Northern Flicker	0.3	0.3	0.42	0.3	0.3	0.50							0.0	0.1	1.00				0.1	0.1	0.67
Eastern Wood-Pewee	0.9	0.8	0.32	0.5	0.1	0.25	1.4	0.0	0.00	0.8	0.1	0.20	0.7	0.0	0.00	0.0	0.1	1.00	0.7	0.2	0.16
Acadian Flycatcher	0.6	0.3	0.33	0.3	0.0	0.00	2.6	0.4	0.12	1.1	0.3	0.34	0.9	0.2	0.14	0.6	0.0	0.00	1.0	0.2	0.17
"Traill's" Flycatcher							0.1	0.0	0.00										0.0	0.0	0.00
Least Flycatcher				0.1	0.0	0.00	0.3	0.0	0.00										0.1	0.0	0.00
Eastern Phoebe	0.1	1.5	0.92	0.2	0.6	0.80										0.1	0.5	0.90	0.1	0.4	0.85
Great Crested Flycatcher	2.1	0.1	0.05	0.4	0.0	0.00	0.5	0.3	0.15				0.3	0.0	0.00	0.3	0.1	0.25	0.6	0.1	0.08
Yellow-throated Vireo										0.0	0.1	1.00							0.0	0.0	1.00
Blue-headed Vireo	1.1	0.0	0.00	0.6	0.0	0.00	2.5	0.0	0.00	0.1	0.1	0.50	1.8	0.5	0.27	1.1	0.3	0.38	1.2	0.1	0.11
Red-eyed Vireo	8.3	2.1	0.29	1.4	0.0	0.00	5.9	0.7	0.12	8.0	0.2	0.01	5.3	1.1	0.14	6.8	0.9	0.12	6.0	0.8	0.12
Blue Jay				0.7	0.1	0.05							0.1	0.0	0.00				0.1	0.0	0.05
Carolina Chickadee	0.3	0.8	0.75	0.8	0.6	0.47	0.6	0.6	0.38	0.6	0.4	0.47	0.7	0.7	0.46	2.4	1.7	0.43	0.9	0.8	0.51
Black-capped Chickadee				0.0	0.2	1.00	0.2	0.0	0.00	0.3	0.2	0.40	0.0	0.1	1.00	0.1	0.0	0.00	0.1	0.1	0.61
Tufted Titmouse	0.6	0.4	0.44	0.1	0.9	0.80	0.7	0.7	0.52	1.3	2.0	0.55	2.7	3.5	0.56	1.0	2.6	0.57	1.1	1.7	0.63
White-breasted Nuthatch	0.3	0.3	0.50	0.3	0.3	0.56	0.0	0.9	1.00	0.0	0.2	1.00	0.0	0.4	1.00	0.0	0.2	1.00	0.1	0.4	0.79
Brown Creeper	0.0	0.1	1.00	0.0	0.2	1.00							0.1	0.0	0.00	0.0	0.1	1.00	0.0	0.1	0.80
Carolina Wren	0.2	0.1	0.33	0.1	0.2	0.67	0.0	0.2	1.00	0.0	0.1	1.00	0.3	0.1	0.25	0.1	0.3	0.89	0.1	0.2	0.55
House Wren	0.0	0.1	1.00																0.0	0.0	1.00
Blue-gray Gnatcatcher																0.5	0.2	0.25	0.1	0.0	0.25
Eastern Bluebird										0.1	0.0	0.00	0.1	0.0	0.00	0.1	0.0	0.00	0.0	0.0	0.00
Veery	16.3	3.7	0.16	17.9	1.8	0.08	30.0	5.2	0.15	13.1	0.9	0.06	0.2	0.1	0.25	0.4	0.3	0.50	12.9	2.0	0.12
Wood Thrush	5.0	0.3	0.06	2.5	0.3	0.05	14.1	1.8	0.11	4.8	1.3	0.15	4.0	0.5	0.11	2.9	0.2	0.08	5.4	0.7	0.12
American Robin	0.3	0.0	0.00	0.1	0.0	0.00	0.1	0.0	0.00	0.3	0.1	0.11	0.2	0.2	0.44	0.3	0.0	0.00	0.2	0.0	0.15
Gray Catbird	10.3	2.7	0.18	14.7	1.6	0.09	2.1	0.3	0.17	0.8	0.1	0.06	0.4	0.0	0.00	0.3	0.1	0.17	4.7	0.8	0.15
Brown Thrasher	0.1	0.1	0.50	0.6	0.2	0.11	0.1	0.0	0.00	0.1	0.0	0.00	0.1	0.2	0.67				0.2	0.1	0.26
Cedar Waxwing	1.0	0.0	0.00	0.4	0.0	0.00	0.1	0.0	0.00				0.1	0.0	0.00	0.9	0.0	0.00	0.4	0.0	0.00

Table 8. (cont.) Mean numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated in Shenandoah National Park averaged over the 11 years, 1993-2003. Data for each species are included only from stations that lie within the breeding range of the species.

Species	Crescent Rock			Pinnacle Cliff			Dean Mountain			Hazeltop Ridge			Big Run			Jeremy's Run			All stations pooled		
	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹	Ad.	Yg.	Prop. Yg. ¹
Chestnut-sided Warbler	4.8	1.5	0.20	0.5	0.1	0.20	2.3	0.3	0.20	0.4	0.4	0.50	0.2	0.2	0.50	0.3	0.0	0.00	1.4	0.4	0.21
Blk-thrtd Blue Warbler				0.1	0.0	0.00	0.2	0.3	0.63				0.1	0.0	0.00	0.0	0.1	1.00	0.1	0.1	0.50
Blk-thrtd Green Warbler				0.9	0.6	0.33							0.2	0.4	0.63	0.2	0.0	0.00	0.2	0.2	0.40
Blackburnian Warbler							0.0	0.1	1.00	0.2	0.0	0.00	0.0	0.1	1.00				0.0	0.0	0.67
Pine Warbler				0.1	0.2	0.50							0.1	0.0	0.00	0.7	0.6	0.39	0.1	0.1	0.35
Cerulean Warbler	0.0	0.2	1.00				0.4	0.2	0.33	0.1	0.0	0.00	0.1	0.1	0.50	0.0	0.2	1.00	0.1	0.1	0.54
Black-and-white Warb.	1.8	2.8	0.61	3.4	4.5	0.54	1.1	1.9	0.65	0.5	0.7	0.47	5.5	3.4	0.37	5.1	2.8	0.34	2.9	2.7	0.48
American Redstart	24.9	28.3	0.52	24.4	31.1	0.54	30.6	9.1	0.20	11.3	1.8	0.14	3.3	6.9	0.67	17.3	14.6	0.45	18.6	15.2	0.44
Worm-eating Warbler	0.7	2.7	0.74	0.6	1.5	0.69	0.9	2.6	0.69	0.4	1.9	0.79	11.0	7.6	0.42	10.5	7.4	0.39	4.1	4.0	0.49
Ovenbird	12.4	5.6	0.30	4.0	1.1	0.24	15.6	9.2	0.37	15.1	9.3	0.36	10.4	4.5	0.30	6.3	4.9	0.43	10.6	5.8	0.35
Louisiana Waterthrush							0.2	0.1	0.17	0.0	0.3	1.00	0.2	0.5	0.75				0.1	0.1	0.62
Kentucky Warbler	0.1	0.1	0.50				0.0	0.2	1.00	0.1	0.1	0.50	0.1	0.5	0.90	0.3	0.2	0.33	0.1	0.2	0.64
Hooded Warbler	1.1	1.0	0.42	2.6	2.6	0.42	0.9	1.3	0.58	0.2	0.2	0.75	12.4	3.4	0.19	15.2	5.4	0.23	5.4	2.3	0.30
Canada Warbler	0.9	2.6	0.63	1.9	2.5	0.59	5.2	2.7	0.30	0.3	0.3	0.50	0.1	0.3	0.75	0.0	0.2	1.00	1.4	1.4	0.51
Scarlet Tanager	1.6	1.7	0.38	0.6	0.6	0.28	2.0	0.3	0.09	2.7	0.3	0.08	2.9	1.3	0.29	2.2	1.8	0.45	2.0	1.0	0.30
Eastern Towhee	5.3	2.2	0.28	5.5	2.3	0.27	3.7	1.3	0.26	2.7	0.9	0.24	4.2	1.3	0.25	9.9	5.6	0.35	5.2	2.3	0.30
Chipping Sparrow													0.6	0.5	0.27	1.4	0.6	0.32	0.3	0.2	0.32
Dark-eyed Junco	1.8	6.2	0.72	6.7	21.8	0.69	5.1	22.2	0.79	1.0	7.5	0.83	0.0	0.3	1.00	0.0	0.3	1.00	2.4	9.7	0.78
Northern Cardinal	0.1	0.0	0.00										0.0	0.1	1.00				0.0	0.0	0.50
Rose-breasted Grosbeak	1.3	1.9	0.54	2.7	0.0	0.00	0.8	0.3	0.21	0.5	0.1	0.08	0.3	0.1	0.25	0.3	0.3	0.50	1.0	0.5	0.29
Indigo Bunting	4.1	0.7	0.10	0.4	0.0	0.00	1.3	0.2	0.08	4.7	0.9	0.12	3.9	1.2	0.33	3.5	3.1	0.36	3.0	1.0	0.22
Common Grackle	0.1	0.0	0.00	0.3	0.0	0.00													0.1	0.0	0.00
Brown-headed Cowbird	0.4	0.1	0.13	0.0	0.1	1.00	0.9	0.0	0.00	0.5	0.2	0.50	0.1	0.0	0.00	0.4	0.3	0.45	0.4	0.1	0.25
American Goldfinch	0.3	0.0	0.00	0.2	0.0	0.00	0.1	0.0	0.00	0.1	0.0	0.00				0.3	0.0	0.00	0.2	0.0	0.00
ALL SPECIES POOLED	111.1	72.5	0.38	98.3	77.2	0.43	134.3	64.7	0.32	73.4	33.3	0.30	75.7	41.7	0.35	93.7	56.6	0.36	97.5	57.6	0.37
Number of Species	38	33		40	29		35	29		32	32		40	35		36	33		49	39	
Total Number of Species		41			43			39			37			46			43			50	

¹ Years for which the proportion of young was undefined (no aged birds were captured in the year) are not included in the mean proportion of young.

² For numbers presented in italics, the mean number of adults or young is greater than 0.1 at one or more stations, but over the entire location the mean number is less than 0.05. The species is counted in the number of species over all stations pooled.

Table 9. Estimates of adult survival and recapture probabilities and proportion of residents using time-constant models for 17 species breeding at MAPS stations in Shenandoah National Park obtained from 11 years (1993-2003) of mark-recapture data.

Species	Num. sta2. ¹	Num. ind. ²	Num. caps. ³	Num. ret. ⁴	Survival probability ⁵	Surv. C.V. ⁶	Recapture probability ⁷	Proportion of residents ⁸
Blue-headed Vireo	6	77	99	7	0.411 (0.150)	36.5	0.207 (0.159)	0.650 (0.513)
Red-eyed Vireo	6	379	470	39	0.506 (0.071)	14.1	0.134 (0.052)	0.895 (0.351)
Tufted Titmouse	5	62	89	10	0.333 (0.139)	41.8	0.369 (0.219)	1.000 (0.668)
Veery	5	617	1281	289	0.602 (0.024)	3.9	0.553 (0.033)	0.552 (0.054)
Wood Thrush	6	349	487	31	0.299 (0.069)	23.0	0.467 (0.138)	0.441 (0.154)
Gray Catbird	4	258	402	66	0.547 (0.048)	8.8	0.355 (0.061)	0.620 (0.133)
Chestnut-sided Warbler	2	59	124	23	0.456 (0.080)	17.5	0.729 (0.126)	0.589 (0.219)
Black-and-white Warbler	6	174	250	27	0.440 (0.085)	19.3	0.346 (0.113)	0.708 (0.270)
American Redstart	6	1114	1550	187	0.558 (0.030)	5.4	0.273 (0.032)	0.547 (0.075)
Worm-eating Warbler	2	217	328	36	0.495 (0.074)	14.9	0.503 (0.105)	0.383 (0.113)
Ovenbird	6	592	951	152	0.540 (0.035)	6.4	0.465 (0.047)	0.501 (0.070)
Hooded Warbler	5	301	592	76	0.480 (0.046)	9.5	0.625 (0.072)	0.393 (0.080)
Scarlet Tanager	6	131	151	11	0.728 (0.122)	16.7	0.048 (0.044)	1.000 (0.930)
Eastern Towhee	6	302	453	64	0.507 (0.053)	10.5	0.466 (0.074)	0.463 (0.102)
Dark-eyed Junco	4	155	217	15	0.297 (0.099)	33.5	0.366 (0.177)	0.633 (0.327)
Rose-breasted Grosbeak	5	62	72	4	0.379 (0.216)	56.9	0.419 (0.348)	0.265 (0.280)
Indigo Bunting	5	183	259	25	0.480 (0.080)	16.6	0.338 (0.103)	0.407 (0.149)

¹ Number of super-stations where the species was a regular or usual breeder at which adults of the species were captured.

² Number of adult individuals captured at stations where the species was a regular or usual breeder (i.e., number of capture histories).

Table 9. (cont.) Estimates of adult survival and recapture probabilities and proportion of residents using both temporally variable and time-constant models for 17 species breeding at MAPS stations in Shenandoah National Park obtained from 11 years (1993-2003) of mark-recapture data.

³ Total number of captures of adult birds of the species at stations where the species was a regular or usual breeder.

⁴ Total number of returns. A return is the first recapture in a given year of a bird originally banded at the same station in a previous year.

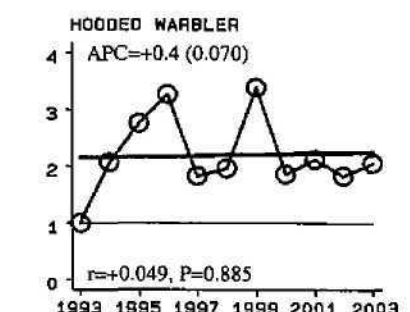
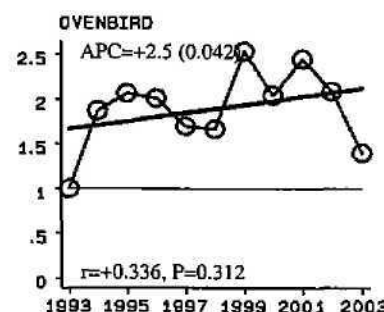
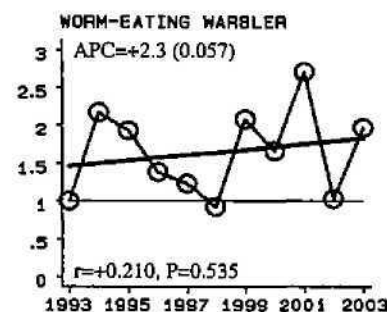
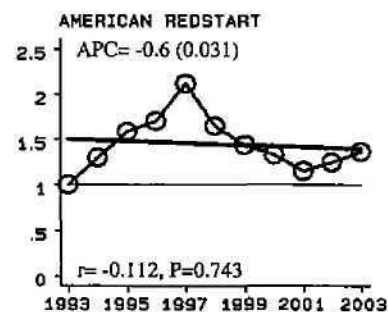
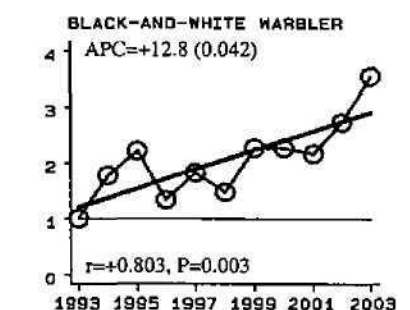
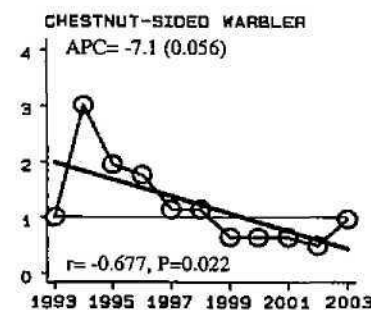
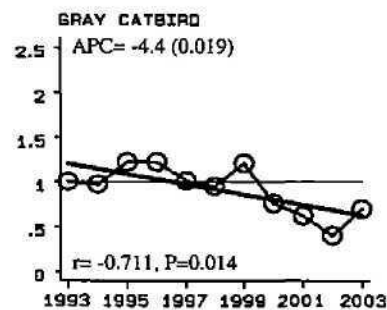
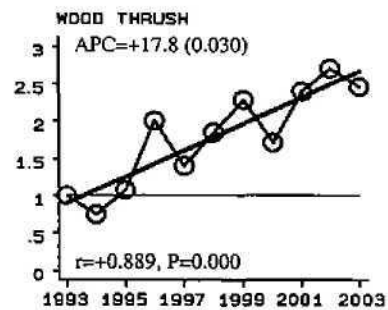
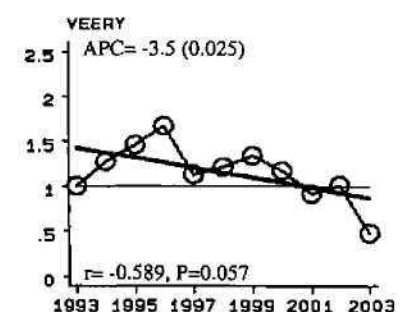
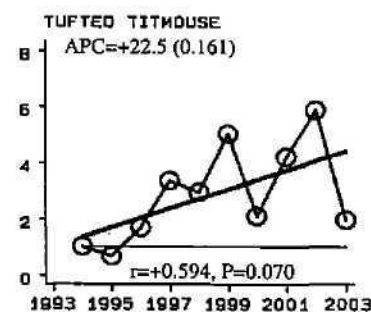
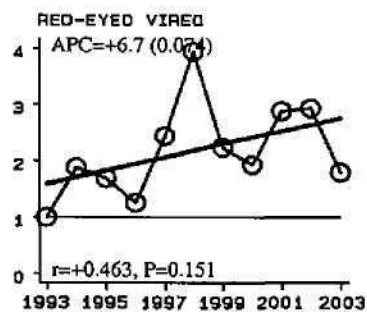
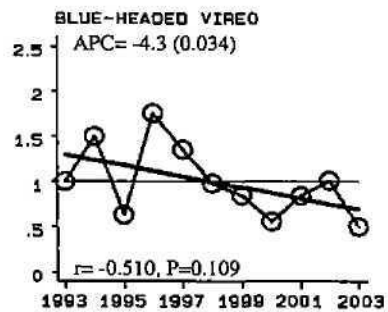
⁵ Survival probability presented as the maximum likelihood estimate (standard error of the estimate).

⁶ The coefficient of variation for survival probability.

⁷ Recapture probability presented as the maximum likelihood estimate (standard error of the estimate).

⁸ The proportion of residents among newly captured adults presented as the maximum likelihood estimate (standard error of the estimate).

Index of adult population size



Year

Figure 1. Population trends for 17 species and all species pooled in Shenandoah National Park over the 11 years 1993-2003. The index of population size was arbitrarily defined as 1.0 in 1993. Indices for subsequent years were determined from constant-effort between-year changes in the number of adult birds captured from stations where the species was a regular or usual breeder and summer resident. The annual percentage change in the index of adult population size was used as the measure of the population trend (APC), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (r) and significance of the correlation coefficient (P) are also shown on each graph.

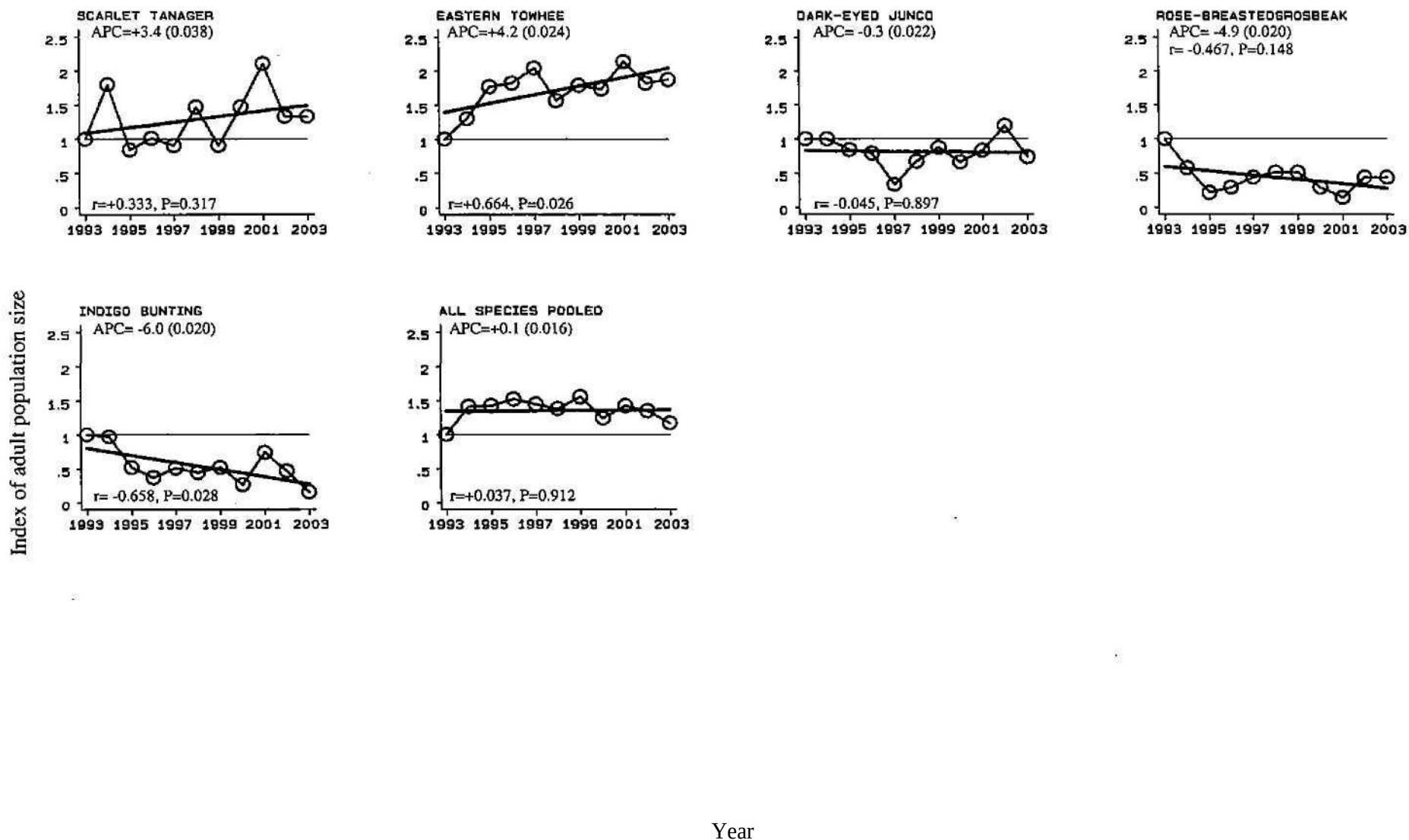


Figure 1. (cont.) Population trends for 17 species and all species pooled in Shenandoah National Park over the 11 years 1993-2003. The index of population size was arbitrarily defined as 1.0 in 1993. Indices for subsequent years were determined from constant-effort between-year changes in the number of adult birds captured from stations where the species was a regular or usual breeder and summer resident. The annual percentage change in the index of adult population size was used as the measure of the population trend (APC), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (r) and significance of the correlation coefficient (P) are also shown on each graph.

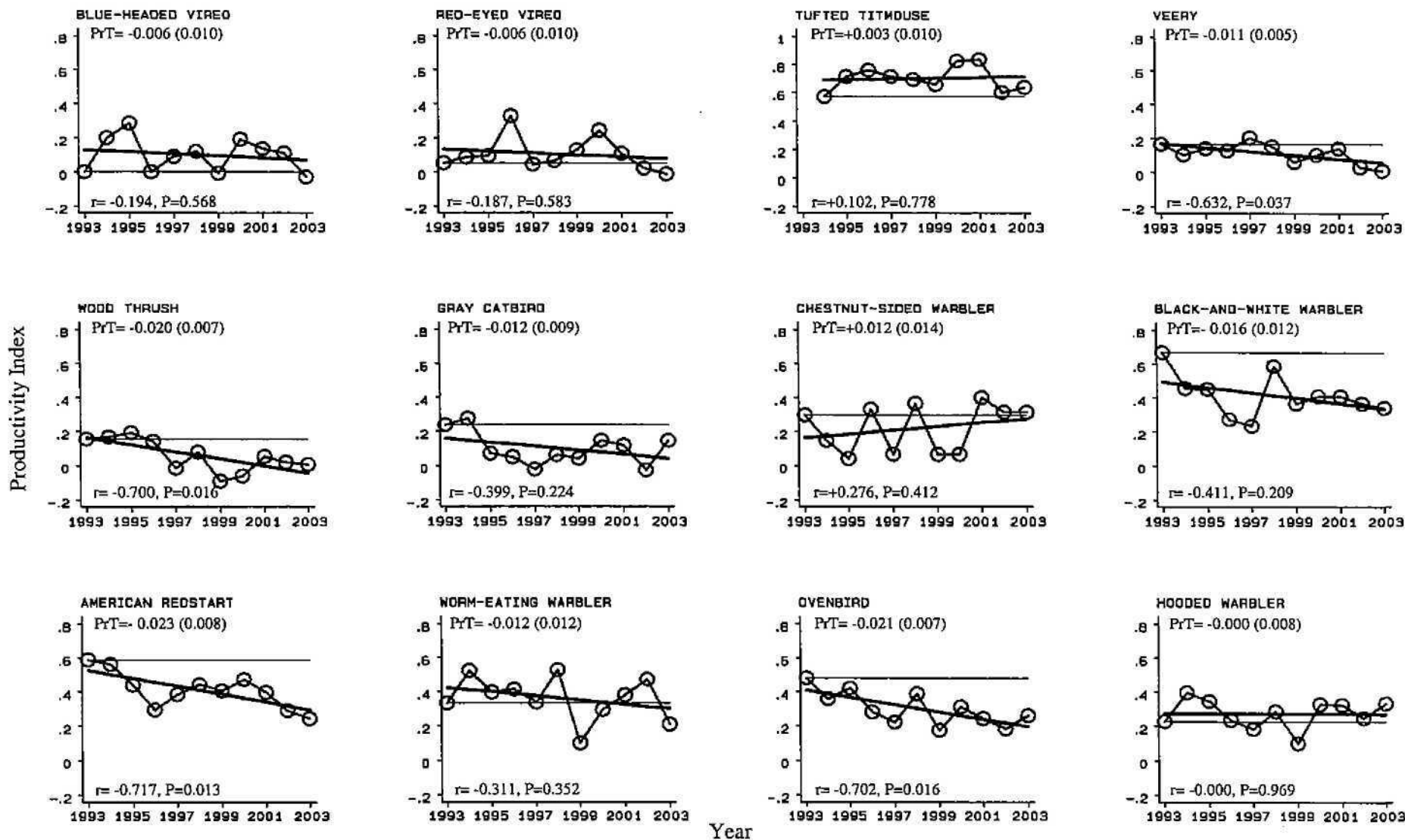


Figure 2. Trend in productivity for 17 species and all species pooled in Shenandoah National Park over the 11 years 1993-2003. The productivity index was defined as the actual productivity value in 1993. Indices for subsequent years were determined from constant-effort between-year changes in proportion of young in the catch from stations where the species was a regular or usual breeder and summer resident. The slope of the regression line for annual change in the index of productivity was used as the measure of the productivity trend (PrT), and it and the standard error of the slope (*in parentheses*) are presented on each graph. The correlation coefficient (*r*) and significance of the correlation coefficient (*P*) are also shown on each graph.

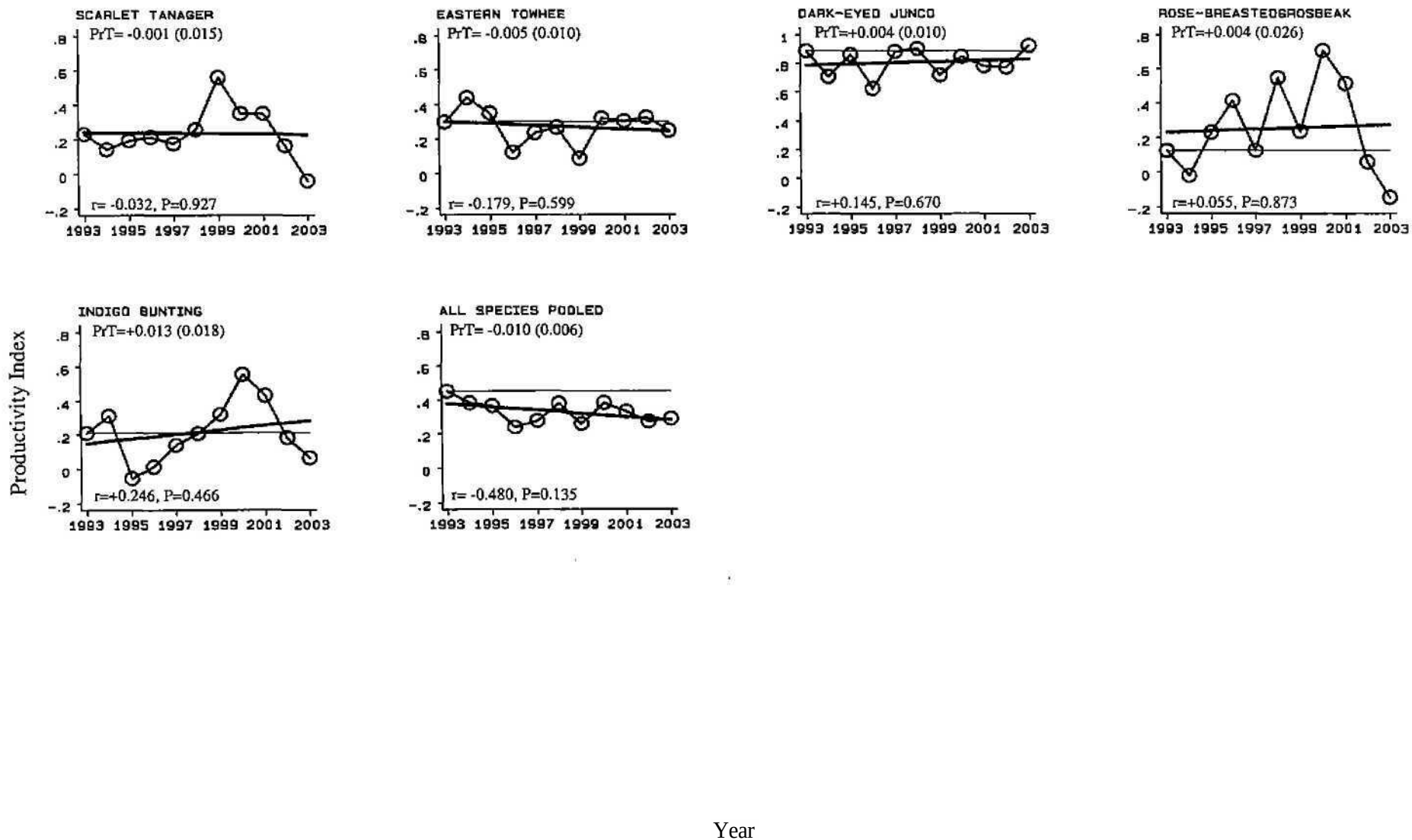


Figure 2. (cont.) Trend in productivity for 17 species and all species pooled in Shenandoah National Park over the 11 years 1993-2003. The productivity index was defined as the actual productivity value in 1993. Indices for subsequent years were determined from constant-effort between-year changes in proportion of young in the catch from stations where the species was a regular or usual breeder and summer resident. The slope of the regression line for annual change in the index of productivity was used as the measure of the productivity trend (PrT), and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (r) and significance of the correlation coefficient (P) are also shown on each graph.