

**THE 2009 REPORT OF THE  
MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP  
(MAPS) PROGRAM ON FORT LEONARD WOOD**

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## SUMMARY

Six Monitoring Avian Productivity and Survivorship (MAPS) stations were established and operated by The Institute for Bird Populations (IBP) in 1993 on Fort Leonard Wood (FLW), Missouri. We continued to operate these stations during the summers of 1994-2002 by means of funding from the DoD Legacy Resource Management Program, and during the summers of 2003-2009 by means of funding provided FLW natural resources program, which also supports studies of Cerulean Warblers on the installation. The objectives of the MAPS Program on FLW are directed at USFWS-listed species of conservation concern, including Neotropical migrant species, in the context of balancing bird conservation with land management intended to enhance military Readiness and Range Sustainment (R&RS). The objectives are to a) monitor year to year changes in population dynamics, b) provide landscape-level population management decision-support tools, and c) monitor and subsequently assess the efficacy of specific management actions intended to create or maintain landscapes that support healthy, productive “source” populations. These conservation goals are particularly relevant to the dispersal and recruitment of individuals into adjacent federal or private lands ([Nott and Morris 2007](#)). These data have also contributed to the information and management decision-support tools developed in collaboration with other DoD installations that support MAPS monitoring, modeling, and management efforts ([Nott 2008](#)).

Following the recommendations of Nott et al. ([2003](#)), the Smith Ridge and Miller Ridge stations at FLW were discontinued in 2003 due to low capture rates and because they were located in dry, upland, mature, closed canopy forest where management results are less

achievable. The two stations were replaced by the Tilley Bottoms station in a moist bottomland forest, and the Bradford Cemetery station to monitor the effects of cessation of fire management on species of conservation concern. Thus, 2009 is the seventh year of operation for the Tilley Bottoms and Bradford Cemetery stations, and the sixth year following management actions at Miller Pond and Macedonia during the spring of 2004.

We operated for a total of 2433.8 net-hours at the six MAPS stations on FLW during the summer of 2009 representing 84.5% of the maximum expected effort. A total of 931 captures of 46 species occurred at FLW during the summer of 2009, with newly banded birds comprised 65.4% of the total captures.

Adult capture rates increased by small amounts from those of 2008 at all stations except Laughlin Bottoms, where capture rate decreased by a small amount. Adults captured at all stations pooled increased by 4.0% over the value recorded in 2008. Indigo Bunting had the most abundant breeding populations at FLW in 2009, followed by Yellow-breasted Chat, Kentucky Warbler, White-eyed Vireo, Red-eyed Vireo, Prairie Warbler, Field Sparrow, Blue-winged Warbler, and Northern Cardinal.

We performed a new analysis for this report in order to assess species emigration and recruitment dynamics at FLW for 38 species at the four long-running stations (Big Piney, Laughlin Bottoms, Miller Pond, and Macedonia). Based on changes in our Breeding Status List we classified each species at each station as Resident, Intermittent, Establishing, or Vacating over the 17 years in which these stations have operated. Of 117 assessments, 59 species were

considered as resident, 15 as intermittent, 35 as establishing, and only 8 as vacating, indicating more recruitment than immigration into the FLW station areas. Ten species were considered establishing at more than one station whereas no species were assessed as vacating at more than one station. Among stations, recruitment to immigration rate was highest at Macedonia (13 species establishing to 1 species vacating) followed by Miller Pond (7:1), Laughlin Bottoms (6:2), and Big Piney (8:4). These data indicate that habitats are generally improving for breeding landbirds around these four stations.

Productivity was higher in 2009 than in 2008 (by 5-121%), with an increase of less than 50% only at Bradford Cemetery, the only station showing an increase in productivity between 2007 and 2008. The overall reproductive index for the six stations in 2009 was 0.30, compared to 0.19 in 2008, 0.27 in 2007 and 2006, and 0.26 in 2005, suggesting a substantial increase in productivity during 2009 compared with consistent values of the previous four years. This reflects generally increased productivity observed throughout the southeastern United States in 2009, perhaps due to poorer reproductive success in this region in 2008 which resulted in a greater proportion of more experienced breeding birds in 2009.

Using 17 years of data from the six long-running stations combined, estimates of adult survival and recapture probabilities were obtained for 24 target species breeding at FLW. Annual adult survival-rate estimates ranged from a low of 0.345 for Carolina Wren to a high of 0.661 for Eastern Towhee, with a mean of 0.532 for the 24 species. The mean C.V. for these 24 species was 16.7%, compared with 18.0% following the 2008 season, 18.6% following the 2008

season, and 19.8% following the 2006 season, indicating that survival estimates are continuing to become more precise, even after 17 years of data have been collected.

Analyses of DoD MAPS data have described strong relationships between demographic parameters and landscape-level habitat characteristics for ten bird species of conservation concern on 13 military installations in the south-central and southeastern United States ([Nott et al. 2003](#), [Nott and Michel 2005](#)). Of these ten species, five species with declining or stable populations at FLW were selected as species of local management concern: Acadian Flycatcher, Worm-eating Warbler, Louisiana Waterthrush, Kentucky Warbler, and Field Sparrow.

Nott et al. ([2003](#)) predicted that fire management practices, implemented in the vicinity of certain stations, should result in increased populations and productivity among Field Sparrows at those stations. Examination of Field Sparrow data since fire management at FLW indicate that adult populations peaked during the year or two following that of the managed burns. From 2004-2007 Field Sparrow productivity was fairly stable at the burn-management stations but declined in value and/or geographic scope between 2007 and 2009, perhaps reflecting post-burn succession of the habitat.

Nott et al. ([2003](#)) also predicted that the establishment of the two new stations, Tilley Bottoms and Bradford Cemetery, should shed further light on landbird population dynamics at FLW. During the 2006, 2007, and 2008 seasons, we recorded high capture rates of two target species, Kentucky Warbler, and Acadian Flycatcher. Two species of regional conservation concern with increasing FLW adult population sizes, Blue-winged Warbler and Prairie Warbler, also exhibited high capture rates. We might expect the numbers and reproductive success of

both these species to decline in coming years, as Bradford Cemetery is managed to allow succession towards the pine forest community currently surrounding it. Thus, the addition of these two stations will help us resolve the driving forces behind the population dynamics of target species of management concern at FLW.

To help interpret MAPS data on landbird dynamics we have recently developed and would like to highlight [installation-specific resource pages](#) for eight installations including [Fort Leonard Wood](#). Resources at the FLW page include the up-to-date [Breeding Status List](#), a [Spatial Statistics Database](#), a page interpreting and highlighting [MAPS reports](#) from FLW, and up to 36 [Data Visualizations](#) for 16 species at FLW. Data visualizations have been completed for the target species, including [Kentucky Warbler](#) and [Field Sparrow](#), and an additional species-management-account page has been developed for [Kentucky Warbler](#). For the 2010 report we will have completed development of these pages, and will incorporate them more fully into the annual report.

The overall goal of this work is to assess the efficacy of on-going management practices (or cessation thereof) aimed at maintaining stable or increasing populations of target landbird species; and to modify those management practices in an adaptive management framework. The results of the first seven years of this effort indicate success in predicting post-management demographic changes with three of five target species. The FLW MAPS data contribute to a continental-scale demographic monitoring dataset collected at numerous DoD installations since 1992. These data have also contributed to the development of management decision-support



tools designed to predict the effects of proposed management on a suite of species of concern

(Nott 2008, and see above).

## 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 1000 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 that may be affecting 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). A recent study (Saracco et al. 2008) used novel analytical methods to a) show that both MAPS and the North American Breeding Bird Survey (BBS) provide similar estimates of population trends for 36 species of wood warblers, and b) show that adult survival, rather than productivity, is the primary demographic parameter driving regional population changes in Yellow Warbler. It is also suggested that the annual survival rate of Neotropical migrants is strongly affected by stressors that act on migrating and overwintering individuals.

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 sensitive barometers 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 a focal project 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, Missouri (FLW). The operation of these stations was continued during the summers of 1994-2002 by means of funding from the DoD Legacy Resource Management Program, and during the summers of 2003-2009 by means of funding from FLW, which also supports studies of Cerulean Warblers on the installation.

The ultimate objective of the MAPS Program on DoD installations such as FLW 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 a population decline.

The Legacy Resource Management Program allowed us to undertake these analyses and formulate management strategies, and management guidelines have been 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 and actions on eight military installations (including FLW) 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 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.

At FLW, 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 beginning in 2003 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 also occurred during the spring of 2004. Thus, 2009 is the seventh year of operation for

the Tilley Bottoms and Bradford Cemetery stations, and the sixth year following management actions at Miller Pond and Macedonia.

A complete summary of the results of the MAPS Program on FLW 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). We have also developed [installation-specific resource pages](#) for eight installations including [Fort Leonard Wood](#). This report briefly updates these resources on the MAPS program at FLW (DeSante et al. 2004, 2005; Pyle et al. 2006; Nott and Morris 2007; Nott et al. 2006, 2008, 2009), and documents the operation of the six MAPS stations on FLW during the 2009 breeding season. In so doing, we have performed a new analysis looking at species-specific emigration and recruitment rates at the four long-running stations at FLW, and we highlight some of the new information available at the resource page mentioned above.

## METHODS

Six MAPS stations were operated in 2009, at the same locations where they were operated in 2003-2008 (Tilley Bottoms and Bradford Cemetery) and in 1993-2008 (the other four stations). 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. 2009](#)). 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 Amy Witt and Kai Zhang, who were trained by IBP field biologists Tiffany Beachy, Julie Remp, and Ron Taylor, and were supervised by Tiffany Beachy throughout the season.

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. 2009](#)):

- (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 combined, 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.

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.

Breeding (summer residency) status (confirmed breeder, likely breeder, non-breeder) of each species seen, heard, or captured at each TMAPS station on each day of operation was recorded using techniques similar to those employed for breeding bird atlas projects (see Appendix I). We used these data to classify each species at each station according to three residency categories for the station over the period of study: breeder, migrant, or transient (Appendix I). In order to assess species emigration and recruitment dynamics at FLW we scored our annual status codes (1.0 = breeder, 0.5 = likely breeder, and 0.0 = non-breeder) for 38 species against year for each of the four long-running stations. We classified each species at each station as Resident, Intermittent, Establishing, Vacating based on the plot over the 17 years in which these stations have operated.

Survival was estimated for 24 target species using Modified Cormack-Jolly-Seber (CJS) mark-recapture analyses (Pollock et al.1990, Lebreton et al.1992) on 17 years (1993-2009) of capture histories of adult birds from all eight stations at FLW (including the discontinued Smith Ridge and Miller Ridge 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 FLW during the summer of 2009 for a total of 2433.8 net-hours. This represents 84.5% of the maximum expected effort. 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, released unbanded (including hummingbirds, which we do not band), and recaptured, are presented for each station in Table 2 and for all stations combined in Table 4. A total of 931 captures of 46 species occurred at FLW during the summer of 2009 (Table 4). Newly banded birds comprised 65.4% of the total captures.

The greatest number of total captures (209) was recorded at the Miller Pond Station and the smallest number of total captures (56) was recorded at the Macedonia station. The highest

species richness occurred at Tilley Bottoms, Bradford Cemetery, and Miller Pond (27 species each) and the lowest species richness occurred at Macedonia (17 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 (202.3 adults/600 net hours; Table 3), followed by Tilley Bottoms (167.8), Big Piney (144.1), Bradford Cemetery (140.4), Laughlin Bottoms (129.2), and Macedonia (56.6). These adult capture rates increased by small amounts from those of 2008 at all stations except Laughlin Bottoms, where capture rate decreased by a small amount. Overall this indicates slightly larger breeding populations at Leonard Wood in 2009. Adults captured at all stations pooled (136.8; Table 4) increased by 4.0% over the value of 131.5 recorded in 2008.

Among individual species, Yellow-breasted Chat was the most frequently captured at the six stations in 2009, followed by Indigo Bunting, Kentucky Warbler, White-eyed Vireo, Carolina Wren, Field Sparrow, Northern Cardinal, American Redstart, Prairie Warbler, Red-eyed Vireo, and Ruby-throated Hummingbird (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, Kentucky Warbler, White-eyed Vireo, Red-eyed Vireo, Prairie Warbler, Field Sparrow, Blue-winged Warbler, and Northern Cardinal (Table 4); we could not calculate

this value for Ruby-throated Hummingbird since individuals were not banded. 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; species of concern, as noted below, in *italics*):

<p><b>Big Piney</b>                      American Redstart                      Indigo Bunting  <i>Kentucky Warbler</i>  <i>Louisiana Waterthrush</i>                      Red-eyed Vireo  <i>Worm-eating Warbler*</i>                      White-eyed Vireo†                      Carolina Wren†</p> <p><b>Laughlin Bottoms</b>  <i>Kentucky Warbler</i>                      Yellow-breasted Chat                      Indigo Bunting                      White-eyed Vireo                      Blue-winged Warbler                      Northern Cardinal†                      Blue-gray Gnatcatcher†                      Common Yellowthroat†</p>	<p><b>Tilley Bottoms</b>                      Yellow-breasted Chat                      White-eyed Vireo                      Northern Cardinal*                      Indigo Bunting                      Blue-winged Warbler                      Carolina Wren*                      Brown Thrasher*                      Eastern Towhee*  <i>Kentucky Warbler</i>†                      Common Yellowthroat†                      Blue-gray Gnatcatcher†</p> <p><b>Bradford Cemetery</b>  <i>Field Sparrow</i>  <i>Kentucky Warbler*</i>                      Yellow-breasted Chat                      Indigo Bunting                      White-eyed Vireo                      Red-eyed Vireo*                      Prairie Warbler</p>	<p><b>Miller Pond</b>                      Yellow-breasted Chat  <i>Field Sparrow</i>                      Prairie Warbler                      Indigo Bunting                      Red-eyed Vireo                      Blue-winged Warbler                      White-eyed Vireo                      Carolina Chickadee*                      Gray Catbird*                      Blue Grosbeak*                      American Goldfinch†                      Common Yellowthroat†</p> <p><b>Macedonia</b>                      Indigo Bunting                      Wood Thrush*                      Red-eyed Vireo†</p>
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\* At least 6.0 adults per 600 net hours in 2009 but not in 2008.

† At least 6.0 adults per 600 net hours in 2008 but not in 2009.

Eleven species shown in the above table were captured at lower rates than in 2008 and 11 species were captured at higher rates than in 2008. The only species showing similar changes at more than one station were Common Yellowthroat, which decreased at three stations, and Blue-gray Gnatcatcher, which decreased at two stations.

Examples of longer-range emigration and recruitment plots for species at the four long-running stations are shown in Figure 1 and these data are summarized for 38 species at four stations in Table 5. Of 117 assessments, 59 species were considered as resident, 15 as intermittent, 35 as establishing, and only 8 as vacating, indicating more recruitment than immigration into the FLW station areas. Ten species were considered establishing at more than one station: Yellow-billed Cuckoo (at Big Piney and Macedonia), Eastern Wood-Pewee (Laughlin Bottoms, Miller Pond, and Macedonia), Blue Jay (Miller Pond and Macedonia), Carolina Wren (Miller Pond and Macedonia), Northern Parula (Miller Pond and Macedonia), Black-and-white Warbler (Big Piney, Miller Pond, and Macedonia), Ovenbird (Big Piney and Laughlin Bottoms), Louisiana Waterthrush (Laughlin Bottoms and Macedonia), Summer Tanager (Big Piney and Macedonia), and Brown-headed Cowbird (Big Piney, Miller Pond, and Macedonia). By contrast, no species were assessed as vacating at more than one station. Among stations, recruitment to immigration rate was highest at Macedonia (13 species establishing to 1 species vacating) followed by Miller Pond (7:1), Laughlin Bottoms (6:2), and Big Piney (8:4).

These data, showing a much greater number of species establishing than vacating stations at FLW, indicate that habitats are generally improving for breeding landbirds around these four stations. To further help interpret these sorts of dynamics at DoD installations we have recently developed [installation-specific resource pages](#) for eight installations including [Fort Leonard Wood](#). Links for up to 36 visualizations per species, [for 16 species at FLW](#), can be found in Table 5. We believe that these resource pages and visualizations will greatly help interpret population dynamics of landbirds at FLW, as well as responses of target species to habitat-management activities on the installation.

Reproductive index (the number of young per adult captured pooled across six stations) showed a different pattern than adult population size (Table 3), being highest at Laughlin Bottoms (0.41), followed by Tilley Bottoms (0.34), Miller Pond (0.32), Big Piney (0.31), Bradford Cemetery (0.23), and Macedonia (0.05). Productivity was higher than in 2008 (by 5-121%), with an increase of less than 50% only at Bradford Cemetery, the only station showing an increase in productivity between 2007 and 2008 (Nott et al. 2009). The overall reproductive index for the six stations in 2009 was 0.30 (Table 4), compared to 0.19 in 2008, 0.27 in 2007 and 2006, and 0.26 in 2005, suggesting a substantial increase in productivity during 2009 compared with consistent values of the previous four years. This reflects generally increased productivity observed throughout the southeastern United States in 2009, perhaps due to poorer reproductive success in this region in 2008 which resulted in a greater proportion of more experienced breeding birds in 2009.

Using 17 years of data from the six long-running stations combined, estimates of adult survival and recapture probabilities were obtained for 24 target species breeding at FLW. 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 6. Annual adult survival-rate estimates ranged from a low of 0.345 for Carolina Wren to a high of 0.661 for Eastern Towhee, with a mean of 0.532 for the 24 species. The C.V.s for the 24 species at FLW were low (21 of the 24 species < 30%, 17 species < 20%, and 10 species < 10%) indicating quite precise estimates. The mean C.V. for these 24 species was 16.7%, compared with 18.0% following the 2008 season (with 16 years of data), 18.6%



following the 2008 season, and 19.8% following the 2006 season, indicating that survival estimates are continuing to become more precise, even after 17 years of data have been collected.

Furthermore, survival of landbirds at FLW 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 FLW 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, along with the numbers of species recruiting into the habitats of the four long-running stations, suggests that FLW 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 FLW ([Nott et al. 2003](#), [Nott and Michel 2005](#)). At FLW, five species with declining or stable populations emerged as candidates for particular management concern: Acadian Flycatcher, Worm-eating Warbler, Louisiana Waterthrush, Kentucky Warbler, and Field Sparrow.

Nott et al. ([2003](#)) predicted that fire management practices, implemented in the vicinity of certain stations, should result in increased populations and productivity among Field Sparrows at those stations. Fire management has occurred at FLW 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 nine-year period 2001-2009. Interestingly, breeding populations declined in most or all cases during the following five-year period, including 2009 (Table 3), suggesting that the positive effects of burn management on Field Sparrow populations last only 2-3 years. Up to and including 2007, Field Sparrow productivity was fairly stable at the four burn-management stations since the burns took place, but it declined between 2007 (mean 0.39 at all four stations) and 2008 (mean 0.04 at all stations except Macedonia), but then increased again in value in 2009 (mean 0.20) but was absent altogether from two of the stations, Laughlin Bottoms and Macedonia (Table 3). This may reflect a change in post-burn successional habitat, which would appear to disfavor Field Sparrow 4-6 years following a burn, although it is good to see that productivity continues to be good at Bradford Cemetery and Miller Pond.

For successional species such as Field Sparrow, the conservation goal is to consistently provide enough primary breeding habitat to annually support a target number of territories (dependent on installation or management zone) and level of productivity consistent with that of a source population in which breeding individuals are able to replace their own numbers. This requires maintaining a mosaic of habitat patches in various stages of post-fire succession such

that every year there is adequate habitat for recruitment, breeding, and strong reproductive success. The ability to maintain an abundant “source” population might be considered an adequate performance measure by which to evaluate landbird conservation efforts and habitat management techniques.

Nott et al. (2003) also predicted that the establishment of the two new stations, Tilley Bottoms and Bradford Cemetery, should shed further light on landbird population dynamics at FLW, including those of the other four target species, Acadian Flycatcher, Worm-eating Warbler, Louisiana Waterthrush, and Kentucky Warbler. In 2005 all of these species except the waterthrush were captured at these two stations, including excellent capture rates of Kentucky Warbler. During 2006-2009, captures of Kentucky Warbler and Acadian Flycatcher have remained fairly consistent whereas those of Worm-eating Warbler have been lower (cf. Table 3). Excellent capture rates of two other target species (with increasing populations), Blue-winged and Prairie warblers, were also obtained at the two new stations in 2005-2009. We might expect the numbers and reproductive success of both these species to decline in coming years, as Bradford Cemetery is managed for succession of the pine forest community currently surrounding it. Although this will eventually represent a loss of productive Field Sparrow habitat, “disclimax” management on other parts of the installation could replace such habitat. Thus, it appears that the addition of these two stations will help us resolve the population dynamics of these target species of management concern at FLW.

Concerning the remaining two target species, Louisiana Waterthrush has never been captured at monitorable rates at FLW, and changes of stations and management actions have had

no impact on this species. Worm-eating Warbler captures continue to decline at FLW (see Nott et al. 2008) indicating an overall decline of this species and indicating that changes at FLW have not been beneficial to this species. However, whereas many of the target species require mature deciduous habitats, Worm-eating Warbler prefers more successional habitat, and habitat maturation may also be a factor in this species' decline at FLW. Further consideration should be given to management actions that might result in increased success of Louisiana Waterthrush and Worm-eating Warbler at FLW.

To help interpret MAPS data on landbird dynamics we have recently developed and would like to highlight [installation-specific resource pages](#) for eight installations including [Fort Leonard Wood](#). Resources at the FLW page include the up-to-date [Breeding Status List](#), a [Spatial Statistics Database](#), a page interpreting and highlighting [MAPS reports](#) from FLW, and up to 36 [Data Visualizations](#) for 16 species at FLW. Data visualizations have been completed for the target species, including [Kentucky Warbler](#) and [Field Sparrow](#), and an additional species-management-account page has been developed for [Kentucky Warbler](#). For the 2010 report we will have completed development of these pages, and will incorporate them more fully into the annual report. The overall goal of this work is to evaluate the efficiency of on-going management practices (or cessation thereof) aimed at reversing declining populations and maintaining stable or increasing populations of target landbird species; and to modify those management practices in an adaptive management framework. The results of the first five years of this effort indicate that we are well on our way to achieving success in this endeavor.

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Table 1. Summary of the 2009 MAPS program on Fort Leonard Wood.

Station					Avg Elev. (m)	2009 operation		
Name	Code	No.	Major Habitat Type	Latitude-longitude		Total number of net-hours <sup>1</sup>	No. of periods	Inclusive dates
Big Piney	BIPO	14422	Bottomland riparian forest, open fields, scrublands	37°44'16"N,92°02'41"W	263	449.8 (439.8)	8	5/21 – 8/01
Laughlin Bottoms	LABO	14423	Oldfield complex, walnut plantation, deciduous forest, mature riparian forest	37°46'44"N,92°10'33"W	248	422.5 (384.2)	8	5/27 – 8/02
Tilley Bottoms	TIBO	14495	Black walnut plantation, mesic lowland	37°46'26"N,92°12'14"W	257	397.0 (360.5)	8	5/28 – 8/04
Bradford Cemetery	BRCE	14494	Oldfield complex burned every three years, oak forest, pond	37°42'17"N,92°07'01"W	319	389.0 (346.3)	8	5/24 - 7/31
Miller Pond	MIPO	14424	Old field complex, deciduous forest of varying ages, ponds, mowed firebreaks	37°41'44"N,92°06'47"W	333	341.0 (298.5)	8	5/25 - 7/30
Macedonia	MACE	14425	Oldfield complex, cedar brakes, secondary woodland	37°36'43"N,92°14'13"W	361	434.5 (376.8)	8	5/26 - 8/03
ALL STATIONS COMBINED						2433.8(2206.2)	8	5/21 - 8/04

<sup>1</sup> Total net-hours in 2009. Net-hours in 2009 that could be compared in a constant-effort manner to 2008 are shown in parentheses.

Table 2. Capture summary for the six individual MAPS stations operated on Fort Leonard Wood in 2009. 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
Ruby-throated Hummingbird					13			7		7			4			4		
Red-bellied Woodpecker	1						1											
Downy Woodpecker	1						4	1				3						
Hairy Woodpecker	1																	
Eastern Wood-Pewee	1						1		1		1	1	1					
Yellow-bellied Flycatcher							1											
Acadian Flycatcher	2			1		1	1		1							1		1
Traill's Flycatcher							3					2						
Unidentified Empid. Flycat.		1									1		1					
Eastern Phoebe										1		4						
Great Crested Flycatcher												2				1		
White-eyed Vireo	4		3	7		5	14	1	4	4	10	8		5				
Red-eyed Vireo	8		1	2						9	1	9	2	1	4			
Blue Jay							1										1	
N. Rough-winged Swallow	1																	
Carolina Chickadee	2	1		2		1	3			2		2		2				
Tufted Titmouse	1		1	3						1		3			2			
Carolina Wren	9	1		14	3	4	12		1	1		7		2				
Blue-gray Gnatcatcher				2						5	1	3	3	1				
Eastern Bluebird												1						
Swainson's Thrush				1						1								
Wood Thrush	4		1	1											4			1
Gray Catbird												3	1	5				
Brown Thrasher							4		1									
Blue-winged Warbler	2		3	7	1		4		3	3	2	6		2				
Northern Parula	3			2			3	1				3	1					
Prairie Warbler				5		1	1		1	5	4	9	1	7	3			1

Table 2. (cont.) Capture summary for the six individual MAPS stations operated on Fort Leonard Wood in 2009. 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
Cerulean Warbler	1																	
Black-and-white Warbler	1						3			2		2				1		
American Redstart	23		10	2	1		4											
Worm-eating Warbler	10		3	3						1		1	2					
Ovenbird	5			5					9			2				3	1	1
Louisiana Waterthrush	12		8													1		3
Kentucky Warbler	8		14	16		5	7		2	11		4				2		
Mourning Warbler							1											
Common Yellowthroat	1			6	1		4		1	1			2	2	2			
Yellow-breasted Chat				16	2	7	17	3	13	9	2	8	18	3	17	1		
Summer Tanager										1			2			2	1	
Scarlet Tanager										2			2					
Eastern Towhee		1					3	1	2	2								
Field Sparrow										14		4	16	3	10			
Northern Cardinal	3		1	6		3	17	1	3	3			4					1
Blue Grosbeak													4	1				
Indigo Bunting	10		10	8		11	11		2	10		2	8		6	9		6
Brown-headed Cowbird			1				1											
House Finch										1								
American Goldfinch							1		1	2			1		1			
ALL SPECIES POOLED	114	4	56	109	21	38	131	14	35	95	10	39	125	22	62	35	7	14
Total Number of Captures		174			168			180			144			209			56	
Number of Species	24	3	12	20	6	9	26	6	13	26	2	11	26	10	14	14	4	7
Total Number of Species		26			21			27			27			27			17	



Table 3. (cont.) Numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Fort Leonard Wood in 2009.

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.
Worm-eating Warbler	8.0	5.3	0.67	2.8	1.4	0.50				3.1	0.0	0.00	0.0	3.5	und.			
Ovenbird	2.7	4.0	1.50	1.4	5.7	4.00	4.5	9.1	2.00	1.5	1.5	1.00				2.8	2.8	1.00
Louisiana Waterthrush	12.0	6.7	0.56													2.8	0.0	0.00
Kentucky Warbler	14.7	5.3	0.36	22.7	5.7	0.25	10.6	3.0	0.29	15.4	1.5	0.10				2.8	0.0	0.00
Common Yellowthroat	0.0	1.3	und.	2.8	5.7	2.00	4.5	3.0	0.67	0.0	1.5	und.	3.5	3.5	1.00			
Yellow-breasted Chat				22.7	4.3	0.19	30.2	7.6	0.25	15.4	1.5	0.10	35.2	8.8	0.25	1.4	0.0	0.00
Summer Tanager										1.5	0.0	0.00	3.5	0.0	0.00	2.8	0.0	0.00
Scarlet Tanager										3.1	0.0	0.00	3.5	0.0	0.00			
Eastern Towhee							6.0	0.0	0.00	3.1	0.0	0.00						
Field Sparrow										18.5	6.2	0.33	26.4	12.3	0.47			
Northern Cardinal	5.3	0.0	0.00	5.7	5.7	1.00	18.1	10.6	0.58	3.1	1.5	0.50	3.5	3.5	1.00	1.4	0.0	0.00
Blue Grosbeak													7.0	0.0	0.00			
Indigo Bunting	18.7	0.0	0.00	21.3	0.0	0.00	18.1	1.5	0.08	15.4	3.1	0.20	19.4	0.0	0.00	18.0	0.0	0.00
Brown-headed Cowbird	1.3	0.0	0.00				1.5	0.0	0.00									
House Finch										0.0	1.5	und.						
American Goldfinch							1.5	0.0	0.00	3.1	0.0	0.00	1.8	0.0	0.00			
ALL SPECIES POOLED	144.1	44.0	0.31	129.2	52.5	0.41	167.8	57.4	0.34	140.4	32.4	0.23	202.3	65.1	0.32	56.6	2.8	0.05
Number of Species	23	12		18	11		24	12		22	13		23	15		15	1	
Total Number of Species		25			19			24			25			26			15	

Table 4. Summary of results for all six Fort Leonard Wood MAPS stations combined in 2009.

Species	Birds captured			Birds/600 nethours		Prop. Young
	Newly banded	Un-banded	Recap-tured	Adults	Young	
Ruby-throated Hummingbird		35				
Red-bellied Woodpecker	2			0.5	0.0	0.00
Downy Woodpecker	8		1	0.7	1.2	1.67
Hairy Woodpecker	1			0.2	0.0	0.00
Eastern Wood-Pewee	5		1	1.5	0.0	0.00
Yellow-bellied Flycatcher	1					
Acadian Flycatcher	6		2	1.5	0.2	0.17
Traill's Flycatcher	5			1.2	0.0	0.00
Unidentified Empidonax Flycat.		3				
Eastern Phoebe	5			0.7	0.5	0.67
Great Crested Flycatcher	3			0.7	0.0	0.00
White-eyed Vireo	37	1	27	9.9	2.0	0.20
Red-eyed Vireo	32	2	3	7.6	0.5	0.06
Blue Jay	1	1		0.2	0.0	0.00
N. Rough-winged Swallow	1			0.2	0.0	0.00
Carolina Chickadee	11	1	3	3.5	0.0	0.00
Tufted Titmouse	10		1	1.5	1.2	0.83
Carolina Wren	43	4	7	3.7	6.4	1.73
Blue-gray Gnatcatcher	10	3	2	1.2	1.7	1.40
Eastern Bluebird	1			0.0	0.2	und.
Swainson's Thrush	2					
Wood Thrush	9		2	2.0	0.7	0.38
Gray Catbird	3	1	5	1.0	0.0	0.00
Brown Thrasher	4		1	1.0	0.0	0.00
Blue-winged Warbler	22	1	10	6.2	0.7	0.12
Northern Parula	11	2		2.0	0.7	0.38
Prairie Warbler	23	1	14	6.7	0.7	0.11
Cerulean Warbler	1			0.2	0.0	0.00
Black-and-white Warbler	7		2	1.5	0.5	0.33
American Redstart	29	1	10	7.4	1.2	0.17
Worm-eating Warbler	16		4	2.5	1.7	0.70
Ovenbird	24	1	1	2.2	3.9	1.78
Louisiana Waterthrush	13		11	2.7	1.2	0.46
Kentucky Warbler	44		25	11.3	2.7	0.24
Mourning Warbler	1					
Common Yellowthroat	14	3	3	1.7	2.5	1.43
Yellow-breasted Chat	61	10	45	16.5	3.5	0.21
Summer Tanager	5	1		1.2	0.0	0.00
Scarlet Tanager	4			1.0	0.0	0.00
Eastern Towhee	5	2	2	1.5	0.0	0.00
Field Sparrow	30	3	14	6.4	2.7	0.42

Table 4. (cont.) Summary of results for all six Fort Leonard Wood MAPS stations combined in 2009.

Species	Birds captured			Birds/600 nethours		Prop. Young
	Newly banded	Un-banded	Recap-tured	Adults	Young	
Northern Cardinal	33	1	8	6.2	3.5	0.56
Blue Grosbeak	4	1		1.0	0.0	0.00
Indigo Bunting	56		37	18.2	0.7	0.04
Brown-headed Cowbird	1		1	0.5	0.0	0.00
House Finch	1			0.0	0.2	und.
American Goldfinch	4		2	1.0	0.0	0.00
ALL SPECIES POOLED	609	78	244	136.8	41.4	0.30
Total Number of Captures		931				
Number of Species	45	20	28	40	25	
Total Number of Species		46			42	



Table 5. Residency patterns for 38 species at the four long-running stations at Fort Leonard Wood. See Figure 5 for examples of patterns reported here<sup>1</sup>.

Species	Big Piney	Laughlin Bottoms	Miller Pond	Macedonia
Yellow-billed Cuckoo	Establishing	Resident	Intermittent	Establishing
Red-bellied Woodpecker	Resident	Establishing		Intermittent
Downy Woodpecker	Resident	Intermittent	Resident	Intermittent
Eastern Wood-Pewee	Resident	Establishing	Establishing	Establishing
Acadian Flycatcher	Resident	Resident		Resident
Eastern Phoebe	Vacating		Intermittent	
Great Crested Flycatcher	Vacating			
<a href="#">White-eyed Vireo</a> <sup>2</sup>	Resident	Resident	Resident	Intermittent
Yellow-throated Vireo	Establishing			
<a href="#">Red-eyed Vireo</a> <sup>2</sup>	Resident	Resident	Establishing	Resident
Blue Jay	Intermittent	Vacating	Establishing	Establishing
<a href="#">Carolina Chickadee</a> <sup>2</sup>	Resident	Resident	Resident	Resident
<a href="#">Tufted Titmouse</a> <sup>2</sup>	Resident	Resident	Resident	Resident
White-breasted Nuthatch	Establishing			
<a href="#">Carolina Wren</a> <sup>2</sup>	Resident	Resident	Establishing	Establishing
<a href="#">Blue-gray Gnatcatcher</a> <sup>2</sup>	Resident	Resident	Resident	Establishing
Eastern Bluebird			Intermittent	
Wood Thrush	Resident			Establishing
<a href="#">Blue-winged Warbler</a> <sup>2</sup>	Resident	Resident	Resident	Establishing
Northern Parula	Resident	Resident	Establishing	Establishing
<a href="#">Prairie Warbler</a> <sup>2</sup>		Resident	Resident	Intermittent
Cerulean Warbler	Intermittent			
Yellow-throated Warbler	Intermittent	Establishing		
Black-and-white Warbler	Establishing	Intermittent	Establishing	Establishing
<a href="#">American Redstart</a> <sup>2</sup>	Resident	Establishing		
Worm-eating Warbler	Establishing			
Ovenbird	Establishing	Establishing	Vacating	Resident
Louisiana Waterthrush	Resident	Establishing		Establishing
<a href="#">Kentucky Warbler</a> <sup>2</sup>	Resident	Resident	Intermittent	Vacating
<a href="#">Common Yellowthroat</a> <sup>2</sup>	Vacating	Resident	Resident	
<a href="#">Yellow-breasted Chat</a> <sup>2</sup>	Intermittent	Resident	Resident	Establishing
Summer Tanager	Establishing			Establishing
Eastern Towhee	Vacating	Resident	Resident	Resident
<a href="#">Field Sparrow</a> <sup>2</sup>		Resident	Resident	Resident
<a href="#">Northern Cardinal</a> <sup>2</sup>	Resident	Resident	Resident	Resident
<a href="#">Indigo Bunting</a> <sup>2</sup>	Resident	Resident	Resident	Resident
Brown-headed Cowbird	Establishing	Intermittent	Establishing	Establishing
<a href="#">American Goldfinch</a> <sup>2</sup>		Vacating	Resident	Establishing

<sup>1</sup> See Figure 1 for examples of plots used for the above assessments.<sup>2</sup> Click on the species names for visualizations of data from Fort Leonard Wood. See [http://birdpop.org/DoD/leon/dod\\_leon\\_viz.htm](http://birdpop.org/DoD/leon/dod_leon_viz.htm) for more information.

Table 6. Estimates of adult annual survival and recapture probabilities and proportion of residents among newly captured adults using a time-constant model for 24 species breeding at the eight MAPS stations ever operated on Fort Leonard Wood obtained from 17 years<sup>1</sup> (1993-2009) of mark-recapture data.

Species	Num. sta <sup>2</sup>	Num. ind. <sup>3</sup>	Num. caps. <sup>4</sup>	Num. ret. <sup>5</sup>	Survival probability <sup>6</sup>	Surv. C.V. <sup>7</sup>	Recapture probability <sup>8</sup>	Proportion of residents <sup>9</sup>
Downy Woodpecker	7	113	130	12	0.594 (0.106)	17.9	0.254 (0.117)	0.287 (0.157)
Acadian Flycatcher	6	202	327	53	0.615 (0.048)	7.8	0.361 (0.062)	0.414 (0.100)
White-eyed Vireo	6	372	710	117	0.537 (0.038)	7.0	0.514 (0.054)	0.532 (0.085)
Red-eyed Vireo	7	348	433	50	0.526 (0.057)	10.8	0.276 (0.065)	0.532 (0.145)
Carolina Chickadee †	7	182	215	20	0.465 (0.091)	19.5	0.144 (0.080)	1.000 (0.577)
Carolina Wren	6	140	185	16	0.345 (0.094)	27.2	0.501 (0.178)	0.410 (0.190)
Blue-gray Gnatcatcher †	7	171	190	5	0.434 (0.190)	43.9	0.043 (0.071)	1.000 (1.652)
Blue-winged Warbler	5	506	778	125	0.585 (0.035)	5.9	0.381 (0.044)	0.450 (0.070)
Northern Parula †	7	108	119	7	0.626 (0.141)	22.6	0.048 (0.058)	1.000 (1.215)
Prairie Warbler	4	303	438	63	0.588 (0.049)	8.4	0.246 (0.051)	0.670 (0.157)
Black-and-white Warbler	6	146	169	9	0.436 (0.142)	32.4	0.367 (0.196)	0.209 (0.135)
American Redstart	2	160	222	38	0.627 (0.068)	10.8	0.336 (0.075)	0.530 (0.149)
Worm-eating Warbler	2	102	135	14	0.539 (0.107)	19.9	0.556 (0.154)	0.181 (0.087)
Ovenbird	6	157	213	24	0.629 (0.074)	11.7	0.282 (0.081)	0.310 (0.113)
Louisiana Waterthrush	2	83	146	24	0.513 (0.091)	17.7	0.579 (0.125)	0.510 (0.178)
Kentucky Warbler	6	443	759	134	0.635 (0.033)	5.1	0.460 (0.044)	0.366 (0.056)
Common Yellowthroat	4	301	568	89	0.460 (0.041)	8.9	0.593 (0.067)	0.499 (0.094)
Yellow-breasted Chat	5	657	1217	250	0.609 (0.025)	4.0	0.378 (0.030)	0.729 (0.077)
Summer Tanager	4	66	76	7	0.410 (0.160)	39.1	0.198 (0.183)	0.924 (0.937)
Eastern Towhee *†	6	63	75	4	0.661 (0.186)	28.1	0.045 (0.057)	1.000 (1.250)
Field Sparrow	4	466	700	97	0.459 (0.040)	8.7	0.321 (0.052)	0.797 (0.151)
Northern Cardinal	7	265	370	57	0.584 (0.052)	8.9	0.279 (0.057)	0.618 (0.148)
Indigo Bunting	7	932	1475	235	0.524 (0.026)	5.0	0.394 (0.035)	0.614 (0.070)
American Goldfinch †	4	241	288	15	0.359 (0.107)	29.8	0.118 (0.086)	1.000 (0.721)

<sup>1</sup> Analysis of all stations pooled include data from 1993-2009 from the Big Piney, Laughlin Bottoms, Miller Pond and Macedonia stations as well as data from 1993-2002 from the Smith Ridge and Miller stations and 2003-2009 from the Tilley Bottoms and Bradford Cemetery stations.

Table 5. (cont.) Estimates of adult annual survival and recapture probabilities and proportion of residents among newly captured adults using a time-constant model for 24 species breeding at the eight MAPS stations ever operated on Fort Leonard Wood obtained from 17 years<sup>1</sup> (1993-2009) of mark-recapture data.

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<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.

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

\* 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 ( $SE(\phi) \geq 0.200$  or  $CV(\phi) \geq 50.0\%$ )

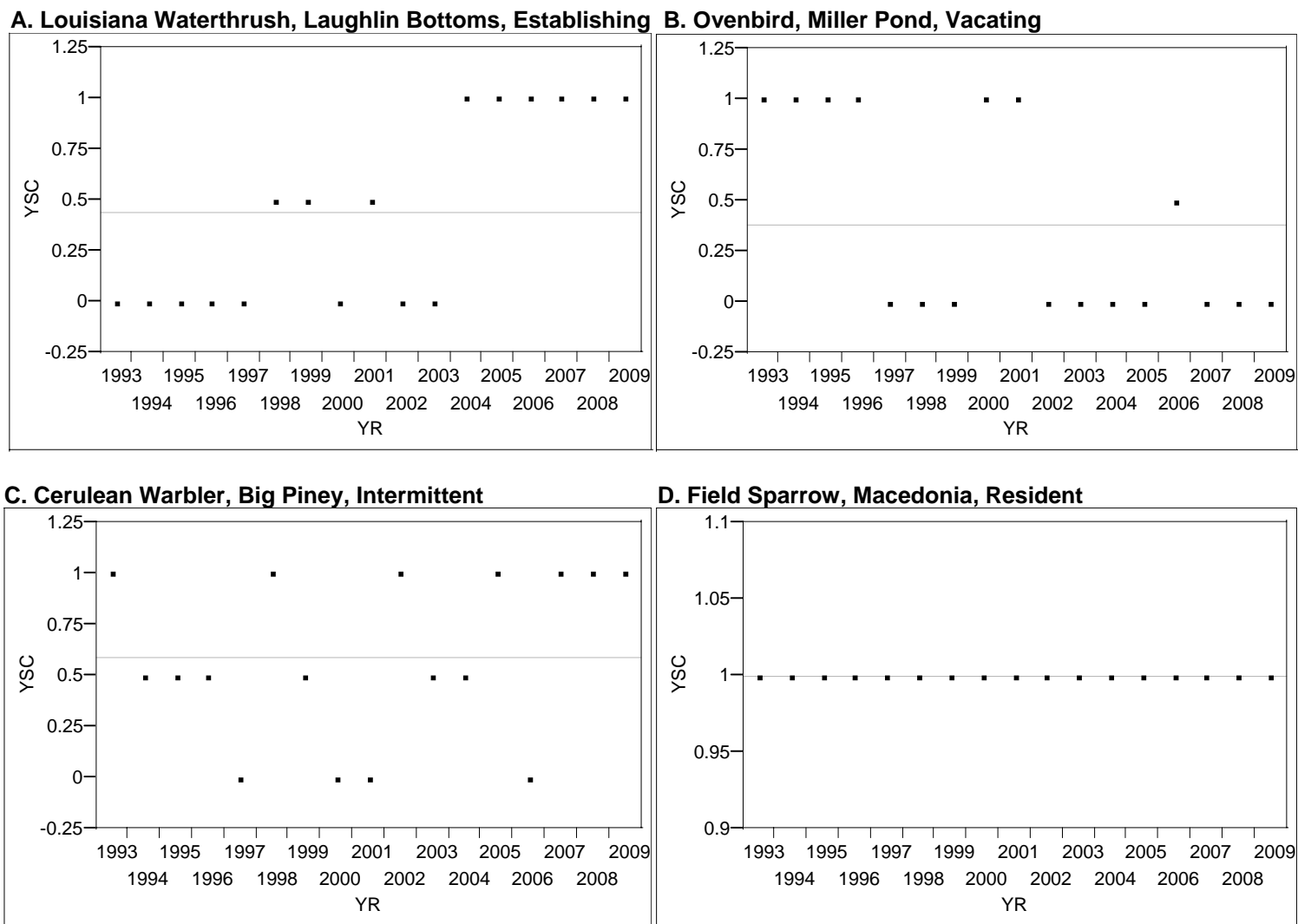


Figure 1. Examples of occurrence patterns at stations based on annual breeding status assessments (YSC) during the 17-year (1993-2009) period of the study at the four long-running stations. Confirmed breeding was scored as 1.0, probable or possible breeding was scored as 0.5, and transient or migrant status was scored as 0.0 for each species annually. Overall patterns for a species at a station were scored as Establishing (Example A), Vacating (Example B), Intermittent (Example C), or Resident (Example D). See Table 5 for species assessments at the four stations.

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 17 years, 1993-2009, of the MAPS Program on the seven stations operated on Fort Leonard Wood.

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	Big Piney (BIP)	Laughlin Bottoms (LABO)	Tilley Bottoms (TIBO)	Bradford Cemetery (BRCE)	Miller Pond (MIPPO)	Macedonia (MACE)	Miller Ridge (MIRI)	Smith Ridge (SMRI)
00130	PBGR	Pied-billed Grebe	T							
00950	AMBI	American Bittern		T						
01010	GBHE	Great Blue Heron	T	T	T	T	T	O	O	
01040	GREG	Great Egret	T				T			
01130	GRHE	Green Heron	T	T			T	O		
01300	TUVU	Turkey Vulture	O	O	T	T	O	O	O	O
01460	CANG	Canada Goose	T		T		T	T		
01570	WODU	Wood Duck	T			T	O	O		
01580	GADW	Gadwall					T	O		
01630	MALL	Mallard					T			
02015	UNDU	Unidentified Duck		?	?		?	?		
02130	BAEA	Bald Eagle	T							
02200	SSHA	Sharp-shinned Hawk	M		M			M		
02210	COHA	Cooper's Hawk		T		O		T	T	
02380	RSHA	Red-shouldered Hawk	O	O	O	T	O	U	U	O
02400	BWHA	Broad-winged Hawk		T	T	T	O	T	T	T
02460	RTHA	Red-tailed Hawk	O	O	O	T	T	T	T	
02545	UNHA	Unidentified Hawk					?	?		
02940	RUGR	Ruffed Grouse			T					
03040	WITU	Wild Turkey	O	O	T	T	U	O	O	O
03160	NOBO	Northern Bobwhite	U	U	T	T	U	O	O	T
03550	AMCO	American Coot	T	T						
03780	KILL	Killdeer					O	T		
04490	AMWO	American Woodcock	O	T			T			
05570	MODO	Mourning Dove	U	U	B	U	U	B	O	O
06400	BBCU	Black-billed Cuckoo	T	T	O		O			T
06410	YBCU	Yellow-billed Cuckoo	U	B	B	B	B	U	U	U
06680	EASO	Eastern Screech-Owl	T	T		T				
06800	GHOW	Great Horned Owl		T		T				
06950	BADO	Barred Owl	O	O	T	T	T	O	O	O
07080	CONI	Common Nighthawk					T			

## Appendix I. Continued.

NUMB	SPEC	SPECIES NAME	BIPI	LABO	TIBO	BRCE	MIPO	MACE	MIRI	SMRI
07170	CWWI	Chuck-will's-widow	T							
07230	WPWI	Whip-poor-will	T	O	T	T	T	O		
07400	CHSW	Chimney Swift	T	T	T	T	T	T	T	
08630	RTHU	Ruby-throated Hummingbird	U	U	B	U	U	U	O	O
08640	BCHU	Black-chinned Hummingbird						M		
08775	UNHU	Unidentified Hummingbird	?	?	?	?	?	?	?	
09110	BEKI	Belted Kingfisher	T	O	T		T	T		
09420	RHOW	Red-headed Woodpecker					T			
09550	RBWO	Red-bellied Woodpecker	U	U	U	O	O	U	U	O
09650	DOWO	Downy Woodpecker	U	U	U	U	B	U	U	U
09660	HAWO	Hairy Woodpecker	O	O	T	O	O	O	O	O
09800	YSFL	Yellow-shafted Flicker	O	O	T		T	O	O	
09860	PIWO	Pileated Woodpecker	B	B	B	U	O	U	U	U
09915	UNWO	Unidentified Woodpecker			?					
11340	OSFL	Olive-sided Flycatcher					M			
11390	EAWP	Eastern Wood-Pewee	B	U	O	B	U	U	U	U
11450	YBFL	Yellow-bellied Flycatcher	M	M	M			M		
11460	ACFL	Acadian Flycatcher	B	B	B	O	O	U	B	U
11475	TRFL	Traill's Flycatcher	O	T	T	T	T	T	O	T
11500	LEFL	Least Flycatcher		M						M
11530	DUFL	Dusky Flycatcher					M			
11595	UEFL	Unidentified Empidonax Flycat.	?	?	?	?	?	?	?	
11610	EAPH	Eastern Phoebe	U	O	O	O	U	O	O	O
11760	GCFL	Great Crested Flycatcher	U	O	T	T	O	T	O	O
12030	EAKI	Eastern Kingbird	T	T			O	O		
12085	UNFL	Unidentified Flycatcher	?	?		?	?	?	?	
12550	WEVI	White-eyed Vireo	B	B	B	B	B	U	U	O
12690	YTVI	Yellow-throated Vireo	U	O	O	U	T	T	U	T
12780	PHVI	Philadelphia Vireo					M			
12790	REVI	Red-eyed Vireo	B	B	B	B	U	B	B	B
12930	BLJA	Blue Jay	U	U	U	U	B	U	U	B
13190	AMCR	American Crow	U	U	B	U	B	B	B	B
13340	PUMA	Purple Martin	T	T	T	T	T	T		
13490	NRWS	Northern Rough-winged Swallow	T	T	T		T	O		
13540	BARS	Barn Swallow	T		T	T	T	T		
13560	CACH	Carolina Chickadee	U	B	B	B	B	B	U	U
13565	CBCC	Carolina X Black-c. Chick.Hybrid				T	T			
13570	BCCH	Black-capped Chickadee	T	O	T		O	O	O	
13575	UPCH	Unidentified Poecile Chickadee	?	?	?	?	?	?		
13660	TUTI	Tufted Titmouse	B	B	B	B	B	B	B	U
13700	WBNU	White-breasted Nuthatch	B	O	T	T	O	O	U	U
14000	CARW	Carolina Wren	B	U	B	U	U	U	U	O

## Appendix I. Continued.

NUMB	SPEC	SPECIES NAME	BIFI	LABO	TIBO	BRCE	MPO	MACE	MIRI	SMRI
14040	BEWR	Bewick's Wren		T		T	O			T
14070	HOWR	House Wren		T	T		T	O		
14205	UNWR	Unidentified Wren					?			
14350	BGGN	Blue-gray Gnatcatcher	U	B	B	B	B	B	U	U
14560	EABL	Eastern Bluebird	T	T		T	O	O		
14780	VEER	Veery						M	M	M
14790	GCTH	Gray-cheeked Thrush	M	M	M					M
14810	SWTH	Swainson's Thrush	M	M	M	M	M	M		M
14830	WOTH	Wood Thrush	B	O	O	T		U	U	O
15000	AMRO	American Robin	T	O	T	T	O	O		
15130	GRCA	Gray Catbird	T	O	O	O	O	T		T
15150	NOMO	Northern Mockingbird					O			
15200	BRTH	Brown Thrasher	O	O	U	T	O	T		
15370	EUST	European Starling						T		
15550	CEDW	Cedar Waxwing	T	O	T	T	T	T		T
15630	BWWA	Blue-winged Warbler	B	B	B	B	B	U	O	
15640	GWWA	Golden-winged Warbler		T						
15650	TEWA	Tennessee Warbler	M							
15670	NAWA	Nashville Warbler							M	
15730	NOPA	Northern Parula	B	B	B	B	U	U	B	U
15750	YWAR	Yellow Warbler	T	T			T			
15760	CSWA	Chestnut-sided Warbler				M				
15770	MAWA	Magnolia Warbler		M	M	M	M			
15870	YTTA	Yellow-throated Warbler	U	O	O		O			
15910	PIWA	Pine Warbler		T		T	T		T	O
15930	PRAW	Prairie Warbler		U	B	B	B	U		
15980	CERW	Cerulean Warbler	U	O	T				O	
16030	BAWW	Black-and-white Warbler	U	U	B	B	U	U	U	O
16040	AMRE	American Redstart	B	U	O			O	O	
16050	PROW	Prothonotary Warbler	O	T						
16060	WEWA	Worm-eating Warbler	B	O	T	T	T	O	U	O
16080	OVEN	Ovenbird	U	U	B	O	O	B	B	B
16090	NOWA	Northern Waterthrush	M	M			M			
16100	LOWA	Louisiana Waterthrush	B	U			T	O	O	
16110	KEWA	Kentucky Warbler	B	B	B	B	U	U	U	T
16130	MOWA	Mourning Warbler	M	M	M		M			
16150	COYE	Common Yellowthroat	U	B	B	U	B	O	O	T
16280	HOWA	Hooded Warbler					T			
16290	WIWA	Wilson's Warbler		M	M	M	M			
16300	CAWA	Canada Warbler	M	M	M			M		
16460	YBCH	Yellow-breasted Chat	U	B	B	B	B	U	O	T
16495	UNWA	Unidentified Warbler	?	?			?		?	?

## Appendix I. Continued.

NUMB	SPEC	SPECIES NAME	BIFI	LABO	TIBO	BRCE	MIPO	MACE	MIRI	SMRI
16820	SUTA	Summer Tanager	O	O	O	B	U	U	U	B
16830	SCTA	Scarlet Tanager	T	T	T	T	O	O	O	O
17820	EATO	Eastern Towhee	U	B	B	B	B	B	U	T
18020	CHSP	Chipping Sparrow	T	O		O	O	O		O
18050	FISP	Field Sparrow	T	B	B	B	B	B		
18090	LASP	Lark Sparrow					T			
18140	GRSP	Grasshopper Sparrow						T		
18160	HESP	Henslow's Sparrow				T				
18240	LISP	Lincoln's Sparrow		M						
18335	UNSP	Unidentified Sparrow		?						
18560	NOCA	Northern Cardinal	B	B	B	B	B	B	B	U
18600	RBGR	Rose-breasted Grosbeak		T				T		
18640	BLGR	Blue Grosbeak	T			T	O	T		
18670	INBU	Indigo Bunting	B	B	B	B	B	B	B	U
18730	RWBL	Red-winged Blackbird	O			T	O	U		
18800	EAME	Eastern Meadowlark	T	T			T	T		
18870	COGR	Common Grackle		T		T	T	T		
18960	BHCO	Brown-headed Cowbird	U	O	U	U	B	U	O	O
19040	OROR	Orchard Oriole	T	O			O			
19160	BAOR	Baltimore Oriole		T			T			
19370	HOFI	House Finch				T		T		
19510	AMGO	American Goldfinch	O	U	B	B	B	U	O	O
20085	UNBI	Unidentified Bird		?		?	?			?