

**THE 2004 REPORT OF THE
MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP
(MAPS) PROGRAM ON FORT LEONARD WOOD**

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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 (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 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 Partners-in-Flight 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 1993, six MAPS stations were established and operated on Fort Leonard Wood. The operation of these stations was continued during the summers of 1994-2002 by means of funding from the DoD Legacy Resource Management Program. The operation of the six stations on Fort Leonard Wood was continued during the summers of 2003-2004 by means of funding from Fort Leonard Wood, in conjunction with studies of Cerulean Warblers on the installation.

The ultimate objective of the MAPS Program on DoD installations such as Fort Leonard Wood is to identify generalized management guidelines and formulate specific management actions that can 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 is 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. Our goal is to identify relationships between productivity (and survivorship for permanent resident species) and these habitat and weather variables. These management strategies involve efforts to modify habitat characteristics from those associated with low productivity to those associated with high productivity, for species for which low productivity is 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 have now been completed (Nott et al. 2003) and management guidelines have been formulated for ten bird species of conservation concern that breed in the southeastern United States. With additional funding from the Legacy Resource Management Program, we are currently implementing these guidelines and actions on eight military installations (including Fort Leonard Wood) 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 their effectiveness, 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 has remained the same. Following the recommendations of Nott et al. (2003), the Smith Ridge and Miller Ridge stations were discontinued in 2003 due to low capture rates and because they were located in mature forest where management results are less achievable. They were replaced by the Tilley Bottoms station (to act as a replicate for the Big Piney station) and the Bradford Cemetery station, a grassland area that is presently undergoing secondary succession and should be monitored. The Big Piney and Laughlin Bottoms stations were maintained as controls. Fire management of open scrubby habitat around the Miller Pond and Macedonia stations occurred during the spring of 2004.

A complete summary of the results of the MAPS Program on Fort Leonard Wood from 1993-1999, as well as on 12 other installations or groups of nearby installations in eastern United States, was presented by DeSante et al. (2001b). This report briefly updates both that earlier report and last year's report (DeSante et al. 2004), and documents the operation of the six MAPS stations on Fort Leonard Wood during the 2004 breeding season.

Methods

Six MAPS stations were operated in 2004, at the same locations where they were operated in 2003. 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. 2004). 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 eight consecutive 10-day periods between May 21 and August 5 (Table 1). The operation of stations occurred on schedule in each of the ten-day periods and was carried out by IBP field biologist interns Kelly Gordon and Elizabeth Johnson, who were trained by IBP field biologists Ramiro Aragon, Victor Sepulveda, and Kerry Wilcox and were supervised throughout the season by Victor Sepulveda.

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. 2004):

- (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, weight, 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, and the proportion of young in the catch was used as an index of post-fledging productivity.

Survival was estimated for 21 target species using Modified Cormack-Jolly-Seber (CJS) mark-recapture analyses (Pollock et al. 1990, Lebreton et al. 1992) on 10 (1993-2002) or 12 years (1993-2004) 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 two between-year returns were recorded from up to all six 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 Leonard Wood during the summer of 2004 for a total of 2628.0 net-hours. Details of the operation of these six stations 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 (including hummingbirds, which we are not licensed to band), and recaptured are presented for each station in Table 2 and for all stations combined in Table 4. A total of 1316 captures of 51 species occurred at Fort Leonard Wood during the summer of 2004 (Table 4). Newly banded birds comprised 68.2% of the total captures. The greatest number of total captures (396) was recorded at the Miller Pond station and the smallest number of total captures (85) was recorded at the Macedonia station. The highest species richness also occurred at Miller Pond (38 species) and the lowest species richness occurred at Macedonia (23 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 Miller Pond (326.4 adults/600 net hours; Table 3), followed by Tilley Bottoms (245.0), Laughlin Bottoms (179.9), Bradford Cemetery (145.0), Big Piney (104.9), and Macedonia (75.4).

Among individual species, Yellow-breasted Chat was the most frequently captured species at the six stations in 2004, followed by Indigo Bunting, Blue-winged Warbler, White-eyed Vireo, Common Yellowthroat, Prairie Warbler, Field Sparrow, Kentucky Warbler, and Blue-gray Gnatcatcher (Table 4). The most abundant breeding species, having a capture rate of at least 6.0 adults per 600 net-hours, in decreasing order, were Indigo Bunting, Yellow-breasted Chat, Blue-winged Warbler, White-eyed Vireo, Field Sparrow, Prairie Warbler, Common Yellowthroat, Carolina Chickadee, and Kentucky Warbler (Table 4). The most abundant breeding species at each installation, having a capture rate of at least 6.0 adults per 600 net-hours were as follows (Table 3):

Big Piney

Indigo Bunting
 American Redstart
 Acadian Flycatcher
 Louisiana Waterthrush
 Carolina Wren

Miller Pond

Yellow-breasted Chat
 Indigo Bunting
 Prairie Warbler
 Common Yellowthroat
 Field Sparrow
 Eastern Wood-Pewee
 Carolina Chickadee
 American Goldfinch
 Blue-winged Warbler
 Tufted Titmouse

Laughlin Bottoms

Indigo Bunting
 Kentucky Warbler
 Yellow-breasted Chat
 White-eyed Vireo
 Carolina Chickadee
 Common Yellowthroat
 Northern Cardinal
 Red-eyed Vireo

Bradford Cemetery

Yellow-breasted Chat
 Prairie Warbler
 Field Sparrow
 White-eyed Vireo
 Blue-winged Warbler
 Indigo Bunting
 Red-eyed Vireo

Tilley Bottoms

Indigo Bunting
 Yellow-breasted Chat
 Blue-winged Warbler
 White-eyed Vireo
 Common Yellowthroat
 Blue-gray Gnatcatcher
 Downy Woodpecker
 Kentucky Warbler
 Field Sparrow
 Carolina Chickadee

Macedonia

Indigo Bunting
 Ovenbird
 Red-eyed Vireo

Productivity (proportion of young in the catch) showed a different pattern over the six stations than adult population size, being highest by far at Bradford Cemetery and Miller Pond (0.28 each), followed by Big Piney (0.22), Tilley Bottoms (0.19), Macedonia (0.17), and Laughlin Bottoms (0.11). The overall productivity index (proportion of young in the catch) for the six stations in 2004 was 0.21. Mean productivity for all species pooled at Fort Leonard Wood during the seven years 1993-1999 was 0.173 (DeSante et al. 2001b), less than the 2004 value. Although productivity at the two newly established stations was higher than at the stations they replaced (DeSante et al. 2001b), it still appears that the generally higher productivity in 2004 than in other years was not due solely to the new stations, and that 2004 was likely a reasonably good year for productivity at Fort Leonard Wood. Productivity, however, was down slightly in 2004 from that of 2003, when the overall mean was 0.23.

Using 12 years of data from the six long-running stations combined, estimates of adult survival and recapture probabilities were obtained for 21 target species breeding at Fort Leonard Wood. 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. Annual adult survival-rate estimates ranged from a low of 0.359 for Louisiana Waterthrush to a high of 0.664 for Downy Woodpecker, with a mean of 0.542 for the 21 species. Furthermore, the C.V.s for the 16 species at Fort Leonard Wood were low (16 of the 21 species < 30%, 15 species < 20%, and 6 species < 10%) indicating quite precise estimates. Moreover, we found that the mean C.V. for 16 species (for which survival rate estimates were obtained from both 11 years (1993-2003) and 12 years (1993-2004) of data) declined from 13.7% to 12.7% with the addition of the 12th year of data, indicating that survival estimates may continue to become more precise, even after 12 years of data have been collected. In summary, survival of landbirds at Fort Leonard Wood appears to be quite good, better than that at other MAPS stations in the South-central MAPS Region (DeSante et al. 2004). We

suggest that the populations of landbirds breeding at Fort Leonard Wood consist of high-quality individuals that are attracted to and able to hold territories in the pristine habitats at the Fort and that, on average, display better survival than birds that breed over the South-central Region as a whole. This suggests that Fort Leonard Wood is very important to landbird populations.

As mentioned earlier, analyses aimed at identifying and describing relationships between four demographic parameters (adult population size, population trend, number of young, and productivity) and landscape-level habitat characteristics for ten bird species of conservation concern have been completed for 13 military installations in south-central and southeastern United States, including Fort Leonard Wood (Nott et al. 2003). At Fort Leonard Wood, three species emerged as candidates for particular management concern: Acadian Flycatcher, Blue-winged Warbler, and Field Sparrow.

In last year's report we predicted that fire management practices, undertaken in the vicinity of certain stations should result in increased populations and productivity of Field Sparrows at those stations. Fire management has occurred at Fort Leonard Wood at various times: during spring 2000 at Laughlin Bottoms, spring 2002 at Miller Pond and Bradford Cemetery, and spring 2003 at Macedonia; no fire management has occurred at the remaining two stations, Big Piney and Tilley Bottoms. Examination of Field Sparrow data indicate that adult populations at each of the four stations having fire management showed increases which peaked during the year or two following that of the managed burns: 2002 at Laughlin Bottoms (10.2 adults/600 net hours), 2003 at Miller Pond (29.3), 2003 at Bradford Cemetery (36.0), and 2004 at Macedonia (4.3). In each case, these totals were the highest recorded during the 4-year period 2001-2004. Interestingly, however, breeding populations declined in each case during the following year (except Macedonia for which we will know after 2005 data has been collected), suggesting that the positive effects of burn management on Field Sparrow populations last only 2-3 years. The effects of burn management on productivity of Field Sparrow are less clear, with no discernable patterns emerging thus far. Increased breeding populations often reflect higher recruitment of first-time breeders into an area, which might be expected to show decreased productivity. Thus, relatively stable productivity in the face of increased population sizes may be interpreted as a relative increase in productivity. At the very least, increased breeding populations without a concomitant decrease in productivity means that, overall, more young are being produced and are available to be recruited in the local breeding populations.

We also predicted that the establishment of the two new stations, Tilley Bottoms and Bradford Cemetery, should shed further light on landbird population dynamics at Fort Leonard Wood, including declines of Acadian Flycatcher and Blue-winged Warbler. In 2003 and 2004, breeding populations and productivity values at these two new stations were among the highest at Fort Leonard Wood. Blue-winged Warbler capture rates at Tilley Bottoms were the highest anywhere on the installation and those at Bradford Cemetery were the second or third highest (Table 3). The capture rate of Acadian Flycatcher at Bradford Cemetery in 2004 was also the second-highest among the six stations (Table 3). We therefore believe that the establishment of these two new stations will allow us to monitor the population dynamics of landbirds at Fort Leonard Wood, including these two target species, even more successfully.

The overall goal of this work is to evaluate the efficiency of on-going management practices aimed at reversing declining populations and maintaining stable or increasing populations of target landbird species; and to modify these management practices in an adaptive management framework. The results of the first two years of this effort indicates that we are well on our way to achieving success in this endeavor.

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Literature Cited

- DeSante, D.F. (1992) Monitoring Avian Productivity and Survivorship (MAPS): a sharp, rather than blunt, tool for monitoring and assessing landbird populations. *In*: D. R. McCullough and R. H. Barrett (Eds.), Wildlife 2001: Populations, pp. 511-521. (London, U.K.: Elsevier Applied Science).
- DeSante, D.F. (1995) Suggestions for future directions for studies of marked migratory landbirds from the perspective of a practitioner in population management and conservation. Journal Applied Statistics 22, pp. 949-965.
- DeSante, D.F., Burton, K.M., Saracco, J.F., & Walker, B.L. (1995) Productivity indices and survival rate estimates from MAPS, a continent-wide programme of constant-effort mist netting in North America. Journal Applied Statistics, 22, pp. 935-947.
- DeSante, D.F., Burton, K.M., Velez, P., & Froehlich, D. (2004) MAPS Manual, Point Reyes Station, CA: The Institute for Bird Populations; 49 pp.
- DeSante, D.F., Nott, M.P., & O'Grady, D.R. (2001a) Identifying the proximate demographic cause(s) of population change by modeling spatial variation in productivity, survivorship, and population trends. Ardea, 89(special issue), pp185-207.
- DeSante, D.F., and D.R. O'Grady. (2000). The Monitoring Avian Productivity and Survivorship (MAPS) program 1997 and 1998 report. Bird Populations 5:49-101.
- DeSante, D.F., O'Grady, D.R. & Pyle, P. (1999) Measures of productivity and survival derived from standardized mist netting are consistent with observed population changes. Bird Study 46 (suppl.):S178-188.
- DeSante, D.F., Pyle, P., & O'Grady, D.R. (2001b) The 1992-1999 report of the Monitoring Avian Productivity and Survivorship (MAPS Program on military installations in eastern United States). The Institute for Bird Populations, Point Reyes Station, CA 113 pp. plus figs. and tables.

- DeSante, D.F., Pyle, P., & Kaschube, D. (2004) The 2003 report of the Monitoring Avian Productivity and Survivorship (MAPS) Program at Fort Leonard Wood. Point Reyes Station, CA: The Institute for Bird Populations; 9 pp.
- DeSante, D.F., & Rosenberg, D.K. (1998) What do we need to monitor in order to manage landbirds? *In*: J. Marzluff & R. Sallabanks (Eds.), Avian Conservation: Research Needs and Effective Implementation, pp. 93-106. Island Press, Washington, DC.
- Hines, J.E., Kendall, W.L., & Nichols, J.D. (2003) On the use of the robust design with transient capture-recapture models. Auk, 120, pp.1151-1158
- Lebreton, J.-D., Burnham, K.P., Clobert, J., & Anderson, D.R. (1992) Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies, Ecological Monographs, 62, pp. 67-118.
- Nott, M.P., & DeSante, D.F. (2002) Demographic monitoring and the identification of transients in mark-recapture models. Pp. 727-736 *in*: J.M. Scott & P. Heglund (eds.), Predicting Species Occurrences: Issues of Scale and Accuracy. Island Press, NY.
- Nott, M.P., D.F. DeSante, and N. Michel. (2003) Management strategies for reversing declines in landbirds of conservation concern on military installations: A landscape-scale analysis of MAPS data. The Institute for Bird Populations, Pt. Reyes Station, CA.
- Peach, W.J., Buckland, S.T., & Baillie, S.R. (1996) The use of constant effort mist-netting to measure between-year changes in the abundance and productivity of common passerines. Bird Study, 43, pp. 142-156.
- Peterjohn, B.G., Sauer, J.R., & Robbins, C.S. (1995) Population trends from the North American Breeding Bird Survey. *In*: T.E. Martin and D.M. Finch, Ecology and Management of Neotropical Migratory Birds, New York: Oxford University Press; pp. 3-39.
- Pollock, K.H., Nichols, J.D., Brownie, C., & Hines, J.E. (1990) Statistical inference for capture-recapture experiments, Wildlife Monographs, No. 107.
- Pradel, R., Hines, J., Lebreton, J.-D., & Nichols, J.D. (1997) Estimating survival probabilities and proportions of 'transients' using capture-recapture data. Biometrics, 53, pp. 60-72.
- Robbins, C.S., Sauer, J.R., Greenberg, R.S., & Droege, S. (1989) Population declines in North American birds that migrate to the Neotropics, Proceedings of the National Academy of Sciences (USA), 86, pp. 7658-7662.
- Terborgh, J. (1989) Where Have All the Birds Gone?, Essays on the Biology and Conservation of Birds that Migrate to the American Tropics, Princeton, NJ: Princeton Univ. Press; 207 pp.
- White, G.C. (1983) Numerical estimation of survival rates from band-recovery and biotelemetry data. J. Wildlife Management, 47, pp. 716-728.

Table 1. Summary of the 2004 MAPS program on Fort Leonard Wood.

Station			Major Habitat Type	Latitude-longitude	Avg Elev. (m)	2004 operation		
Name	Code	No.				Total number of net-hours ¹	No. of periods	Inclusive dates
Big Piney	BIPO	14422	Bottomland riparian forest, open fields, scrublands	37°44'20"N,92°02'40"W	235	446.3 (439.7)	8	5/22-8/01
Laughlin Bottoms	LABO	14423	Oldfield complex, walnut plantation, deciduous forest, mature riparian forest	37°46'40"N,92°10'40"W	300	413.7 (387.3)	8	5/24-8/03
Tilley Bottoms	TIBO	14495	Black walnut plantation, mesic lowland	37°46'26"N,92°12'03"W	250	482.5 (442.7)	8	5/25-8/04
Bradford Cemetery	BRCE	14494	Oldfield complex burned every three years, oak forest, pond	37°42'18"N,92°07'00"W	317	442.8 (367.8)	8	5/26-8/05
Miller Pond	MIPO	14424	Old field complex, deciduous forest of varying ages, ponds, mowed firebreaks	37°41'40"N,92°06'40"W	326	421.0 (354.3)	8	5/23-8/02
Macedonia	MACE	14425	Oldfield complex, cedar brakes, secondary woodland	37°36'40"N,92°14'10"W	360	421.7 (408.7)	8	5/21-7/31
ALL STATIONS COMBINED						2628.0(2400.5)	8	5/21 - 8/05

¹ Total net-hours in 2004. Net-hours in 2004 that could be compared in a constant-effort manner to 2003 are shown in parentheses.

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

Species	Big Piney			Laughlin Bottoms			Tilley Bottoms			Bradford Cemetery			Miller Pond			Macedonia		
	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Northern Bobwhite															1			
Ruby-throated Hummingbird					2			2			2			1				
Unidentified Hummingbird		2			2			16			2			4				3
Red-bellied Woodpecker													2					
Downy Woodpecker				2			9			3			2		2			
Hairy Woodpecker	1			2									2				1	
Pileated Woodpecker		1																1
Eastern Wood-Pewee							3		1	2			23	1	1			
Acadian Flycatcher	7		4	3		2	3											
"Traill's" Flycatcher	1						4						3					
Unident. Empidonax Flycat.								1										1
Great Crested Flycatcher																		1
White-eyed Vireo	2		3	13		3	25		15	8	1	8	4		2		1	
Yellow-throated Vireo											1		1					
Red-eyed Vireo	3			5		1	5			5		1	6				5	1
Blue Jay													1					
Carolina Chickadee				8		1	6		1				11		8		2	
Tufted Titmouse	2		1				2			1			11		2		6	
White-breasted Nuthatch																	1	
Carolina Wren	8		2	2			10		4	1			5		2			
Bewick's Wren													1					
Blue-gray Gnatcatcher				4		1	12	1	3	8			24		1			1
Swainson's Thrush							1											
Wood Thrush	4			1						1								1
Gray Catbird							1	1					2		1			

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

Species	Big Piney			Laughlin Bottoms			Tilley Bottoms			Bradford Cemetery			Miller Pond			Macedonia		
	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Brown Thrasher							3											
Blue-winged Warbler	7	1	1	3		3	21	1	16	10	2	5	27	1	5	4		
Northern Parula	1			2		2				6			12		1	1		
Magnolia Warbler							1											
Pine Warbler													1					
Prairie Warbler				3			5		7	19	1	10	25		10	2		1
Cerulean Warbler	1																	
Black-and-white Warbler	5			4			1			2			2			7		2
American Redstart	6		3	1			1											
Worm-eating Warbler	3		1	1			2			2			1					
Ovenbird	6			3			6			1			1			6	1	2
Louisiana Waterthrush	6		1	1														
Kentucky Warbler	8	3	3	12		10	10		1	4		1	3	1	1		1	
Mourning Warbler							2											
Common Yellowthroat	1			8		5	13		14	2			24	1	16			
Hooded Warbler													1					
Yellow-breasted Chat	2			13	3	6	26	1	20	13	1	16	28	1	21	2		
Summer Tanager				1			1					2						
Scarlet Tanager										1			1					
Eastern Towhee	4			2			2		1	2								
Field Sparrow				1		1	5		2	28		11	18	1	9	4		
Northern Cardinal	5		3	5		1	5		1	4	1	2	4		1	2	1	1
Blue Grosbeak													2					
Indigo Bunting	10	1	4	19	1	10	21	3	12	6		2	18		13	13	1	3
Brown-headed Cowbird		1		1									1					

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

Species	Big Piney			Laughlin Bottoms			Tilley Bottoms			Bradford Cemetery			Miller Pond			Macedonia		
	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Orchard Oriole													4					
Baltimore Oriole													1					
American Goldfinch							2		1	1		1	14		2	2		1
ALL SPECIES POOLED	93	9	26	120	8	46	208	26	99	130	13	57	286	12	98	61	11	13
Total Number of Captures		128			174				333			200		396				85
Number of Species	22	6	11	26	4	13	30	8	15	23	9	10	35	9	18	18	9	8
Total Number of Species		25			28				33			27		38				23

Table 3. Numbers of adult and young individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Fort Leonard Wood in 2004.

Species	Big Piney			Laughlin Bottoms			Tilley Bottoms			Bradford Cemetery			Miller Pond			Macedonia		
	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.
Red-bellied Woodpecker													2.9	0.0	0.00			
Downy Woodpecker				2.9	0.0	0.00	11.2	0.0	0.00	4.1	0.0	0.00	4.3	0.0	0.00			
Hairy Woodpecker	1.3	0.0	0.00	2.9	0.0	0.00							2.9	0.0	0.00	1.4	0.0	0.00
Eastern Wood-Pewee							3.7	0.0	0.00	2.7	0.0	0.00	25.7	7.1	0.22			
Acadian Flycatcher	10.8	0.0	0.00	4.4	0.0	0.00	2.5	1.2	0.33									
"Traill's" Flycatcher	1.3	0.0	0.00				5.0	0.0	0.00				4.3	0.0	0.00			
Great Crested Flycatcher																1.4	0.0	0.00
White-eyed Vireo	4.0	0.0	0.00	16.0	2.9	0.15	29.8	7.5	0.20	16.3	1.4	0.08	1.4	5.7	0.80	1.4	0.0	0.00
Yellow-throated Vireo													1.4	0.0	0.00			
Red-eyed Vireo	4.0	0.0	0.00	7.3	1.5	0.17	5.0	1.2	0.20	6.8	0.0	0.00	4.3	2.9	0.40	7.1	0.0	0.00
Blue Jay													1.4	0.0	0.00			
Carolina Chickadee				11.6	1.5	0.11	6.2	1.2	0.17				22.8	1.4	0.06	4.3	0.0	0.00
Tufted Titmouse	2.7	1.3	0.33				1.2	1.2	0.50	0.0	1.4	1.00	10.0	5.7	0.36	2.8	7.1	0.71
White-breasted Nuthatch																1.4	0.0	0.00
Carolina Wren	6.7	2.7	0.29	2.9	0.0	0.00	5.0	5.0	0.50	1.4	0.0	0.00	4.3	2.9	0.40			
Bewick's Wren													1.4	0.0	0.00			
Blue-gray Gnatcatcher				1.5	2.9	0.67	13.7	2.5	0.15	5.4	4.1	0.43	5.7	28.5	0.83			
Wood Thrush	5.4	0.0	0.00	1.5	0.0	0.00				1.4	0.0	0.00				1.4	0.0	0.00
Gray Catbird							1.2	0.0	0.00				2.9	0.0	0.00			
Brown Thrasher							1.2	2.5	0.67									
Blue-winged Warbler	5.4	4.0	0.43	5.8	1.5	0.20	32.3	1.2	0.04	12.2	4.1	0.25	18.5	18.5	0.50	1.4	2.8	0.67

Table 3. (cont.) Numbers of adult and young individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Fort Leonard Wood in 2004.

Species	Big Piney			Laughlin Bottoms			Tilley Bottoms			Bradford Cemetery			Miller Pond			Macedonia		
	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.
Northern Parula	1.3	0.0	0.00	5.8	0.0	0.00				1.4	6.8	0.83	4.3	12.8	0.75	1.4	0.0	0.00
Prairie Warbler				1.5	2.9	0.67	5.0	3.7	0.43	20.3	6.8	0.25	29.9	8.6	0.22	4.3	0.0	0.00
Cerulean Warbler	1.3	0.0	0.00															
Black-and-white Warbler	4.0	1.3	0.25	5.8	0.0	0.00	1.2	0.0	0.00	2.7	0.0	0.00	1.4	1.4	0.50	5.7	4.3	0.43
American Redstart	12.1	0.0	0.00	1.5	0.0	0.00	0.0	1.2	1.00									
Worm-eating Warbler	1.3	4.0	0.75	1.5	0.0	0.00	1.2	1.2	0.50	0.0	1.4	1.00	1.4	0.0	0.00			
Ovenbird	2.7	5.4	0.67	2.9	1.5	0.33	5.0	2.5	0.33	1.4	0.0	0.00	1.4	0.0	0.00	8.5	0.0	0.00
Louisiana Waterthrush	8.1	1.3	0.14	1.5	0.0	0.00												
Kentucky Warbler	5.4	4.0	0.43	23.2	1.5	0.06	7.5	5.0	0.40	4.1	2.7	0.40	1.4	1.4	0.50			
Common Yellowthroat	0.0	1.3	1.00	11.6	1.5	0.11	18.7	3.7	0.17	0.0	2.7	1.00	28.5	11.4	0.29			
Hooded Warbler													1.4	0.0	0.00			
Yellow-breasted Chat	2.7	0.0	0.00	20.3	2.9	0.13	33.6	11.2	0.25	24.4	2.7	0.10	45.6	8.6	0.16	2.8	0.0	0.00
Summer Tanager				1.5	0.0	0.00	1.2	0.0	0.00									
Scarlet Tanager										1.4	0.0	0.00	1.4	0.0	0.00			
Eastern Towhee	5.4	0.0	0.00	2.9	0.0	0.00	2.5	0.0	0.00	2.7	0.0	0.00						
Field Sparrow				2.9	0.0	0.00	7.5	0.0	0.00	20.3	17.6	0.46	27.1	2.9	0.09	4.3	1.4	0.25
Northern Cardinal	5.4	2.7	0.33	8.7	0.0	0.00	3.7	2.5	0.40	4.1	2.7	0.40	4.3	2.9	0.40	2.8	0.0	0.00
Blue Grosbeak													2.9	0.0	0.00			
Indigo Bunting	13.4	1.3	0.09	30.5	1.5	0.05	36.1	1.2	0.03	9.5	1.4	0.13	32.8	1.4	0.04	19.9	0.0	0.00
Brown-headed Cowbird				1.5	0.0	0.00							1.4	0.0	0.00			
Orchard Oriole													4.3	1.4	0.25			

Table 3. (cont.) Numbers of adult and young individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Fort Leonard Wood in 2004.

Species	Big Piney			Laughlin Bottoms			Tilley Bottoms			Bradford Cemetery			Miller Pond			Macedonia		
	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.
Baltimore Oriole													0.0	1.4	1.00			
American Goldfinch							3.7	0.0	0.00	2.7	0.0	0.00	22.8	0.0	0.00	2.8	0.0	0.00
ALL SPECIES POOLED	104.9	29.6	0.22	179.9	21.8	0.11	245.0	56.0	0.19	145.0	55.6	0.28	326.4	126.8	0.28	75.4	15.7	0.17
Number of Species	21	11		26	11		26	18		20	13		33	19		18	4	
Total Number of Species		22			26			27			23			34			18	

Table 4. Summary of results for all six Fort Leonard Wood MAPS stations combined in 2004.

Species	Birds captured			Birds/600 nethours		Prop. Young
	Newly banded	Un-banded	Recap-tured	Adults	Young	
Northern Bobwhite		1				
Ruby-throated Hummingbird		7				
Unidentified Hummingbird		29				
Red-bellied Woodpecker	2			0.5	0.0	0.00
Downy Woodpecker	16		2	3.9	0.0	0.00
Hairy Woodpecker	6			1.4	0.0	0.00
Pileated Woodpecker		2				
Eastern Wood-Pewee	28	1	2	5.3	1.1	0.18
Acadian Flycatcher	13		6	3.0	0.2	0.07
"Traill's" Flycatcher	8			1.8	0.0	0.00
Unident. Empidonax Flycatcher		2				
Great Crested Flycatcher	1			0.2	0.0	0.00
White-eyed Vireo	53	1	31	11.9	3.0	0.20
Yellow-throated Vireo	1	1		0.2	0.0	0.00
Red-eyed Vireo	29	1	2	5.7	0.9	0.14
Blue Jay	1			0.2	0.0	0.00
Carolina Chickadee	27		11	7.3	0.7	0.09
Tufted Titmouse	22		5	2.7	2.7	0.50
White-breasted Nuthatch	1			0.2	0.0	0.00
Carolina Wren	26		8	3.4	1.8	0.35
Bewick's Wren	1			0.2	0.0	0.00
Blue-gray Gnatcatcher	48	2	5	4.6	6.2	0.57
Swainson's Thrush	1					
Wood Thrush	7			1.6	0.0	0.00
Gray Catbird	3	1	1	0.7	0.0	0.00
Brown Thrasher	3			0.2	0.5	0.67
Blue-winged Warbler	72	5	30	12.8	5.3	0.29
Northern Parula	22		3	2.3	3.2	0.58
Magnolia Warbler	1					
Pine Warbler	1					
Prairie Warbler	54	1	28	10.0	3.7	0.27
Cerulean Warbler	1			0.2	0.0	0.00
Black-and-white Warbler	21		2	3.4	1.1	0.25
American Redstart	8		3	2.3	0.2	0.09

Table 4. (cont.) Summary of results for all six Fort Leonard Wood MAPS stations combined in 2004.

Species	Birds captured			Birds/600 nethours		Prop. Young
	Newly banded	Un-banded	Recap-tured	Adults	Young	
Worm-eating Warbler	9		1	0.9	1.1	0.56
Ovenbird	23	1	2	3.7	1.6	0.30
Louisiana Waterthrush	7		1	1.6	0.2	0.13
Kentucky Warbler	37	5	16	6.8	2.3	0.25
Mourning Warbler	2					
Common Yellowthroat	48	1	35	9.8	3.4	0.26
Hooded Warbler	1			0.2	0.0	0.00
Yellow-breasted Chat	84	6	63	21.7	4.3	0.17
Summer Tanager	2	2		0.5	0.0	0.00
Scarlet Tanager	2			0.5	0.0	0.00
Eastern Towhee	10		1	2.3	0.0	0.00
Field Sparrow	56	1	23	10.3	3.7	0.26
Northern Cardinal	25	2	9	4.8	1.8	0.28
Blue Grosbeak	2			0.5	0.0	0.00
Indigo Bunting	87	6	44	23.7	1.1	0.05
Brown-headed Cowbird	2	1		0.5	0.0	0.00
Orchard Oriole	4			0.7	0.2	0.25
Baltimore Oriole	1			0.0	0.2	1.00
American Goldfinch	19		5	5.0	0.0	0.00
ALL SPECIES POOLED	898	79	339	179.5	50.7	0.22
Total Number of Captures		1316				
Number of Species	48	20	26	43.0	25.0	
Total Number of Species		51			44.0	

Table 5. Time-constant estimates of annual adult apparent survival and recapture probabilities and proportion of residents among newly captured adults for 21 species breeding at MAPS stations on Fort Leonard Wood obtained from 12 years (1993-2004) of mark-recapture data.

Species	Num. sta. ¹	Num. ind. ²	Num. caps. ³	Num. ret. ⁴	Survival probability ⁵	Surv. C.V. ⁶	Recapture probability ⁷	Proportion of residents ⁸
Downy Woodpecker	6	87	100	9	0.664 (0.118)	17.7	0.298 (0.137)	0.185 (0.109)
Acadian Flycatcher	5	164	278	49	0.628 (0.053)	8.4	0.427 (0.070)	0.397 (0.099)
White-eyed Vireo	5	165	318	46	0.599 (0.057)	9.5	0.455 (0.078)	0.347 (0.096)
Red-eyed Vireo	6	221	275	32	0.501 (0.073)	14.5	0.232 (0.079)	0.736 (0.273)
Carolina Chickadee	6	117	144	16	0.543 (0.107)	19.7	0.195 (0.105)	0.879 (0.512)
Blue-gray Gnatcatcher	6	85	92	3	0.574 (0.228)	39.7	0.033 (0.075)	1.000 (2.287)
Blue-winged Warbler	4	299	446	64	0.542 (0.050)	9.3	0.523 (0.073)	0.320 (0.070)
Northern Parula	4	47	55	5	0.536 (0.184)	34.3	0.109 (0.133)	1.000 (1.257)
Prairie Warbler	3	178	236	24	0.532 (0.088)	16.5	0.208 (0.079)	0.703 (0.289)
American Redstart	1	79	100	13	0.695 (0.103)	14.7	0.208 (0.094)	0.441 (0.219)
Worm-eating Warbler	2	80	104	10	0.547 (0.125)	22.9	0.556 (0.184)	0.147 (0.085)
Ovenbird	4	88	124	15	0.577 (0.095)	16.4	0.417 (0.132)	0.270 (0.127)
Louisiana Waterthrush	1	55	96	12	0.359 (0.111)	31.0	0.772 (0.193)	0.486 (0.247)
Kentucky Warbler	5	271	476	90	0.600 (0.041)	6.9	0.506 (0.057)	0.435 (0.079)
Common Yellowthroat	3	192	362	50	0.503 (0.054)	10.7	0.595 (0.085)	0.384 (0.100)
Yellow-breasted Chat	3	335	590	104	0.611 (0.037)	6.1	0.361 (0.046)	0.601 (0.102)
Summer Tanager	3	39	46	4	0.465 (0.204)	43.9	0.238 (0.230)	0.523 (0.557)
Field Sparrow	3	306	446	65	0.487 (0.050)	10.3	0.344 (0.065)	0.699 (0.158)
Northern Cardinal	6	158	222	31	0.587 (0.075)	12.8	0.209 (0.066)	0.860 (0.294)
Indigo Bunting	6	594	925	136	0.476 (0.035)	7.4	0.387 (0.049)	0.745 (0.115)
American Goldfinch	3	162	193	9	0.364 (0.134)	36.8	0.111 (0.105)	1.000 (0.933)

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

⁶ The coefficient of variation for survival probability.

Table 5 (cont.). Time-constant estimates of annual adult apparent survival and recapture probabilities and proportion of residents among newly captured adults for 21 species breeding at MAPS stations on Fort Leonard Wood obtained from 12 years (1993-2004) of mark-recapture data.

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).