

**THE 2006 REPORT OF THE  
MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP  
(MAPS) PROGRAM ON FORT BRAGG**

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**January 19, 2007**

## 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 information on the vital rates (productivity or birth rate, and survivorship or death rate) of landbirds that is critically needed for efforts to identify demographic causes of the severe and sometimes accelerating population declines documented (Robbins et al. 1989, Terborgh 1989, Peterjohn et al. 1995) for many species of North American landbirds (DeSante 1992, DeSante et al. 1995, 1999, [2001a](#)). 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.

Accordingly, 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 2006 by means of funding from Fort Bragg, while the comprehensive analyses of data from 1995-2002 was 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 Legacy Resource Management Program allowed us to undertake these analyses and formulate management strategies. 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 ([Nott and Michel 2005](#)). 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.

At Fort Bragg Wood Thrush and Prairie Warbler, were identified as management species of concern. 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.

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 2000-2005 results was presented by DeSante et al. (2002, 2004, and 2005) and Pyle et al. (2006). This report briefly updates these earlier reports and documents the operation of the six MAPS stations on Fort Bragg during the 2006 breeding season.

## **Methods**

Six MAPS stations were operated in 2006, 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. 2006](#)). 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 hectares of each 20 hectare 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 14 and August 7 (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 Ann Graham, who was trained by IBP field biologists Amy Finfera and Ron Taylor, and assisted by volunteer Michael McCloy.

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. The following data were taken on all birds captured, including recaptures, according to MAPS guidelines using standardized codes and forms ([DeSante et al. 2006](#)):

- (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 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. For our estimate of post-fledging productivity, we are now using “reproductive index” (number of young divided by number of adults) as opposed to “proportion of young in the catch” previously used. Reproductive index is a more intuitive value for productivity, and it is also more comparable to other calculated MAPS parameters such as recruitment indices.

Survival of target species was estimated using Modified Cormack-Jolly-Seber (CJS) mark-recapture analyses (Pollock et al. 1990, Lebreton et al. 1992) on 12 years (1995-2006) of capture histories of adult birds from the seven stations ever operated at this location. Target species were those for which, on average, at least 2.5 individual adults per year and at least two between-year returns were recorded from the seven stations pooled, at which the species was a breeder during more than half of the years 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 (*SEs*) 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 2006. A total of 2990.0 net-hours were accumulated at all six stations pooled, representing 92.3% of the maximum possible effort at the six stations. Of these, 2765.8 net-hours overlap with those of 2005. The details of the operation of these six stations during 2006 are presented in Table 1.

For each individual species and for all species pooled, the numbers of 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 448 captures of 45 species occurred at Fort Bragg during the summer of 2006 (Table 4). Newly banded birds comprised 65.1% of the total captures. The greatest number of total captures (102) was recorded at the I113 station and the smallest number of total captures (53) was recorded at the S112 station. The highest species richness occurred at Stations I104 and I113 (21 species each) and the lowest species richness occurred at Sandstone Hill (15 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 Station I113 (63.0 adults/600 net hours; Table 3), followed by Station I104 (50.9), Station S110 (40.4), Sandstone Hill (35.8), Station S114 (29.0), and Station S112 (28.3). Reproductive index (number of young birds per adult) showed a different pattern, being highest at Sandstone Hill (1.40), followed by Station S112 (0.57), Station S110 (0.47), Station S114 (0.46), Station I113 (0.35), and Station I104 (0.34). The mean adult capture rate for the six stations combined was 41.3 per 600 net hours in 2006, compared with 43.9 adults per 600 net-hours for the same six stations in 2005, and the overall reproductive index was 0.55 in 2006, compared with 0.37 in 2005, indicating similar breeding population sizes but a substantial increase in productivity between the two years.

Among individual species, Carolina Wren was the most frequently captured species at the six stations in 2006, followed by Common Yellowthroat, Pine Warbler, Prairie Warbler, Northern Cardinal, Tufted Titmouse, and Carolina Chickadee (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 Prairie Warbler, Common Yellowthroat, Northern Cardinal, Carolina Wren, Pine Warbler, and American Goldfinch. The most abundant breeding species at each station, having a capture rate of at least 3.0 birds per 600 net-hours in 2006 are as follows (species of concern, as noted above, in italics):

**Sandstone Hill**

*Prairie Warbler*\*  
 Pine Warbler\*  
 Blue Jay\*  
 Bachman's Sparrow†  
 Chipping Sparrow†  
 Blue Grosbeak†  
 Indigo Bunting†

**S110**

Common Yellowthroat  
*Prairie Warbler*\*  
 Great Crested Flycatcher  
 Chipping Sparrow†  
 Summer Tanager†  
 Indigo Bunting†

**I 104**

Common Yellowthroat  
 American Goldfinch\*  
 Carolina Chickadee\*  
 Eastern Towhee  
 Chipping Sparrow  
 Northern Cardinal†

**S112**

Northern Cardinal  
 Tufted Titmouse\*  
 Carolina Wren\*  
 Common Yellowthroat†  
 Blue Grosbeak†  
 Summer Tanager†  
 Indigo Bunting†

**I113**

*Prairie Warbler*\*  
 Northern Cardinal  
 Carolina Wren\*  
 Common Yellowthroat  
 Pine Warbler\*  
 American Goldfinch\*  
 Great Crested Flycatcher\*  
 Summer Tanager\*  
 Eastern Towhee  
 American Redstart†

**S114**

Carolina Wren\*  
 Blue-gray Gnatcatcher\*  
 Northern Cardinal  
 Indigo Bunting  
 Hooded Warbler†

\* At least 3.0 adults per 600 net hours in 2006 but not in 2005.

† At least 3.0 adults per 600 net hours in 2005 but not in 2006

As can be seen from the number and position of marked species (\* and †), there was considerable turnover between 2005 and 2006, despite a similar overall capture rate. Prairie Warbler, a species of concern, increased substantially at three stations whereas Indigo Bunting, Chipping Sparrow, and Summer Tanager decreased substantially at two or three stations.

Using 12 years of data (1995-2006) from all seven stations ever operated on Fort Bragg combined, estimates of adult survival and recapture probabilities were obtained for 17 target species breeding at Fort Bragg. Maximum-likelihood estimates of annual adult survival probability, recapture probability, and proportion of residents among newly captured adults from the time-constant transient model are presented in Table 5 for these 17 species. Survival-rate estimates for all 17 species showed variable precision (CVs between 11% and 72%) with a mean CV of 31.1%. The mean CV for these same 17 species using 11 years of data (Pyle et al. 2005) was 31.4%, indicating a slight improvement in precision with the addition of an 12<sup>th</sup> year at Fort Bragg. Annual adult survival rates for these 17 species in 2006 ranged from a low of 0.280 for Great Crested Flycatcher to a high of 0.566 for Ovenbird, with a mean survival rate of 0.404 for the 17 species.

Survival estimates are low at Fort Bragg compared to other locations, especially for resident species. In comparing survival values from Fort Bragg (1995-2006) with those of the [Southeast Region of the United States \(1992-2001\)](#), 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 (0.404) being 17% 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 0.406) 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, 2005a). The Institute for Bird Populations has initiated the Monitoring Avian Wintering Survival (MAWS) 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 any overwintering survival problem and relationships between survival 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 that overwinter in the United States.

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](#), [Nott and Michel 2005](#)). These analyses were funded by Legacy Resource Management Program Project #103. At Fort Bragg, two species (Wood Thrush and Prairie Warbler) emerged as candidates for particular management concern.



In 2003 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 risk of wildfire. Prior to the 2004 season the area around Sandstone Hill was burned, and in 2004 a single Prairie Warbler was captured. But in 2005 the capture rates of adult and young Prairie Warblers increased to 15.5 and 4.8 individuals per 600 net-hours, respectively, and in 2006 14.3 adults per 600 net-hours were captured but no young (Table 3). This indicates that the management actions at Sandstone Hill has successfully resulted in increased populations of Prairie Warblers. Wood Thrushes were only captured in low numbers at Fort Bragg in 2006, at only one station, S112 (Table 3). Bachman's Sparrow, a USFWS Bird of Conservation Concern with IUCN Red List near threatened status, also was also captured at Sandstone Hill, I113, and S110 in 2006 (Table 3).

In summary, our data suggest that Prairie Warblers will occupy potential habitat immediately following a springtime burn but that breeding individuals will recruit into the habitat the second year after fire. As this fire-managed "disclimax" community succeeds towards forest, we predict that continued effectiveness monitoring of these populations will detect the onset of a decline in reproductive success or population size. Perhaps that has already becoming apparent, with no young of this species captured in 2006. However, based on an understanding of these temporal dynamics, we can adjust the prescribed fire frequency to maximize mean annual productivity of Prairie Warbler populations (and perhaps Bachman's Sparrows and other species) while meeting the management goals associated with Readiness and Range Sustainment. Through such adaptive management cycles, we are confident that we can achieve the long-term goal of reversing declining populations and maintaining stable or increasing source populations of target landbird species at Fort Bragg and other military installations.

### **Acknowledgments**

We thank IBP field biologist intern Ann Graham and IBP biologists Amy Finfera and Ron Taylor for providing additional training and supervision. We also thank volunteer Michael McCloy for assistance with station operation, and Joel and Vicki Smith for help with housing and orientation. We especially thank Jessie Schillaci for her enthusiastic support of and kind assistance with all of the logistical and administrative aspects of this work. Financial support for this program was provided by U.S. Army Fort Bragg for which we are very grateful. This is Contribution Number 311 of The Institute for Bird Populations.

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Table 1. Summary of the 2006 MAPS program on U.S. Army Fort Bragg.

Station					Avg Elev. (m)	2006 operation		
Name	Code	No.	Major Habitat Type	Latitude-longitude		Total number of net-hours <sup>1</sup>	No. of periods	Inclusive dates
Sandstone Hill	SAHI	16706	Controlled burn pine savanna, mixed scrub oak woodland	35°03'04"N,79°19'37"W	152	503.3 (472.0)	9	5/14 – 7/30
I 104	I104	16657	Controlled burn pine savanna, riparian fields and scrub	35°07'00"N,79°19'13"W	84	483.3 (361.5)	9	5/19 – 8/07
I 113	I113	16658	Controlled burn riparian, savanna and pine-oak woodland	35°05'37"N,79°19'28"W	110	514.7 (468.0)	9	5/16 – 8/04
S 110	S110	16659	Riparian woodland, pine savanna and pine-oak woodland	35°07'07"N,79°20'04"W	94	505.3 (499.8)	9	5/18 – 8/06
S 114	S114	16661	Pine-oak and riparian woodland bordering grain fields	35°02'58"N,79°16'11"W	70	496.0 (480.2)	9	5/15 – 8/03
S 112	S112	16660	Pine-oak mixed with riparian woodland	35°06'46"N,79°21'45"W	114	487.3 (484.3)	9	5/17 – 8/05
ALL STATIONS COMBINED						2990.0(2765.8)	9	5/15 – 8/07

<sup>1</sup> Total net-hours in 2006. Net-hours in 2006 that could be compared in a constant-effort manner to 2005 are shown in parentheses.



Table 2. (cont.) Capture summary for the six individual MAPS stations operated on U.S. Army Fort Bragg in 2006.  
 N = Newly Banded, U = Unbanded, R = Recaptures of banded birds.

Species	Sandstone Hill			I 104			I 113			S 110			S 114			S 112		
	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Brown Thrasher	1																	
Pine Warbler	32		3				4			2			1			1		
Prairie Warbler	9		10	3			9	1	3	6								
Black-and-white Warbler																		2
American Redstart				1														
Ovenbird	2																	1
Northern Waterthrush																		1
Kentucky Warbler													3					
Common Yellowthroat	1			14		17	6		7	8		11	1					
Hooded Warbler							3						2	1				2
Summer Tanager	1						2		1			1						2
Eastern Towhee		1		3		1	3		1	2		2	1					
Bachman's Sparrow	2						2			1								
Chipping Sparrow	4			3			2			1		1						
Northern Cardinal				2		2	6		7	3		2	1		2	3	1	8
Blue Grosbeak				1								1						
Indigo Bunting				1			1						2		1			
Red-winged Blackbird				1														
American Goldfinch				4			4		1	2								
ALL SPECIES POOLED	69	1	13	52	2	28	63	5	34	43	3	26	31	15	10	34	5	14
Total Number of Captures		83			82			102			72			56			53	
Number of Species	14	1	2	19	1	8	19	3	9	15	2	8	15	5	3	16	3	3
Total Number of Species		15			21			21			18			17			17	



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 2006.

Species	Sandstone Hill			I 104			I 113			S 110			S 114			S 112		
	Ad.	Yg.	Repr. index	Ad.	Yg.	Repr. index	Ad.	Yg.	Repr. index	Ad.	Yg.	Repr. index	Ad.	Yg.	Repr. index	Ad.	Yg.	Repr. index
Pine Warbler	4.8	34.6	7.25				4.7	0.0	0.00	2.4	0.0	0.00	1.2	0.0	0.00	1.2	0.0	0.00
Prairie Warbler	14.3	0.0	0.00	2.5	1.2	0.50	8.2	2.3	0.29	5.9	1.2	0.20						
Black-and-white Warbler																2.5	0.0	0.00
American Redstart				1.2	0.0	0.00												
Ovenbird	2.4	0.0	0.00													1.2	0.0	0.00
Kentucky Warbler													1.2	2.4	2.00			
Common Yellowthroat	1.2	0.0	0.00	9.9	7.4	0.75	5.8	2.3	0.40	9.5	2.4	0.25	1.2	0.0	0.00			
Hooded Warbler							2.3	1.2	0.50				2.4	0.0	0.00	0.0	2.5	und.
Summer Tanager	1.2	0.0	0.00				3.5	0.0	0.00	1.2	0.0	0.00				2.5	0.0	0.00
Eastern Towhee				3.7	0.0	0.00	3.5	1.2	0.33	2.4	1.2	0.50	1.2	0.0	0.00			
Bachman's Sparrow	2.4	0.0	0.00				2.3	0.0	0.00	0.0	1.2	und.						
Chipping Sparrow	0.0	4.8	und.	3.7	0.0	0.00	2.3	0.0	0.00	2.4	0.0	0.00						
Northern Cardinal				2.5	0.0	0.00	7.0	2.3	0.33	2.4	1.2	0.50	3.6	0.0	0.00	4.9	1.2	0.25
Blue Grosbeak				1.2	0.0	0.00				1.2	0.0	0.00						
Indigo Bunting				1.2	0.0	0.00	1.2	0.0	0.00				3.6	0.0	0.00			
Red-winged Blackbird				1.2	0.0	0.00												
American Goldfinch				5.0	0.0	0.00	4.7	0.0	0.00	2.4	0.0	0.00						
ALL SPECIES POOLED	35.8	50.1	1.40	50.9	17.4	0.34	63.0	22.2	0.35	40.4	19.0	0.47	29.0	13.3	0.46	28.3	16.0	0.57
Number of Species	11	6		19	7		19	7		14	8		13	6		12	6	
Total Number of Species		13			20			19			16			15			14	

<sup>1</sup> 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 2006.

Species	Birds captured			Birds/600 nethours		Reprod. Index
	Newly banded	Un-banded	Recap-tured	Adults	Young	
Sharp-shinned Hawk	1					
Northern Bobwhite		1				
Ruby-throated Hummingbird		14				
Red-headed Woodpecker	1			0.2	0.0	0.00
Red-bellied Woodpecker	1			0.2	0.0	0.00
Downy Woodpecker	2	2		0.0	0.4	und. <sup>1</sup>
Hairy Woodpecker	2			0.2	0.2	1.00
Red-cockaded Woodpecker			1	0.2	0.0	0.00
Northern Flicker	1			0.0	0.0	und.
Pileated Woodpecker		1				
Eastern Wood-Pewee	3		1	0.6	0.0	0.00
Acadian Flycatcher	3			0.4	0.2	0.50
Great Crested Flycatcher	8			1.6	0.0	0.00
White-eyed Vireo	3			0.6	0.0	0.00
Blue-headed Vireo	1			0.2	0.0	0.00
Red-eyed Vireo	4			0.8	0.0	0.00
Blue Jay	4			0.6	0.2	0.33
Carolina Chickadee	16		3	1.6	2.0	1.25
Tufted Titmouse	15	1	7	1.8	1.6	0.89
Brown-headed Nuthatch	1			0.0	0.2	und.
Carolina Wren	30	8	31	3.0	4.6	1.53
Blue-gray Gnatcatcher	9			1.4	0.4	0.29
Eastern Bluebird	8			0.4	1.2	3.00
Swainson's Thrush	2					
Wood Thrush	1			0.2	0.0	0.00
Gray Catbird	1			0.2	0.0	0.00
Brown Thrasher	1			0.2	0.0	0.00
Pine Warbler	40		3	2.4	5.8	2.42
Prairie Warbler	27	1	13	5.2	0.8	0.15
Black-and-white Warbler	2			0.4	0.0	0.00
American Redstart	1			0.2	0.0	0.00
Ovenbird	3			0.6	0.0	0.00
Northern Waterthrush	1					
Kentucky Warbler	3			0.2	0.4	2.00

Table 4. (cont.) Summary of results for all six U.S. Army Fort Bragg MAPS stations combined in 2006.

Species	Birds captured			Birds/600 nethours		Reprod. Index
	Newly banded	Un-banded	Recap-tured	Adults	Young	
Common Yellowthroat	30		35	4.6	2.0	0.44
Hooded Warbler	7	1		0.8	0.6	0.75
Summer Tanager	5		2	1.4	0.0	0.00
Eastern Towhee	9	1	4	1.8	0.4	0.22
Bachman's Sparrow	5			0.8	0.2	0.25
Chipping Sparrow	10		1	1.4	0.8	0.57
Northern Cardinal	15	1	21	3.4	0.8	0.24
Blue Grosbeak	1		1	0.4	0.0	0.00
Indigo Bunting	4		1	1.0	0.0	0.00
Red-winged Blackbird	1			0.2	0.0	0.00
American Goldfinch	10		1	2.0	0.0	0.00
ALL SPECIES POOLED	292	31	125	41.3	22.9	0.55
Total Number of Captures		448				
Number of Species	41	10	15	36	19	
Total Number of Species		45			38	

<sup>1</sup> 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 time-constant models for 17 species breeding at MAPS stations on U.S. Army Fort Bragg obtained from 12 years (1995-2006) of mark-recapture data.

Species	Num. sta. <sup>2</sup>	Num. ind. <sup>2</sup>	Num. caps. <sup>3</sup>	Num. ret. <sup>4</sup>	Survival probability <sup>5</sup>	Surv. C.V. <sup>6</sup>	Recapture probability <sup>7</sup>	Proportion of residents <sup>8</sup>
Great Crested Flycatcher ‡†	6	118	133	8	0.280 (0.142)	50.7	0.194 (0.184)	1.000 (0.949)
White-eyed Vireo	2	44	90	6	0.317 (0.133)	41.8	0.539 (0.291)	0.361 (0.294)
Red-eyed Vireo ‡	4	59	66	4	0.520 (0.189)	36.3	0.111 (0.102)	0.506 (0.486)
Carolina Chickadee	6	98	134	14	0.528 (0.101)	19.2	0.288 (0.113)	0.399 (0.198)
Tufted Titmouse	6	125	213	26	0.363 (0.067)	18.4	0.693 (0.136)	0.408 (0.158)
Carolina Wren	5	159	359	34	0.314 (0.056)	17.8	0.718 (0.127)	0.621 (0.206)
Blue-gray Gnatcatcher ‡	5	65	76	3	0.320 (0.229)	71.5	0.146 (0.169)	0.512 (0.613)
Wood Thrush	1	58	85	6	0.508 (0.158)	31.1	0.143 (0.099)	0.537 (0.445)
Brown Thrasher	2	48	64	5	0.391 (0.165)	42.2	0.234 (0.174)	0.356 (0.385)
Pine Warbler	6	108	118	5	0.394 (0.187)	47.5	0.158 (0.128)	0.207 (0.227)
Prairie Warbler	4	220	332	32	0.391 (0.066)	16.8	0.373 (0.097)	0.285 (0.147)
Ovenbird	2	40	55	8	0.566 (0.126)	22.2	0.197 (0.109)	0.795 (0.528)
Common Yellowthroat	5	357	817	48	0.286 (0.045)	15.9	0.519 (0.106)	0.180 (0.105)
Summer Tanager	6	80	96	7	0.425 (0.149)	34.9	0.220 (0.137)	0.215 (0.227)
Eastern Towhee	6	108	194	32	0.388 (0.058)	15.0	0.767 (0.111)	0.375 (0.168)
Northern Cardinal	5	167	391	50	0.438 (0.049)	11.2	0.661 (0.090)	0.283 (0.115)
Indigo Bunting †	4	55	64	6	0.442 (0.159)	36.0	0.162 (0.117)	1.000 (0.800)

<sup>1</sup> Analysis of all stations pooled include data from 1995-2006 from the I 104, I 113, S 110, and S112, from 1995-2002 from the S 102 station and 2003-2006 from the Sandstone Hill station which replaced the S 102 station. Only data from 1995-2001 is included from the S114 station.

<sup>2</sup> 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.

<sup>3</sup> Number of adult individuals captured at stations where the species was a regular or usual breeder (i.e., number of capture histories).

<sup>4</sup> Total number of captures of adult birds of the species at stations where the species was a regular or usual breeder.

Table 5. (cont.) Estimates of adult annual survival and recapture probabilities and proportion of residents among newly captured adults using time-constant models for 17 species breeding at MAPS stations on U.S. Army Fort Bragg obtained from 12 years (1995-2006) of mark-recapture data.

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<sup>5</sup> 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.

<sup>6</sup> Survival probability ( $\phi$ ) presented as the maximum likelihood estimate (standard error of the estimate).

<sup>7</sup> The coefficient of variation for survival probability,  $CV(\phi)$ .

<sup>8</sup> Recapture probability ( $p$ ) presented as the maximum likelihood estimate (standard error of the estimate).

<sup>9</sup> The proportion of residents among newly captured adults ( $\tau$ ) presented as the maximum likelihood estimate (standard error of the estimate).

‡ The estimate for survival probability should be viewed with caution because it is based on fewer than five between-year recaptures, or the estimate is very imprecise ( $SE(\phi) > 0.200$  or  $CV(\phi) > 50.0\%$ ), or the proportion of residents is equal to zero.

† The estimate for recapture probability (and possibly survival probability as well) may be biased low because the estimate for  $\tau$  was 1.000.

Appendix I. Numerical listing (in AOU checklist order) of all the species sequence numbers, species alpha codes, and species names for all species banded or encountered during the 12 years, 1995-2006, of the MAPS Program on the seven stations ever operated on **U.S. Army Fort Bragg**.

Cumulative breeding status for all years in which each station was operated are also included (B = Regular Breeder (all years); U = Usual Breeder (>½, not all, years); O = Occasional Breeder (≤½ years); T = Transient; M = Migrant; A= Altitudinal Disperser; ? = Uncertain Species ID

NUMB	SPEC	SPECIES NAME	Sandstone Hill (SAHI)	I 104 (I104)	I 113 (I113)	S 110 (S110)	S 114 (S114)	S 112 (S112)	I 102 (I102)
00860	DCCO	Double-crested Cormorant		T					
00950	AMBI	American Bittern		T					
01010	GBHE	Great Blue Heron	T	T	T	T		T	T
01040	GREG	Great Egret						T	
01130	GRHE	Green Heron		T					
01290	BLVU	Black Vulture		T		T			
01300	TUVU	Turkey Vulture	T	T	T	T	T	O	T
01460	CANG	Canada Goose		T		T		T	
01570	WODU	Wood Duck		U	T	T	T	T	T
01630	MALL	Mallard		T					
02200	SSHA	Sharp-shinned Hawk		M		M			
02210	COHA	Cooper's Hawk				T			T
02380	RSHA	Red-shouldered Hawk		T	T	T	O	O	
02400	BWHA	Broad-winged Hawk		T	T		T	T	
02460	RTHA	Red-tailed Hawk		T	T	T	T	O	T
02630	AMKE	American Kestrel	O	T	T	T		T	U
03040	WITU	Wild Turkey			T		T		
03160	NOBO	Northern Bobwhite	B	B	U	U	U	U	B
04490	AMWO	American Woodcock		T	T	T			
05570	MODO	Mourning Dove	B	U	B	B	U	B	B
06410	YBCU	Yellow-billed Cuckoo	O	U	U	U	U	U	O
06680	EASO	Eastern Screech-Owl		T	O	T	T	T	T
06800	GHOW	Great Horned Owl		T	T				
07080	CONI	Common Nighthawk	O	U	U	O	O	O	U
07170	CWWI	Chuck-will's-widow	T	O		O	T	O	
07230	WPWI	Whip-poor-will		T	O	O		T	
07400	CHSW	Chimney Swift	T	O	T	T	T	O	T
08630	RTHU	Ruby-throated Hummingbird	O	O	O	U	O	U	O
09110	BEKI	Belted Kingfisher	T	T				T	T
09420	RHWO	Red-headed Woodpecker	O	U	U	O	O	O	U
09550	RBWO	Red-bellied Woodpecker	O	B	U	U	U	U	B
09650	DOWO	Downy Woodpecker	O	U	U	U	U	U	O
09660	HAWO	Hairy Woodpecker		T	T	T	O	U	O

Appendix I. Continued.

NUMB	SPEC	SPECIES NAME	SAHI	I104	I113	S110	S114	S112	I102
09680	RCWO	Red-cockaded Woodpecker	U	O	U	O	T	T	B
09800	YSFL	Yellow-shafted Flicker	B	U	U	U	U	U	B
09860	PIWO	Pileated Woodpecker	O	O	O	O	U	U	U
11390	EAWP	Eastern Wood-Pewee	O	B	B	U	O	O	B
11460	ACFL	Acadian Flycatcher		T	T	T	O	O	T
11595	UEFL	Unidentified Empidonax Flycatcher				?			
11610	EAPH	Eastern Phoebe		T					T
11760	GCFL	Great Crested Flycatcher	B	B	B	B	U	B	B
12030	EAKI	Eastern Kingbird	T	T	T	O	T	T	
12550	WEVI	White-eyed Vireo	T	U	O	U	O	O	O
12690	YTVI	Yellow-throated Vireo		O	O	O	O	O	
12720	BHVI	Blue-headed Vireo						T	T
12790	REVI	Red-eyed Vireo	T	O	U	U	U	B	T
12930	BLJA	Blue Jay	B	U	U	U	U	B	B
13190	AMCR	American Crow	U	O	O	O	O	U	O
13270	FICR	Fish Crow	B	O	O	O	O	T	O
13340	PUMA	Purple Martin	T	T	T	T	T	T	T
13410	TRES	Tree Swallow	M					M	M
13540	BARS	Barn Swallow			T	T	T	T	T
13560	CACH	Carolina Chickadee	B	B	B	B	B	B	B
13660	TUTI	Tufted Titmouse	B	B	B	B	B	B	B
13700	WBNU	White-breasted Nuthatch	O	U	U	O	U	U	U
13720	BHNU	Brown-headed Nuthatch	B	U	U	U	T	O	U
14000	CARW	Carolina Wren	O	B	B	B	B	B	B
14350	BGGN	Blue-gray Gnatcatcher	O	B	U	B	U	B	U
14560	EABL	Eastern Bluebird	U	O	O	O	T	O	U
14780	VEER	Veery				M		M	M
14790	GCTH	Gray-cheeked Thrush		M		M			
14810	SWTH	Swainson's Thrush		M		M		M	M
14830	WOTH	Wood Thrush		T	T	T	O	B	
15000	AMRO	American Robin	T	O	O	T	O	O	U
15130	GRCA	Gray Catbird		U	O	O	O	O	U
15150	NOMO	Northern Mockingbird		T	T				
15200	BRTH	Brown Thrasher	O	U	O	U	O	O	U
15550	CEDW	Cedar Waxwing	M	M		M			
15630	BWWA	Blue-winged Warbler		M					
15730	NOPA	Northern Parula		T	T	T	T	T	T
15750	YWAR	Yellow Warbler			M			M	
15770	MAWA	Magnolia Warbler		M		M	M	M	M
15790	BTBW	Black-throated Blue Warbler		M	M	M	M	M	M
15830	BTNW	Black-throated Green Warbler		M				M	

Appendix I. Continued.

NUMB	SPEC	SPECIES NAME	SAHI	I104	I113	S110	S114	S112	I102
15870	YTWA	Yellow-throated Warbler	T	O	T	O	O	O	T
15910	PIWA	Pine Warbler	B	B	B	B	U	U	B
15930	PRAW	Prairie Warbler	B	B	U	B	O	O	B
15970	BLPW	Blackpoll Warbler		M				M	M
16030	BAWW	Black-and-white Warbler		T	O	O	O	U	
16040	AMRE	American Redstart		O	T	T	T	T	T
16050	PROW	Prothonotary Warbler		T	T		O	T	T
16060	WEWA	Worm-eating Warbler			T			T	
16080	OVEN	Ovenbird	T	O	O	O	U	B	T
16090	NOWA	Northern Waterthrush		M	M		M	M	
16100	LOWA	Louisiana Waterthrush		T		O	T	T	
16110	KEWA	Kentucky Warbler				T	U	O	T
16150	COYE	Common Yellowthroat	T	B	B	B	U	U	B
16280	HOWA	Hooded Warbler		O	O	U	B	U	U
16290	WIWA	Wilson's Warbler		M					
16300	CAWA	Canada Warbler					M		
16460	YBCH	Yellow-breasted Chat		O	O	T	T	T	T
16820	SUTA	Summer Tanager	B	B	B	B	U	B	U
17820	EATO	Eastern Towhee	B	B	B	B	U	B	B
17930	BACS	Bachman's Sparrow	B	U	U	U		O	U
18020	CHSP	Chipping Sparrow	O	U	U	U	O	T	U
18050	FISP	Field Sparrow	O		T	O			T
18080	VESP	Vesper Sparrow		T					
18270	WTSP	White-throated Sparrow		M					M
18560	NOCA	Northern Cardinal	O	B	B	B	B	B	B
18640	BLGR	Blue Grosbeak	U	O	O	O	T	O	T
18670	INBU	Indigo Bunting	O	U	U	B	U	B	U
18730	RWBL	Red-winged Blackbird		O					
18800	EAME	Eastern Meadowlark			T				
18870	COGR	Common Grackle	T	O	T	T		T	T
18960	BHCO	Brown-headed Cowbird	T	U	O	U	O	U	U
19040	OROR	Orchard Oriole							T
19160	BAOR	Baltimore Oriole						M	
19370	HOFI	House Finch	T			T		O	
19510	AMGO	American Goldfinch	O	B	U	U	U	B	U
19920	HOSP	House Sparrow				T	T		