# THE 2004 REPORT OF THE MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP (MAPS) PROGRAM ON FORT BRAGG

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## Introduction

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 over 500 constant-effort mist-netting and banding stations. MAPS was designed to provide critically needed information on the vital rates (productivity or birth rate, and survivorship or death rate) of landbirds that is crucial for efforts to identify demographic causes of the severe and sometimes accelerating population declines documented for many species of North American landbirds (Robbins et al. 1989, Terborgh 1989, DeSante 1992, DeSante et al. 1995, 1999, 2001a, Peterjohn et al.1995). Such data on vital rates are also critically needed in efforts to identify management strategies to reverse such population declines (DeSante 1995, DeSante and Rosenberg 1998).

MAPS is organized to fulfill three sets 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, and recruitment into the adult population from modified Cormack- Jolly-Seber analyses of mark-recapture data on adult birds.

The specific **research** goals of MAPS are to identify and describe: (a) 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 (b) 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 relationships, 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.

All of these monitoring, research, and management goals are in agreement with the Department of Defense (DoD) Partners-in-Flight (PIF) strategy. Moreover, because birds are excellent indicators of the health of ecological systems, they can serve as a sensitive barometer of the overall effectiveness of efforts to maintain the biodiversity and ecological integrity of military installations. Accordingly, the MAPS program was initiated on select military installations beginning in 1992 and soon became one of the focus projects of the DoD PIF program. It was expected that information from the MAPS program would be capable of aiding research and management efforts on these military installations to protect and enhance the installations'

avifauna and ecological integrity, while allowing them to fulfill their military mission.

In 1995, six MAPS stations were established and operated on Fort Bragg. The operation of these stations during the summers of 1995 and 1996 and the subsequent analyses of data from those years were accomplished through funding from U.S. Army Fort Bragg. Operation of these six MAPS station and associated data analyses during the three years 1997-1999 was accomplished by means of funding from the DoD Legacy Resource Management Program. The operation of the six stations was continued during the summers of 2000 through 2004 by means of funding from Fort Bragg, but the comprehensive analyses of data from those years was again funded by the DoD Legacy Resource Management Program.

The initial objective of the MAPS Program on DoD installations such as Fort Bragg has been to identify generalized management guidelines and formulate specific management actions that could be implemented on military installations and elsewhere to reverse the population declines of target landbird species and to maintain the populations of stable or increasing species. The identification and formulation of these management guidelines and actions was to be achieved by modeling the vital rates (productivity and survivorship) of the various landbird species as a function of landscape-level habitat characteristics and spatially explicit weather variables. The goal was to identify relationships between adult population size, numbers of young produced, productivity (ratio of young to adults), and trends in those parameters and these habitat and weather variables. The resultant management strategies were designed to involve efforts to modify the habitat from characteristics associated with low population size, population trend, or productivity to characteristics associated with high population size, population trend, or productivity (especially for species for which low productivity was found to be driving the population decline).

The funding necessary to undertake these analyses and formulate management strategies was obtained from the Legacy Resource Management Program during 2000-2002. These analyses were completed in 2003 and management guidelines were formulated for ten bird species of conservation concern that breed in the southeastern United States (Nott et al. 2003). With additional funding from the Legacy Resource Management Program, we are currently implementing these guidelines through management actions on eight military installations (including Fort Bragg) in conjunction with efforts to increase military Readiness and Range Sustainment. The strategy for implementing these guidelines includes the establishment of new MAPS stations to monitor the effectiveness of such proposed or on-going management, the discontinuance 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. In this way, the total number of stations operated will remain the same.

Following the recommendations of Nott et al. (2003), the I102 station was discontinued in 2003 to reduce the probability of capturing endangered Red-cockaded Woodpeckers that breed within the boundaries of that station. The I102 station was replaced by the Sandstone Hill station in a mosaic of upland patchy forest, shrubland, and grasslands that are frequently managed to reduce fire risks. Controlled burns as part of this fire management are planned for the spring of 2005, and this station will continue to be operated to assess the effects of these management actions.

A complete summary of the results of the MAPS Program on Fort Bragg from 1993-1999, as well as on 12 other installations or groups of nearby installations in the eastern United States, was presented by DeSante et al. (2001b), a summary of 2000-2002 results was presented by DeSante et al. (2002), and a summary of 2003 results was presented by DeSante et al. (2004a). This report briefly updates these earlier reports and documents the operation of the six MAPS stations on Fort Bragg during the 2004 breeding season.

## Methods

Six MAPS stations were operated in 2004, in the same locations where they were first established in 1995 (five stations) or 2003 (Sandstone Hill station). Each of these six MAPS stations was operated in accordance with the highly standardized banding protocols established by The Institute for Bird Populations for use by the MAPS Program throughout North America and spelled out in detail in the MAPS Manual (DeSante et al. 2004b). On each day of operation each year, one 12-m long, 30-mm mesh, 4-tier nylon mist net was erected at each of ten fixed mist-netting sites within the interior eight ha of each 20-ha station. These ten nets at each station were operated for six morning hours per day (beginning at local sunrise), and for one day in each of nine consecutive 10-day periods between May 11 and August 4 (Table 1). The operation of stations occurred on schedule in each of the ten-day periods and was carried out by IBP field biologist intern Matt Schaap, who was trained by IBP field biologists Ken Burton and Richard Gibbons, supervised occasionally during the season by Richard Gibbons, and assisted by volunteers Michael McCloy, Mike Leonwiczs, David McCloy, and Lisa Richmond.

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 comprised. The following data were taken on all birds captured, including recaptures, according to MAPS guidelines using standardized codes and forms (DeSante et al. 2004b):

(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., extent of 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) presence of molt limits and plumage characteristics;
(12) wing chord;
(13) fat class and body mass;
(14) date and time of capture (net-run time);
(15) station and net site where captured; and
(16) any pertinent notes.

Effort data (i.e., the number and timing of net-hours on each day of operation) 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 (summer residency) 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.

The computer entry, proofing, and verification of all banding, effort, and breeding status data were completed by IBP biologists using specially designed data entry, verification, and editing programs. 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. 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 effort and breeding status 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), extent of juvenal plumage, extent of body and flight-feather molt, extent of primary-feather wear, and presence of molt limits and plumage characteristics;
(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, body mass, fat content, date and station of capture, and any pertinent notes were used as supplementary information for the correct determination of species, age, and sex in all of these verification processes. The proofed, verified, and corrected banding data from each year were then run through a series of analysis programs that calculated for each species and for all species pooled at each station and for all stations pooled on each forest:

(1) the numbers of newly banded birds, recaptured birds, and birds released unbanded;
(2) the numbers and capture rates (per 600 net-hours) of first captures (in each year) for individual adult and young birds; and
(3) the reproductive index (number of young captured/number of adults captured).

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. As our index of post-fledging productivity we are now using the “reproductive

index" (number of young divided by number of adults) as opposed to the "productivity index" (proportion of young in the catch) which was previously used. Reproductive index is a more intuitive value for productivity, and it is also more comparable to other MAPS parameters estimated from mark-recapture analyses, such as recruitment.

Survival was estimated for 14 target species using modified Cormack-Jolly-Seber (CJS) mark-recapture analyses (Pollock et al.1990, Lebreton et al.1992) on ten years (1995-2004) of capture histories of adult birds from the six long-running stations. Target species were those for which, on average, at least 2.5 individual adults per year and at least five between-year returns were recorded from data pooled from all of those stations at which the species was a breeder during more than half of the years that the station was operated. Using the computer program TMSURVIV (White 1983, Hines et al. 2003), we calculated, for each target species, maximum-likelihood estimates and standard errors (*SE*s) for adult survival probability, adult recapture probability, and the proportion of residents among newly captured adults using a time-constant, between- and within-year transient model (Pradel et al. 1997, Nott and DeSante 2002, Hines et al. 2003). The use of the transient model accounts for the existence of transient adults (dispersing and floater individuals which are only captured once) in the sample of newly captured birds, and provides survival estimates that are unbiased with respect to these transient individuals (Pradel et al. 1997). 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.

## Results and Discussion

We operated six MAPS stations on Fort Bragg during the summer of 2004. A total of 3144.7 net-hours were accumulated at all six stations pooled. The details of the operation of these six stations during 2004 are presented in Table 1.

For each individual species and for all species pooled, the numbers of individual birds newly banded, captured and released unbanded, and recaptured are presented for each station in Table 2 and, for all stations combined, in Table 4. A total of 659 captures of 44 species occurred at Fort Bragg during the summer of 2004 (Table 4). Newly banded birds comprised 70.6% of the total captures. The greatest number of total captures (176) was recorded at the Sandstone Hill station and the smallest number of total captures (63) was recorded at the S114 station. The highest species richness occurred at Station I104 (28 species) and the lowest species richness occurred at Sandstone Hill, Station S114, and Station S112 (18 species each).

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 Station I104 (67.9 adults/600 net hours; Table 3), followed by population sizes at Station S110 (52.3), Station S113 (49.0), Sandstone Hill (33.8), Station S112 (31.1), and Station S114 (27.9). Reproductive index (number of young birds per adult) showed a different pattern, being highest

by far at Sandstone Hill (4.10), followed by Station S112 (0.86), Station I114 (0.83), Station I104 (0.82), Station I113 (0.67), and Station S110 (0.53). A notable event in 2004 was the capture of a very large number (108) of young Pine Warblers at Sandstone Hill, resulting in very high reproductive indices for this species and for all species pooled at this station (and, consequently, at all stations combined) that were not detected at this station in 2003. At present, we have no explanation for the very large number of young Pine Warblers captured at the Sandstone Hill station in 2004.

Among individual species, Pine Warbler was the most frequently captured species at the six stations in 2004 (see above), followed by Carolina Wren, Common Yellowthroat, Northern Cardinal, Carolina Chickadee, Prairie Warbler, Tufted Titmouse, and Ruby-throated Hummingbird (Table 4). The most abundant breeding species, having a capture rate of at least 2.0 adults per 600 net-hours, in decreasing order, were Common Yellowthroat, Prairie Warbler, Great Crested Flycatcher, Carolina Wren, Northern Cardinal, Pine Warbler, Indigo Bunting, and Carolina Chickadee. The most abundant breeding species at each station, having a capture rate of at least 3.0 birds per 600 net-hours (Table 3), were as follows:

**Sandstone Hill**
Pine Warbler
Indigo Bunting
Carolina Chickadee
Chipping Sparrow
Blue Grosbeak

**I113**
Great Crested Flycatcher
Prairie Warbler
Common Yellowthroat
Blue Jay
Brown Thrasher

**I 104**
Common Yellowthroat
Great Crested Flycatcher
Carolina Wren
Prairie Warbler
Carolina Chickadee
Northern Cardinal
Red-bellied Woodpecker
Tufted Titmouse
Blue-gray Gnatcatcher

**S114**
Carolina Wren
Northern Cardinal

**S110**
Prairie Warbler
Blue-gray Gnatcatcher
Common Yellowthroat
Yellow-billed Cuckoo
Carolina Wren
Pine Warbler
Summer Tanager
Chipping Sparrow

**S112**
Wood Thrush
Hooded Warbler
Northern Cardinal

A rough comparison of data from 2003 and 2004 indicates that while adult population sizes remained very similar between 2003 (43.4 adults/600 net hours) and 2004 (43.7 adults/600 net hours), the reproductive index increased from 0.47 young/adult in 2003 to 1.16 young/adult in 2004. This very large increase, however, was primarily caused by the huge increase in productivity for Pine Warblers at the Sandstone Hill station. Nevertheless, productivity did increase in 2004 compared to 2003, even when all Pine Warblers are removed from the data for both years. In this case, we find that the reproductive index increased from 0.49 young/adult in 2003 to 0.70 young/adult in 2004 (a 43.5% increase). Thus, the conditions that led to truly exceptional productivity for Pine Warblers, also led to excellent productivity for all other species pooled. A detailed analysis of constant-effort changes between 2003 and 2004 in numbers of adults and young and reproductive index for all of the species (and all species pooled) at each of the stations (and all stations combined) at Fort Bragg, however, is beyond the scope of this report.

Using ten years (1995-2004) of data from the six long-running stations, estimates of annual adult survival ($\phi$), recapture probability ($p$), and proportion of residents ($\tau$) were obtained for 14 target species breeding at Fort Bragg (Table 5). Survival-rate estimates ranged from a low of 0.268 for Carolina Wren to a high of 0.597 for Ovenbird, with a mean of 0.435. Similarly, recapture probability ranged from a low of 0.091 for Wood Thrush (likely biased low because the proportion of residents was estimated at 1.000) to a high of 0.870 for Tufted Titmouse, with a mean of 0.457, while the proportion of residents among newly captured adults ranged from a low of 0.090 for Brown Thrasher to a high of 1.000 for Wood Thrush and Ovenbird, with a mean of 0.560. The precision of these estimates continues to improve with each additional year of data. Mean CV($\phi$) for the survival estimate for nine species with comparable data from nine years (1995-2003) of analysis was lower or equal for all nine species after ten years (1995-2004) had been collected. The mean CV($\phi$) for these nine species improved from 25.8% after nine years to 23.3% after ten years at Fort Bragg.

Survival estimates are low at Fort Bragg compared to other locations, especially for resident species. In comparing survival values from Fort Bragg (1995-2004) with those of the Southeast Region of the United States (1992-2001; see http://www.birdpop.org/nbii/surv/default.asp), for example, survival at Fort Bragg was lower than that of the Southeast Region for 9 of the 14 target species, with the mean at Fort Bragg (0.435) being 10% lower than that of the Southeast Region (0.485). Importantly, survival for all five of the resident target species (Carolina Chickadee, Tufted Titmouse, Carolina Wren, Eastern Towhee, and Northern Cardinal) were substantially lower at Fort Bragg (mean 0.381) than in the Southeast Region (mean 0.478), indicating problems with survival of landbirds on the Fort Bragg installation itself.

These results provide a strong suggestion that overwintering survival of individuals wintering on Fort Bragg may be poor (DeSante et al. 2004). The Institute for Bird Populations has initiated the MAWS (Monitoring Avian Wintering Survival) Program to assess habitat-specific overwintering survival rates in the southern parts of the United States. Six of the initial 24 MAWS stations have been established on Fort Bragg through funding from the Legacy Resources Management Program. Four or five years of data from these MAWS stations should be able to provide information as to the extent of this overwintering survival problem and relationships between it and various habitat variables. Eventually, the MAWS Program, in conjunction with MAPS, should lead to the formulation of management strategies and guidelines to enhance overwintering survival, especially for declining species of conservation concern.

As mentioned earlier, analyses aimed at identifying and describing relationships between four demographic parameters (adult population size, population trends, numbers of young, and productivity) and landscape-level habitat characteristics have been completed for 13 military installations including Fort Bragg (Nott et al. 2003). These analyses were also funded by the Legacy Resource Management Program. At Fort Bragg, two species (Wood Thrush and Prairie Warbler) emerged as candidates for particular management concern. The new Sandstone Hill MAPS station has proven very productive, recording the highest reproductive index of any station, due in large part to the number of young Pine Warblers captured. Data from this station should also help shed further light on declines of Prairie Warbler, a species of concern in the region.

Another objective of this monitoring work on Fort Bragg is to evaluate the effectiveness of avian management guidelines that can be integrated into both new and on-going land management practices. The I102 station was replaced by the Sandstone Hill station in a mosaic of upland patchy forest, shrubland, and grasslands that are frequently managed to reduce fire risks. Controlled burns as part of this fire management are planned for the spring of 2005, and this station will continue to be operated to assess the effects of these management actions. Through such adaptive management processes, we are confident that we can achieve the long-term goal of reversing declining populations and maintaining stable or increasing populations of target landbird species at Fort Bragg.

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Table 1. Summary of the 2004 MAPS program on U.S. Army Fort Bragg.

| Station | | | | | | 2004 operation | | |
|---|---|---|---|---|---|---|---|---|
| Name | Code | No. | Major Habitat Type | Latitude-longitude | Avg Elev. (m) | Total number of net-hours | No. of periods | Inclusive dates |
| Sandstone Hill | SAHI | 16706 | Controlled burn pine savanna, mixed scrub oak woodland | 35˚02'50"N,79˚19'38"W | 152 | 514.7 | 9 | 5/14 – 7/30 |
| I 104 | I104 | 16657 | Controlled burn pine savanna, riparian fields and scrub | 35˚07'40"N,79˚19'00"W | 84 | 530.0 | 9 | 5/11 – 8/02 |
| I 113 | I113 | 16658 | Controlled burn riparian, savanna and pine-oak woodland | 35˚05'30"N,79˚19'30"W | 110 | 526.7 | 9 | 5/13 – 8/03 |
| S 110 | S110 | 16659 | Riparian woodland, pine savanna and pine-oak woodland | 35˚07'10"N,79˚20'10"W | 94 | 516.3 | 9 | 5/12 – 8/01 |
| S 114 | S114 | 16661 | Pine-oak and riparian woodland bordering grain fields | 35˚02'50"N,79˚16'10"W | 70 | 517.0 | 9 | 5/16 – 7/31 |
| S 112 | S112 | 16660 | Pine-oak mixed with riparian woodland | 35˚06'40"N,79˚22'00"W | 114 | 540.0 | 9 | 5/15 – 8/04 |
| ALL STATIONS COMBINED | | | | | | 3144.7 | 9 | 5/11 – 8/04 |

Table 2. Capture summary for the six individual MAPS stations operated on U.S. Army Fort Bragg in 2004.
N = Newly Banded, U = Unbanded, R = Recaptures of banded birds.

| | Sandstone Hill | | | I 104 | | | I 113 | | | S 110 | | | S 114 | | | S 112 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | N | U | R | N | U | R | N | U | R | N | U | R | N | U | R | N | U | R |
| Northern Bobwhite | | | | | | | | | | | 1 | | | | | | | |
| Mourning Dove | | | | | 1 | | | | | | 1 | | | | | | | |
| Yellow-billed Cuckoo | | | | 1 | | | | | | 3 | | | | | | | | |
| Whip-poor-will | | | | | | | 1 | | | | | | | | | | | |
| Ruby-throated Hummingbird | | 5 | | 1 | 1 | | | 5 | | | 6 | | | 2 | | | 1 | |
| Red-headed Woodpecker | 1 | | | 1 | | | | | | | | | | | | | | |
| Red-bellied Woodpecker | 1 | | | 2 | | 1 | 1 | | | | | | | | | 1 | | |
| Downy Woodpecker | 4 | | 1 | | | | | | | | | | | | | 2 | | |
| Red-cockaded Woodpecker | | | | | | 1 | | | | | | 1 | | | | | | |
| Eastern Wood-Pewee | 1 | | | 1 | | | | | | | | | | | | | | |
| Great Crested Flycatcher | | | | 7 | | | 5 | | 1 | 2 | | | 1 | | | 1 | | 1 |
| White-eyed Vireo | | | | | | | 3 | | 1 | 1 | | | 1 | | | | | |
| Red-eyed Vireo | | | | 1 | | | | | | 1 | | | 1 | | | | | |
| Blue Jay | | | | | | | 7 | | | | | | | | | | | |
| Carolina Chickadee | 4 | 1 | | 13 | 1 | 8 | 4 | | | | | | 2 | | | 6 | | 2 |
| Tufted Titmouse | 6 | | | 5 | | 5 | | | 2 | 3 | | | 4 | | 1 | 4 | 1 | |
| White-breasted Nuthatch | | | | 1 | | | | | | | | | | | | | | |
| Brown-headed Nuthatch | 1 | | | | | | 1 | | | | | | | | | | | |
| Carolina Wren | 3 | | | 17 | 1 | 13 | 7 | | 6 | 8 | | 8 | 19 | | 12 | 9 | 3 | 6 |
| Blue-gray Gnatcatcher | | | | 9 | 1 | | | | | 5 | | 1 | | | | | | |
| Wood Thrush | | | | | | | | | | | | | | | | 5 | | 2 |
| Gray Catbird | | | | 4 | | | | | | 1 | | 1 | | | | | | |
| Brown Thrasher | 1 | | 1 | 2 | | | 2 | | 1 | 1 | | 1 | | | | | | |
| Black-throated Blue Warbler | | | | | | | 2 | | 2 | | | | | | | | | |
| Pine Warbler | 108 | 3 | 15 | 3 | | | 8 | | | 3 | | | 2 | | | 2 | | |
| Prairie Warbler | 1 | | | 7 | | 3 | 5 | | 1 | 9 | 1 | 5 | | | | | | |

Table 2. (cont.) Capture summary for the six individual MAPS stations operated on U.S. Army Fort Bragg in 2004.
N = Newly Banded, U = Unbanded, R = Recaptures of banded birds.

| | Sandstone Hill | | | I 104 | | | I 113 | | | S 110 | | | S 114 | | | S 112 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | N | U | R | N | U | R | N | U | R | N | U | R | N | U | R | N | U | R |
| Black-and-white Warbler | | | | | | | | | | | | | 1 | | 1 | | | |
| American Redstart | | | | 2 | | | 1 | | | | | | | | | | | |
| Prothonotary Warbler | | | | | | | 1 | | 1 | | | | 1 | | 1 | | | |
| Ovenbird | | | | | | | | | | | | | 1 | | | 1 | | 1 |
| Northern Waterthrush | | | | 2 | | | | | | | | | 1 | | | 1 | | |
| Kentucky Warbler | | | | | | | | | | | | | | | 1 | | | |
| Common Yellowthroat | 1 | | | 12 | | 5 | 6 | | 9 | 7 | | 4 | | | | 1 | | |
| Hooded Warbler | | | | | | | | | | | | | 1 | | | 4 | | |
| Yellow-breasted Chat | | | | 1 | | | | | | | | | | | | | | |
| Summer Tanager | 1 | | | 1 | | | 3 | | | 2 | | 1 | 1 | | | 1 | | |
| Eastern Towhee | | | | 1 | | | 1 | | 1 | 1 | | 4 | 1 | 1 | | | | 1 |
| Bachman's Sparrow | 2 | | 1 | | | | 2 | | 1 | 2 | | | | | | | | |
| Chipping Sparrow | 4 | | | | | | | | | 4 | | | | | | | | |
| Northern Cardinal | | | | 6 | | 7 | 2 | | 2 | 6 | | 6 | 2 | | 3 | 7 | | 2 |
| Blue Grosbeak | 3 | | 1 | | | | | | | | | | | | | 1 | | 1 |
| Indigo Bunting | 6 | | | 1 | | | 1 | | | 1 | | | 2 | | | 1 | | |
| Common Grackle | | | | | 1 | | | | | | | | | | | | | |
| American Goldfinch | | | | 1 | | | 2 | | | 2 | | | | | | | | |
| ALL SPECIES POOLED | 148 | 9 | 19 | 102 | 6 | 43 | 65 | 5 | 28 | 62 | 9 | 32 | 41 | 3 | 19 | 47 | 5 | 16 |
| Total Number of Captures | | 176 | | | 151 | | | 98 | | | 103 | | | 63 | | | 68 | |
| Number of Species | 17 | 3 | 5 | 25 | 6 | 8 | 21 | 1 | 12 | 19 | 4 | 10 | 16 | 2 | 6 | 16 | 3 | 8 |
| Total Number of Species | | 18 | | | 28 | | | 23 | | | 23 | | | 18 | | | 18 | |

Table 3. Numbers of adult and young individual birds captured per 600 net-hours and reproductive index (young/adult) at the six individual MAPS stations operated on U.S. Army Fort Bragg in 2004.

| | Sandstone Hill | | | I 104 | | | I 113 | | | S 110 | | | S 114 | | | S 112 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index |
| Yellow-billed Cuckoo | | | | 1.1 | 0.0 | 0.00 | | | | 3.5 | 0.0 | 0.00 | | | | | | |
| Whip-poor-will | | | | | | | 1.1 | 0.0 | 0.00 | | | | | | | | | |
| Red-headed Woodpecker | 1.2 | 0.0 | 0.00 | 1.1 | 0.0 | 0.00 | | | | | | | | | | | | |
| Red-bellied Woodpecker | 1.2 | 0.0 | 0.00 | 3.4 | 0.0 | 0.00 | 1.1 | 0.0 | 0.00 | | | | | | | 1.1 | 0.0 | 0.00 |
| Downy Woodpecker | 0.0 | 4.7 | undf.[1] | | | | | | | | | | | | | 2.2 | 0.0 | 0.00 |
| Red-cockaded Woodpecker | | | | 1.1 | 0.0 | 0.00 | | | | 0.0 | 1.2 | undf.[1] | | | | | | |
| Eastern Wood-Pewee | 0.0 | 1.2 | undf. | 0.0 | 1.1 | undf.[1] | | | | | | | | | | | | |
| Great Crested Flycatcher | | | | 7.9 | 0.0 | 0.00 | 6.8 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | 1.2 | 0.0 | 0.00 | 2.2 | 0.0 | 0.00 |
| White-eyed Vireo | | | | | | | 2.3 | 1.1 | 0.50 | 0.0 | 1.2 | undf. | 0.0 | 1.2 | undf.[1] | | | |
| Red-eyed Vireo | | | | 0.0 | 1.1 | undf. | | | | 0.0 | 1.2 | undf. | 0.0 | 1.2 | undf. | | | |
| Blue Jay | | | | | | | 4.6 | 3.4 | 0.75 | | | | | | | | | |
| Carolina Chickadee | 4.7 | 0.0 | 0.00 | 4.5 | 11.3 | 2.50 | 0.0 | 4.6 | undf.[1] | | | | 1.2 | 1.2 | 1.00 | 2.2 | 5.6 | 2.50 |
| Tufted Titmouse | 0.0 | 7.0 | undf. | 3.4 | 3.4 | 1.00 | 2.3 | 0.0 | 0.00 | 1.2 | 2.3 | 2.00 | 2.3 | 2.3 | 1.00 | 1.1 | 3.3 | 3.00 |
| White-breasted Nuthatch | | | | 0.0 | 1.1 | undf. | | | | | | | | | | | | |
| Brown-headed Nuthatch | 0.0 | 1.2 | undf. | | | | 0.0 | 1.1 | undf. | | | | | | | | | |
| Carolina Wren | 0.0 | 3.5 | undf. | 5.7 | 17.0 | 3.00 | 2.3 | 8.0 | 3.50 | 3.5 | 7.0 | 2.00 | 7.0 | 17.4 | 2.50 | 0.0 | 10.0 | undf.[1] |
| Blue-gray Gnatcatcher | | | | 3.4 | 6.8 | 2.00 | | | | 4.6 | 1.2 | 0.25 | | | | | | |
| Wood Thrush | | | | | | | | | | | | | | | | 6.7 | 1.1 | 0.17 |
| Gray Catbird | | | | 2.3 | 2.3 | 1.00 | | | | 1.2 | 0.0 | 0.00 | | | | | | |
| Brown Thrasher | 1.2 | 0.0 | 0.00 | 1.1 | 1.1 | 1.00 | 3.4 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | | | | | | |
| Pine Warbler | 7.0 | 118.9 | 17.00 | 2.3 | 1.1 | 0.50 | 0.0 | 9.1 | undf. | 3.5 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | 0.0 | 2.2 | undf. |
| Prairie Warbler | 1.2 | 0.0 | 0.00 | 5.7 | 3.4 | 0.60 | 5.7 | 1.1 | 0.20 | 9.3 | 2.3 | 0.25 | | | | | | |

Table 3. (cont.) Numbers of adult and young individual birds captured per 600 net-hours and reproductive index (young/adult) at the six individual MAPS stations operated on U.S. Army Fort Bragg in 2004.

| | Sandstone Hill | | | I 104 | | | I 113 | | | S 110 | | | S 114 | | | S 112 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index | Ad. | Yg. | Repr. index |
| Black-and-white Warbler | | | | | | | | | | | | | 1.2 | 0.0 | 0.00 | | | |
| American Redstart | | | | 1.1 | 1.1 | 1.00 | 1.1 | 0.0 | 0.00 | | | | | | | | | |
| Prothonotary Warbler | | | | | | | 1.1 | 0.0 | 0.00 | | | | 1.2 | 0.0 | 0.00 | | | |
| Ovenbird | | | | | | | | | | | | | 1.2 | 0.0 | 0.00 | 2.2 | 0.0 | 0.00 |
| Kentucky Warbler | | | | | | | | | | | | | 1.2 | 0.0 | 0.00 | | | |
| Common Yellowthroat | 1.2 | 0.0 | 0.00 | 14.7 | 1.1 | 0.08 | 5.7 | 1.1 | 0.20 | 4.6 | 3.5 | 0.75 | | | | 0.0 | 1.1 | undf. |
| Hooded Warbler | | | | | | | | | | | | | 1.2 | 0.0 | 0.00 | 4.4 | 0.0 | 0.00 |
| Yellow-breasted Chat | | | | 1.1 | 0.0 | 0.00 | | | | | | | | | | | | |
| Summer Tanager | 0.0 | 1.2 | undf. | 0.0 | 1.1 | undf. | 1.1 | 2.3 | 2.00 | 3.5 | 0.0 | 0.00 | 1.2 | 0.0 | 0.00 | 1.1 | 0.0 | 0.00 |
| Eastern Towhee | | | | 1.1 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | 1.2 | 1.2 | 1.00 | 1.2 | 0.0 | 0.00 | 1.1 | 0.0 | 0.00 |
| Bachman's Sparrow | 2.3 | 0.0 | 0.00 | | | | 2.3 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | | | | | | |
| Chipping Sparrow | 3.5 | 1.2 | 0.33 | | | | | | | 3.5 | 1.2 | 0.33 | | | | | | |
| Northern Cardinal | | | | 4.5 | 2.3 | 0.50 | 2.3 | 1.1 | 0.50 | 2.3 | 5.8 | 2.50 | 3.5 | 0.0 | 0.00 | 4.4 | 3.3 | 0.75 |
| Blue Grosbeak | 3.5 | 0.0 | 0.00 | | | | | | | | | | | | | 1.1 | 0.0 | 0.00 |
| Indigo Bunting | 7.0 | 0.0 | 0.00 | 1.1 | 0.0 | 0.00 | 1.1 | 0.0 | 0.00 | 1.2 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | 1.1 | 0.0 | 0.00 |
| American Goldfinch | | | | 1.1 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | 2.3 | 0.0 | 0.00 | | | | | | |
| ALL SPECIES POOLED | 33.8 | 138.7 | 4.10 | 67.9 | 55.5 | 0.82 | 49.0 | 33.0 | 0.67 | 52.3 | 27.9 | 0.53 | 27.9 | 23.2 | 0.83 | 31.1 | 26.7 | 0.86 |
| Number of Species | 11 | 8 | | 20 | 15 | | 18 | 10 | | 17 | 11 | | 14 | 5 | | 13 | 7 | |
| Total Number of Species | | 17 | | | 24 | | | 21 | | | 20 | | | 16 | | | 16 | |

[1] Reproductive index (young/adult) is undefined because no adults of this species were captured at this station in this year.

Table 4. Summary of results for all six U.S. Army Fort Bragg MAPS stations combined in 2004.

| Species | Birds captured | | | Birds/600 nethours | | Reprod. Index |
|---|---|---|---|---|---|---|
| | Newly banded | Un-banded | Recap-tured | Adults | Young | |
| Northern Bobwhite | | 1 | | | | |
| Mourning Dove | | 2 | | | | |
| Yellow-billed Cuckoo | 4 | | | 0.8 | 0.0 | 0.00 |
| Whip-poor-will | 1 | | | 0.2 | 0.0 | 0.00 |
| Ruby-throated Hummingbird | 1 | 20 | | | | |
| Red-headed Woodpecker | 2 | | | 0.4 | 0.0 | 0.00 |
| Red-bellied Woodpecker | 5 | | 1 | 1.1 | 0.0 | 0.00 |
| Downy Woodpecker | 6 | | 1 | 0.4 | 0.8 | 2.00 |
| Red-cockaded Woodpecker | | | 2 | 0.2 | 0.2 | 1.00 |
| Eastern Wood-Pewee | 2 | | | 0.0 | 0.4 | undf.[1] |
| Great Crested Flycatcher | 16 | | 2 | 3.4 | 0.0 | 0.00 |
| White-eyed Vireo | 5 | | 1 | 0.4 | 0.6 | 1.50 |
| Red-eyed Vireo | 3 | | | 0.0 | 0.6 | undf. |
| Blue Jay | 7 | | | 0.8 | 0.6 | 0.75 |
| Carolina Chickadee | 29 | 2 | 10 | 2.1 | 3.8 | 1.82 |
| Tufted Titmouse | 22 | 1 | 8 | 1.7 | 3.1 | 1.78 |
| White-breasted Nuthatch | 1 | | | 0.0 | 0.2 | undf. |
| Brown-headed Nuthatch | 2 | | | 0.0 | 0.4 | undf. |
| Carolina Wren | 63 | 4 | 45 | 3.1 | 10.5 | 3.44 |
| Blue-gray Gnatcatcher | 14 | 1 | 1 | 1.3 | 1.3 | 1.00 |
| Wood Thrush | 5 | | 2 | 1.1 | 0.2 | 0.17 |
| Gray Catbird | 5 | | 1 | 0.6 | 0.4 | 0.67 |
| Brown Thrasher | 6 | | 3 | 1.3 | 0.2 | 0.14 |
| Black-throated Blue Warbler | 2 | | 2 | | | |
| Pine Warbler | 126 | 3 | 15 | 2.5 | 21.6 | 8.69 |
| Prairie Warbler | 22 | 1 | 9 | 3.6 | 1.1 | 0.32 |
| Black-and-white Warbler | 1 | | 1 | 0.2 | 0.0 | 0.00 |
| American Redstart | 3 | | 0 | 0.4 | 0.2 | 0.50 |
| Prothonotary Warbler | 2 | | 2 | 0.4 | 0.0 | 0.00 |
| Ovenbird | 2 | | 1 | 0.6 | 0.0 | 0.00 |
| Northern Waterthrush | 4 | | | | | |
| Kentucky Warbler | | | 1 | 0.2 | 0.0 | 0.00 |
| Common Yellowthroat | 27 | | 18 | 4.4 | 1.1 | 0.26 |
| Hooded Warbler | 5 | | | 1.0 | 0.0 | 0.00 |

Table 4. (cont.) Summary of results for all six U.S. Army Fort Bragg MAPS stations combined in 2004.

| Species | Birds captured | | | Birds/600 nethours | | Reprod. Index |
|---|---|---|---|---|---|---|
| | Newly banded | Un-banded | Recap-tured | Adults | Young | |
| Yellow-breasted Chat | 1 | | | 0.2 | 0.0 | 0.00 |
| Summer Tanager | 9 | | 1 | 1.1 | 0.8 | 0.67 |
| Eastern Towhee | 4 | 1 | 6 | 1.1 | 0.2 | 0.17 |
| Bachman's Sparrow | 6 | | 2 | 1.1 | 0.0 | 0.00 |
| Chipping Sparrow | 8 | | | 1.1 | 0.4 | 0.33 |
| Northern Cardinal | 23 | | 20 | 2.9 | 2.1 | 0.73 |
| Blue Grosbeak | 4 | | 2 | 0.8 | 0.0 | 0.00 |
| Indigo Bunting | 12 | | | 2.3 | 0.0 | 0.00 |
| Common Grackle | | 1 | | | | |
| American Goldfinch | 5 | | | 1.0 | 0.0 | 0.00 |
| ALL SPECIES POOLED | 465 | 37 | 157 | 43.7 | 50.6 | 1.16 |
| Total Number of Captures | | 659 | | | | |
| Number of Species | 39 | 11 | 25 | 34 | 23 | |
| Total Number of Species | | 44 | | | 38 | |

[1] Reproductive index (young/adult) is undefined because no adults of this species were captured at this location in this year.

Table 5. Estimates of adult annual survival and recapture probabilities and proportion of residents among newly captured adults using a time-constant transient model for 14 species breeding at MAPS stations on U.S. Army Fort Bragg obtained from ten years (1995-2004) 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] |
|---|---|---|---|---|---|---|---|---|
| Great Crested Flycatcher | 6 | 99 | 112 | 8 | 0.302 (0.148) | 49.2 | 0.291 (0.257) | 0.786 (0.793) |
| White-eyed Vireo | 3 | 42 | 88 | 6 | 0.330 (0.148) | 44.7 | 0.524 (0.295) | 0.475 (0.357) |
| Carolina Chickadee | 6 | 77 | 109 | 12 | 0.465 (0.113) | 24.3 | 0.418 (0.166) | 0.409 (0.213) |
| Tufted Titmouse | 6 | 111 | 188 | 24 | 0.333 (0.074) | 22.3 | 0.870 (0.120) | 0.487 (0.176) |
| Carolina Wren | 6 | 140 | 308 | 27 | 0.268 (0.061) | 22.9 | 0.727 (0.153) | 0.829 (0.287) |
| Wood Thrush † | 1 | 55 | 81 | 5 | 0.550 (0.187) | 34.1 | 0.091 (0.091) | 1.000 (0.985) |
| Gray Catbird | 4 | 125 | 197 | 11 | 0.497 (0.124) | 25.0 | 0.141 (0.082) | 0.621 (0.369) |
| Brown Thrasher | 3 | 47 | 63 | 5 | 0.541 (0.165) | 30.6 | 0.400 (0.225) | 0.090 (0.097) |
| Prairie Warbler | 4 | 166 | 247 | 21 | 0.428 (0.089) | 20.7 | 0.290 (0.109) | 0.619 (0.257) |
| Ovenbird † | 2 | 39 | 54 | 8 | 0.597 (0.145) | 24.3 | 0.178 (0.122) | 1.000 (0.713) |
| Common Yellowthroat | 6 | 315 | 703 | 44 | 0.376 (0.051) | 13.7 | 0.616 (0.103) | 0.228 (0.072) |
| Eastern Towhee | 6 | 96 | 176 | 29 | 0.383 (0.073) | 19.0 | 0.816 (0.114) | 0.606 (0.195) |
| Northern Cardinal | 6 | 147 | 339 | 42 | 0.456 (0.056) | 12.4 | 0.699 (0.096) | 0.342 (0.112) |
| Indigo Bunting | 5 | 47 | 56 | 6 | 0.570 (0.180) | 31.5 | 0.332 (0.208) | 0.349 (0.264) |

[1] Number of stations where the species was a regular or usual breeder and at which adults of the species were captured. Stations within one km of each other were combined into a single super-station to prevent individuals whose home ranges included portions of two or more stations from being counted as multiple individuals.
[2] Number of adult individuals captured at stations where the species was a regular or usual breeder (i.e., number of capture histories).
[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 ($\phi$) presented as the maximum likelihood estimate (standard error of the estimate).
[6] The coefficient of variation for survival probability, CV($\phi$).
[7] Recapture probability (p) presented as the maximum likelihood estimate (standard error of the estimate).

Table 5. (cont.) Estimates of adult annual survival and recapture probabilities and proportion of residents among newly captured adults using a time-constant transient model for 14 species breeding at MAPS stations on U.S. Army Fort Bragg obtained from ten years (1995-2004) of mark-recapture data.

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[8] The proportion of residents among newly captured adults ($\tau$) presented as the maximum likelihood estimate (standard error of the estimate).
† The estimate for recapture probability (and possibly survival probability as well) may be biased low because the estimate for $\tau$ was 1.000.