Department of Defense
Legacy Resource Management Program

PROJECT 06-186

Modeling Over-wintering Survival of Declining Landbirds

Final Report on Four Years of the Monitoring Avian Winter Survival (MAWS) Program on Southeastern U.S. DoD Installations

James F. Saracco, David F. DeSante, and Danielle R. Kaschube

THE INSTITUTE FOR
BIRD POPULATIONS

11435 State Route One, Suite 23
P.O. Box 1346
Point Reyes Station, CA 94956-1346

jsaracco@birdpop.org Voice: 415-663-2054
ddesante@birdpop.org Voice: 415-663-2052
Fax: 415-663-9482

February 5, 2008

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

EXECUTIVE SUMMARY

Many landbird species that overwinter in temperate North America are declining. Effective conservation and management of these species will require precise estimates of their population densities, vital rates, and population growth rates, and a basic understanding of how these parameters vary across space and in relation to specific habitat features and management actions. Broad-scale monitoring of demographic parameters during the breeding season is well-established (The Monitoring Avian Productivity and Survivorship [MAPS] program). Yet many bird populations may be limited by factors acting during the non-breeding season. Complimentary monitoring efforts during the non-breeding season can lend further insight into causes of avian population changes and the habitat characteristics that promote stable and increasing populations.

In an effort to better understand the ecology of temperate-wintering landbirds in the United States, and to identify habitat features and management actions associated with their body condition, winter site persistence, and between-year apparent survival, The Institute for Bird Populations initiated the Monitoring Avian Winter Survival program (MAWS) in 2003. The four-year pilot phase of this project has been supported by the DoD Legacy Resources Management Program, and the first 24 MAWS monitoring stations were established on four military installations in the southeastern U.S. during the winter of 2003-04. Many of the bird species monitored by MAWS are declining species that inhabit edge, shrub, and grassland habitats. Because these habitats are also favored for military training activities, MAWS offers a unique opportunity to develop management prescriptions that benefit declining bird populations and the military's mission of Readiness and Range Sustainment.

Here we summarize monitoring data collected during the four-year pilot MAWS project. We focus on 10 bird species that were widely distributed at the 24 MAWS stations and were captured and recaptured in large numbers. These focal species inhabit a broad range of forested, edge, and shrubland associated habitat types and populations of most of them have significantly declined over the past 40 years. Our objectives are to: (1) summarize bird captures and examine annual changes in capture rates at each of the four installations, (2) summarize field (station-scale) and satellite-derived (1-km radius land cover) habitat data collected at each MAWS station, (3) model body condition and survival as functions of bird age-class and local and landscape habitat features, (4) compare body condition and survival among installations and age-classes, (5) summarize behavioral data collected at the two Arkansas installations during January-March 2007, and (6) provide management guidelines based on habitat models.

Through four years of the pilot MAWS project we have met or exceeded all mist-netting effort goals for each of the four southeastern DoD installations. This effort has yielded more than 20,000 banded birds of 70 species and more than 6,000 between-pulse recaptures. These data indicate high variation in bird abundance (as indexed by capture rates), body condition, and apparent survival (site persistence and site fidelity) of birds among geographic areas (installations) and years.

Habitats differed among installations. Forests at the Arkansas installations were primarily deciduous; those at Ft. Benning tended to be mixed coniferous/deciduous; and those at Ft. Bragg were primarily coniferous (pine). All stations contained a mixture of forested, edge, and open habitats. Fort Chaffee contained the least-forested stations. Ft. Benning had the greatest land cover diversity. We derived three habitat variables for use in the body condition and survival

analyses using a principal components analysis and varimax rotation on the first three axes of this analysis. This ‘data reduction’ successfully captured 52% of the variation in habitat data.

Body condition of nine focal species was strongly related to at least one of the three habitat variables. Body condition was typically highest at the Arkansas installations and lowest at Fort Benning. Body condition tended to increase as a function of increased patch size, decreased patch diversity, greater deciduous cover, decreased mixed and evergreen forest, greater grassland/herbaceous edge and decreased numbers of cultivated crop patches. The pattern in habitat quality suggested by the body condition analysis was not (entirely) borne out by the survival analysis. Evidence for differences in apparent survival among installations was strong for only one focal species, Song Sparrow. The pattern in apparent survival for this species, however, differed between the over-wintering season (lowest at Ft. Benning, highest at Ft. Bragg) and between-year (highest at Ft. Benning, lowest at Ft. Bragg) period. Apparent survival of two additional species that didn’t show strong installation effects appeared to respond strongly to habitat: Tufted Titmouse and Ruby-crowned Kinglet. Between-year apparent survival of Tufted Titmouse (particularly young birds) tended to be greater at sites with relatively high urban development (possibly due to increased feeders or cover around developments). Ruby-crowned Kinglet over-wintering apparent survival appeared to be greater at sites with greater habitat heterogeneity, including mixed and evergreen forest, shrub/scrub, and woody wetlands.

As a major cooperating partner in the Neotropical Migratory Bird Conservation Initiative, Partners in Flight (PIF), and the North American Bird Conservation Initiative (NABCI), the DoD can play an important role in managing winter habitat for migratory bird species. This role is facilitated by the fact that many migratory species that overwinter on these installations likely benefit from management actions that are applied to enhance the military mission of Readiness and Range Sustainment. Results of the pilot MAWS program can assist DoD land managers by providing specific data on winter habitat quality for many declining landbird species that overwinter on DoD land. Models and avian management guidelines deriving from the MAWS project can also aid in the develpment of Integrated Natural Resources Management Plans (INRMP) for each installation. We are very pleased with the accomplishments of the pilot MAWS program. Given the large potential role that the wintering grounds play in the population dynamics of North American landbirds, we suggest that growth of the program to span broad habitat gradients within relatively small regions (e.g., PIF Physiographic Areas or NABCI Bird Conservation Regions) and the integration of the program into testing for effects of current and planned management actions on wintering bird populations should be a priority of future landbird conservation efforts in North America.

INTRODUCTION

Many landbird species that overwinter in temperate North America are declining; particularly short-distance migrants and species that inhabit shrublands and grasslands (Brennan and Kuvlesky 2005). Indeed, North American Breeding Bird Survey (BBS) data suggest that most grassland species, about one third of scrub/successional species, and more than one quarter of woodland species that overwinter largely in the United States or Canada have significantly declined over the past 40 years (Sauer et al. 2006). Unfortunately, little is known regarding proximate (demographic) or ultimate (environmental) causes of these declines.

Effective conservation and management of temperate-wintering landbirds will require precise estimates of their population densities, vital rates, and population growth rates, and a basic understanding of how these parameters vary across space and in relation to specific habitat features and management actions (DeSante and Rosenburg 1998, DeSante et al. 2005a). Broad-scale monitoring of demographic parameters during the breeding season is well-established (DeSante et al. 1995, 2004). Yet many bird populations may be limited by factors acting during the non-breeding season (Marra et al. 1998, Sillett et al. 2000, DeSante et al. 2001, Nott et al. 2002). Complimentary monitoring efforts during the non-breeding season can lend further insight into causes of avian population changes and the habitat characteristics that promote stable and increasing populations (Sandercock and Jaramillo 2002; DeSante et al. 2005b).

Adult survival may be the key demographic component driving population trends of many bird species (Sæther and Baake 2000), and so may be the best metric for gauging habitat quality (Crone 2001). Much of the mortality of temperate-wintering birds likely occurs during the over-wintering period when food resources scarce (Newton 1998). Winter mortality may be especially important in limiting populations of small passerine species (Cawthorne and Marchant 1980). Few data exist, however, on within-winter site persistence or between-winter apparent survival (both of these measures incorporate survival and site fidelity) of temperate-wintering landbirds in North America (Piper 1990, Piper and Wiley 1990, Sandercock and Jaramillo 2002).

In an effort to better understand the ecology of temperate-wintering landbirds in the United States, and to identify habitat features and management actions associated with their body condition, winter site persistence, and between-year apparent survival, The Institute for Bird Populations initiated the Monitoring Avian Winter Survival program (MAWS) in 2003. The pilot phase of this project has been supported by the DoD Legacy Resources Management Program, and the first 24 MAWS monitoring stations were established on four military installations in the southeastern U.S. during the winter of 2003-04. Many of the bird species monitored by MAWS are declining species that inhabit edge, shrub, and grassland habitats; these habitats are also favored for military training activities. Thus, MAWS offers a unique opportunity to develop management prescriptions capable of enhancing both bird populations and the military's mission of Readiness and Range Sustainment (R&RS).

Here we summarize monitoring data collected during the four-year pilot MAWS project. We focus on 10 bird species that were widely distributed at the 24 MAWS stations and were captured and recaptured in large numbers. These focal species inhabit a broad range of forested, edge, and shrubland associated habitat types and populations of most of them have significantly declined over the past 40 years. Our objectives are to: (1) summarize bird captures and examine annual changes in capture rates at each of the four installations, (2) summarize field (station-scale) and satellite-derived (1-km radius land cover) habitat data collected at each MAWS station, (3) model body condition and apparent survival as functions of bird age-class and local and landscape habitat features, (4) compare body condition and apparent survival among installations and age-classes, (5) summarize behavioral data collected at the two Arkansas installations during January-March 2007, and (6) provide management guidelines based on habitat models.

METHODS

Study Areas

Twenty-four Monitoring Avian Wintering Survival (MAWS) stations were established on Fort Chafee, AR, Camp Joseph T. Robinson, AR, Fort Bragg, NC, and Fort Benning, GA during 2003-04 (Table 1; Fig. 1), and were operated during four winters between 2003 and 2007. Each MAWS station consisted of a study area of approximately 20 ha. Stations were selected to represent a range of habitats used by common wintering sparrows, including shrubland and forest- and woodland-edge.

Focal Species

We selected 10 focal species based on their having large numbers of captures (in the top 12 species banded) and recaptures (> 1/3 as many pulse-unique recaptures as the number of individuals banded) and being widely distributed among MAWS stations (Table 2). These species showed a variety of population trends (6 significantly declining, 3 significantly increasing, and one species with no significant change according to 40 years of BBS data) and occupied a variety of habitat types (ranging from predominantly forest species to predominantly edge/open species). In earlier annual reports we presented data on an expanded set of species; however, data were too sparse for most of those species to offer meaningful insights into spatial and habitat-related variation on body condition or apparent survival, which is the main focus of the results presented here.

Collecting Mark-recapture Data

The 24 MAWS stations were operated according to the MoSI (Monitoreo de Sobrevivencia Invernal) protocol (DeSante et al. 2005b), which was developed as part of an earlier project funded by the DoD Legacy Resources Management Program on Naval Station Guantanamo Bay, Cuba (Siegel et al. 2004). The MoSI protocol consists of five monthly pulses of mist netting and banding between November and March. Each pulse consisted of 2-3 consecutive (or nearly-consecutive) days of field work during one of five 30-day periods (Period 1: Nov 2-Dec 1; Period 2: Dec 2-31; Period 3: Jan 1-30; Period 4: Jan 31-Mar 1; and Period 5: Mar 2-31). To accommodate time off for Christmas/New Years' Day holidays, we allowed stations to be operated within five days periods of the first or last day of a period.

Sixteen 12-m long, 30-mm mesh mist nets were erected at permanent net sites within the central 12 ha of each station. We attempted to operate all nets for six morning hours (beginning at about local sunrise or up to 1 hr later on especially cold mornings) on three consecutive days during each banding period. If realized, this protocol would have resulted in the accumulation of 1,728 net-hours per installation per year. Nevertheless, inclement weather (precipitation and wind) and the movement of stations during the first season (2003-04) precluded our meeting this level of effort. Despite our crews erring on the side of bird safety, we have achieved 40 % of the maximum net-hours in 2003-04 and more than 60% of the maximum effort in subsequent seasons (Table 2). On each day of station operation, all nets were opened, closed, and if possible, checked in the same order. Banding effort (i.e., the number and timing of net-hours recorded to the nearest 10 min) and resighting effort (in winters of 2005-06 and 2006-07; see below for detail) were carefully recorded during all station visits.

Unmarked birds captured in mist nets were banded with uniquely numbered, USGS-Bird Banding Laboratory (BBL) metal leg bands; band numbers of recaptured birds were carefully recorded. All birds captured were identified to species, age (first winter = hatching-year or "HY" [before Jan 1]/second-year [after Dec 31] versus adult = after-hatching-year or "AHY" [before Jan 1]/after-second-year [after Dec 31]), and, if possible, sex (based on Pyle 1997). Age determinations were based largely on molt limits (or lack thereof) and plumage characteristics. We recorded ancillary data that were also sometimes useful for age determinations; these included extent of skull pneumaticization, body and flight feather molt, and extent of primary-feather wear. We measured the unflattened wing chord (to the nearest 1 mm), body weight (to 0.1 g), and fat score (based on a scale that ranged from 0 [no fat] to 5 [continuous bulging fat]) of each captured bird. In situations where bird safety might have been compromised (e.g., exceptionally high capture rates or sudden onset of severe weather), we released birds immediately upon capture (before banding and processing). Finally, we recorded the date, time of capture, station, and net number for all captures.

In an effort to increase the precision of apparent survival-rate estimates, we began color banding and re-sighting six target species during the 2004-05 season: Field Sparrow, Fox Sparrow, Song Sparrow, Swamp Sparrow, White-throated Sparrow, and Dark-eyed Junco (see Appendix for scientific names). Color-band combinations included two plastic color bands on one leg and one color band and the USGS-BBL band on the other leg. Resighting effort was considerable but variable during the 2004-05 season. Based on preliminary analysis of the efficacy of those efforts (DeSante et al. 2005c), we reduced the number of target species to three for the 2005-06 and 2006-07 seasons: Song Sparrow, White-throated Sparrow, and Dark-eyed Junco (scientific names listed in Appendices 1-4). In addition, two observers conducted intensive resighting efforts on color-banded birds in Jan-Mar 2007 at the two Arkansas installations (see 'Behavioral Observations' below).

Computer entry of banding data was completed by John W. Shipman of Zoological Data Processing, Socorro, NM. 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. Entered data were run through a series of verification programs. These programs flagged suspicious codes and records to help ensure that: (1) all codes and values were valid; (2) date and net field values in banding and effort files matched; (3) species, age, and sex determinations agreed with associated ancillary data (e.g., molt limits and plumage characteristics, degree of skull pneumaticization, extent of body and flight-feather molt, primary-feather wear); (4) no unusual or duplicate band numbers or unusual band sizes were included in the database; and (5) species, age, and sex determinations were consistent for each band number among pulses and years. Discrepancies or suspicious data identified by any of these programs were examined manually and corrected if necessary. Wing chord, body weight, station of capture, date, and any pertinent notes were used as supplementary information for the correct errors in species, age, and sex determinations.

Residency Status Lists

Residency status of all bird species seen or heard on each study area was recorded on each visit in a manner similar to that used in bird atlas projects (categories included: confirmed resident [from recapture data], probable resident, visitor). These Residency Status Lists (RSLs) provide another means (in addition to mark-recapture data) of monitoring the site occupancy of bird species at MAWS stations throughout the winter season. By incorporating information on bird behavior, the RSL also helps determine whether a particular species is a resident at the site.

Cumulative observations at a station within a MAWS season were used to designate each species as either “resident” or “observed” at that station. Resident species are defined as those observed on the study area throughout the winter period. Territoriality noted during at least two pulses or repeated observations of individual birds at particular locations were taken to be good indicators of residency. Observed species are defined as those that were encountered during only one or two pulses (particularly the November and March pulses) and exhibiting no signs of territoriality.

Residency status across seasons was determined for each species at each MoSI station based on cumulative residency determinations across years. Species present as residents in all years were designated “regular residents” (RR); residents in > ½ of all seasons were designated “usual residents” (UR); and residents in ≤ ½ of all seasons were designated “occasional residents” (OR). Species encountered at stations within their normal winter range but not showing evidence of residency were designated “transients” (TR), while species encountered outside of their wintering range were designated “migrants” (MI).

Weather Data

On each visit to study sites, we recorded temperature (°C), wind (Beaufort scale), and precipitation at the beginning of the day (time of net opening), approximately three hours after net opening, and at the time of net closing.

Local Habitat Data

We assessed habitat structure and plant community composition at each station during February in 2005, 2006, and 2007 (during the time when resources for birds were thought to be at a minimum). First, we traversed each station (the boundaries of which were defined as the area contained within 50 m of each net site) to determine the number of major habitat types present and to create habitat maps that delineate habitat-type boundaries. We visually estimated cover within each of four vegetation layers (ground, shrub, subcanopy, canopy) for each station and major habitat type using 11 cover classes (%): < 5, 5-15, 15-25, 25-35, 35-45, 45-55, 55-65, 65-75, 75-85, 85-95, >95. The number of snags in two layers (subcanopy and canopy) was indexed for each station and habitat type using three categories: < 5 snags, 5-15 snags, or > 15 snags. We produced lists of dominant species in each major habitat type and vegetation layer and described other habitat components such as successional stage and/or age of each habitat, moisture regime and presence of water, homogeneity of vegetative cover, characteristics of edges between habitat types, and any natural- or human-caused disturbances and management history.

For each station, season, and vegetation layer; we computed weighed-average percent coverages (using midpoints of cover classes and weights equal to the proportions of each habitat type present) and a weighted-average index of snag abundance. We collapsed habitat-type designations determined in the field into on of five broad classes because these designations differed somewhat among stations, installations, and seasons. These classes included: (1) open (i.e., cropland, grassland, and other mostly herbaceous habitats), (2) shrub/scrub (i.e., habitats dominated by woody vegetation of short stature), (3) deciduous forest, (4) evergreen forest, and (5) mixed forest. We then averaged the weighted-average cover and snag index values across seasons to obtain a single value for each variable.

Landscape Habitat Data

We used 1-km radius 30-m resolution data from the 2001 National Land Cover Dataset (NLCD) (Homer et al. 2007). Although the satellite imagery used for these classifications were obtained prior to the initiation of the MAWS study (circa 2001), land cover classifications and boundaries closely matched composite images obtained within the time frame of our study (© DigitalGlobe images on Google Earth® [http://earth.google.com] between 2002 and 2005). We considered 13 land cover classes (based on classification of Homer et al. 2007): (1) open water, (2) developed open space (primarily lawns, golf courses), (3) developed low-high intensity (buildings and other impervious surfaces), (4) barren land/ unconsolidated shore, (5) deciduous forest (> 75% deciduous trees > 5 m tall with > 20% cover), (6) evergreen forest (> 75% coniferous trees > 5 m tall with > 20% cover), (7) mixed forest (trees > 5 m tall and covering > 20% of area; neither conifers nor deciduous trees predominate), (8) shrub/scrub (woody plants < 5 m tall covering > 20% of area), (9) grassland/herbaceous (graminoid or herbaceous cover on > 80% of area; relatively 'unmanaged'), (10) pasture/hay (herbaceous; > 20 % of cover planted for livestock), (11) cultivated crops (actively tilled areas; annual crops planted accounting for > 20% of area), (12) woody wetlands (> 20 % of area with submerged or saturated soil [ephemeral or permanent] and shrub/scrub or forest vegetation), and (13) emergent herbaceous wetlands (> 80% of area with submerged/saturated soil [ephemeral or permanent] and herbaceous vegetation).

We used the computer program FRAGSTATS (McGarigal and Marks 1995) to calculate metrics of land cover pattern and structure at the 1-km (landscape) scale. Because land cover metrics are often highly correlated (Ritters et al. 1995), and because only one or a few explanatory variables could be included in any single regression or capture-recapture model (see below), we only considered a (relatively) small set of landscape variables. Two variables described composite aspects of all land cover classes ("landscape metrics" of McGarigal and Marks 1995): (1) Shannon Diversity Index (SHDI) and (2) Aggregation Index (AI). Although strongly correlated (r = - 0.76), SHDI and AI each provide unique information regarding landscape structure. SHDI reflects the number of land cover classes and their evenness of distribution (increasing with greater patch diversity), while AI reflects the spatial distribution of land cover patches (increasing with clumping of patches). Additionally, we considered three metrics that described aspects of individual land cover classes: (1) class area (CA; in m^2), (2) number of patches (NP), and (3) total edge (TE; in m). We considered each of these metrics for all of the land cover classes except open water (only edge considered) and barren land/unconsolidated shore (none considered).

Behavioral Observations

We collected detailed behavioral data on color-banded Song Sparrows, White-throated Sparrows, and Dark-eyed Juncos. Observations were conducted on 54 days (4-5 days per station) during January-March 2007. Effort was evenly distributed among the 12 Arkansas MAWS stations. Observations were initiated from a random starting point on each station visit at approximately local sunrise. Stations were systematically traversed while listening and looking for activity of target species. In general, the activity of target species was used to guide movement through the study area, although we attempted to cover stations completely and relatively evenly on each station visit. Whenever an individual of a target species was detected, it was checked for color bands using binoculars or a spotting scope. For each color-banded bird observed actively foraging, we recorded species identity, color combination, location on the study area, whether the bird was part of a flock (and flock composition), interactions with other birds (including species identity of bird that was interacted with), number of feeding pecks, and the duration of continuous observation. We also recorded foraging substrates (ground, grass/herb, shrub, or tree) and details of agonistic interactions (which bird initiated interaction and outcome). All observations were recorded using a digital voice recorder and later transcribed and entered into the computer.

Data Summaries and Analyses

Mark-recapture summary

We summarized capture rates (birds*100 net-hours^{-1}) for each installation and year for each of the10 focal species and for all species combined. Summaries represent averaged (across stations) capture rates per pulse of newly-captured birds and pulse-unique recaptures. We tested for differences in capture rates among years for each target species and installation using one-way ANOVAs (stations served as replicates). Assumptions of equal variances (Levene's Test $P > 0.05$) were met in all cases (Sokal and Rohlf 1995). For ANOVA models with statistically-significant year effects, we compared all means using Tukey's HSD tests (using JMP for Windows v. 7.0.1, SAS Institute, Cary, NC).

Habitat data reduction

Because bird and habitat data were only available for a maximum of 24 stations for a given focal bird species, we needed to reduce the dimensionality of habitat data for inclusion in bird-habitat models. We did so by conducting a principal components analysis (PCA) on the 47 local and landscape habitat variables (described above), and then using a varimax rotation on three axes to best explain axes of variation in terms of the original variables (using JMP for Windows v. 7.0.1, SAS Institute, Cary, NC). Scores on these three axes for each of the 24 MAWS stations were used as habitat variables. This procedure enabled us to analyze strongly correlated habitat variables simultaneously (see below).

Body condition

In an earlier report (Saracco et al. 2006), we considered the ratio of weight to wing length (e.g., as in Latta and Faaborg 2002) during the last (March) pulse as an index of body condition. We limited consideration to the last pulse because we hypothesized that conditions may be harshest during that time. However, winter temperatures during the study were lowest during the middle pulses (Dec.-Feb.), and conditions may have also been stressful earlier in the season (Nov.) when (migratory) birds may have recently arrived from breeding or post-breeding areas. Furthermore, by limiting ourselves to only using data from the final banding pulse, we ignored the bulk of the data, which might have been used to provide useful information on body condition and greater power to detect differences in body condition among locations and relationships between body condition and habitat variables. Thus, for this year's report, we took a different approach in order to best utilize all of the information available.

To obtain station-level indices of body condition for each focal species, we first extracted the residuals from a multiple linear regression of body weight (individual captures considered replicates) on a maximum of five predictor variables: wing chord length (a continuous variable measured to the nearest 1 mm) season (3 indicator variables for the four seasons), time of day (a continuous variable measured to the nearest 10 min), day of season (a continuous variable beginning at the earliest date of first banding), and temperature (in °C; the mean of three measurements taken on each banding day). We conducted this analysis on three subsets of the data: all records (with complete data), records of birds aged as adults (AHY until Dec. 31, ASY afterwards), and records of birds aged as young (HY until Dec. 31; ASY afterwards). We considered a quadratic term for time of day in models as scatterplots suggested curvilinear relationships. We eliminated non-significant ($P < 0.05$) terms in a backwards stepwise fashion to obtain the final model for each species. We did not consider interaction terms primarily to maintain simplicity; exploration of interaction terms for a few species suggested they added little explanatory power (minimal increases in R^2). Once an index was obtained for each capture, we calculated a mean residual score for each species-station combination.

We used one-way ANOVAs to test for differences in body condition among installations. We used multiple linear regression to model station-level body condition as a function of the three habitat principal components (see "Habitat data reduction", above). We eliminated non-significant ($P >$ 0.05 variables in a backward stepwise fashion. To examine the composite response of the suite of 10 focal species to various habitat features, we ranked body condition for each species (highest body condition = highest rank) and examined simple linear or quadratic regressions of the mean rank across the 10 species and each of the individual local and landscape habitat features.

Apparent Survival

We conducted modified Cormack-Jolly-Seber (CJS) mark-recapture analyses (Pollock et al.1990, Lebreton et al.1992) for each of the 10 focal species using data from 3-5 (depending on station) pulses of mist netting (one during each of the five 30-day capture periods defined above) during the winter of 2003-04 and five pulses during the winters of 2004-05, 2005-06, and 2006-07. We used the computer program MARK (White and Burnham 1999) to estimate effects of habitat variables on monthly apparent survival rates (ϕ) and recapture probabilities (p) and to estimate installation- station- and year-specific monthly apparent survival rates. Apparent survival rate is the probability of a marked (banded) bird surviving between monthly (30-day) netting pulses and remaining at the station at which it was first captured. Recapture probability refers to the probability of recapturing (or resighting) a bird at a station subsequent to the period in which it was banded, given that it survived and remained at the station where it was banded. A minimum of three capture sessions (pulses) is required to estimate both recapture probability and apparent survival rate. With three MAWS seasons completed, we have now accumulated data from 18-20 capture sessions (pulses) at each of the 24 stations.

As in the 2006 MAWS report (Saracco et al. 2006; but not in earlier reports [DeSante et al. 2005b, DeSante and Kaschube 2004]), we do not allow for 'transient' effects (Nott and DeSante 2002, Hines et al. 2003) in survival models. Although such models do effectively reduce bias associated with non-resident individuals, they may not be appropriate for winter studies conducted largely outside of the main migratory periods because individuals that attempt to settle at a station but soon move on (e.g., because they cannot acquire sufficient resources or are competitively excluded) would not contribute to apparent survival-rate (i.e., site persistence) estimates when, in fact, they should.

We conducted two sets of mark-recapture analyses (Table 4). Following Burnham and Anderson (1998), we first created *a priori* lists of modified CJS models. Because eight months elapsed between the final (March) and first (November) capture sessions of each field season, and because those eight months included spring migration, the breeding season, the prebasic molting period, and fall migration, we always modeled apparent survival rate as a function of season, where monthly apparent survival rate between November and March (over-wintering survival) was allowed to differ from monthly apparent survival rate between March and November. For the first set of analyses, we modeled installation-scale monthly apparent survival rates and recapture probabilities as functions of age (HY/SY vs. AHY/ASY; birds of unknown age in their initial year of capture did not enter into the analysis unless captured in subsequent years), installation, and year. We considered all combinations of these variables (including interaction terms), such that a total of 64 models was considered. In the second set of analyses, we modeled station-specific monthly apparent survival rates and recapture probabilities as functions of age and the three composite (principal component) habitat variables. We only considered interaction terms between age and season and the three habitat variables (i.e., we did not consider interactions between habitat variables) in an effort to limit the numbers of parameters estimated (thus increasing the precision of remaining parameter estimates). We only considered habitat models that included all three habitat variables together, such that 16 station-level age/habitat models were constructed for each species.

We compared survival models using Akaike's Information Criterion (AIC_c; adjusted for small sample size; Burnham & Anderson 1998) after adjusting for overdispersion of the capture-recapture data. The overdispersion parameter, *c*, was estimated using the bootstrap goodness-of-fit test included in Program MARK (Cooch and White 2002). The $\hat{c}$ was calculated by dividing observed deviance by the mean deviance of simulated models. This value was then used to adjust AIC_c values, producing a new, more conservative model selection criteria, $QAIC_c$. Relative model likelihoods in each of the two analyses were estimated with $QAIC_C$ weights (w_i; Burnham & Anderson 1998). Statistical support for models including particular explanatory variables (e.g., installation) was assessed by summing the w_i values for all models in which the variable of interest was included. We obtained best estimates of monthly apparent survival and recapture probability (and standard errors and 95% confidence intervals) using model averaging. Slopes of linear relationships between habitat variables and apparent survival were obtained from best-fit models.

Behavioral observations

We summarized agonistic interactions (across the entire study) and feeding rates (at the station scale) and from behavioral observations. We tested for differences in feeding rates among stations with one-way ANOVAs and tested for differences between all pairs of stations using Tukey's HSD tests. Despite having just three pulses of observational data from 12 stations, we conducted exploratory analyses to examine correlation between feeding rate and body condition. We indexed body condition as the station-level mean of the residuals from a regression of weight on wing chord (using only data from the Arkansas installations during Jan-Mar 2007). For feeding rate, we used the mean feeding rate across individuals. We weighted correlations with the mean proportion of observations represented by the body condition and feeding rate summaries.

RESULTS

Mark-recapture Summary

We banded 20,642 individual birds of 70 species and recorded 6,042 pulse-unique recaptures (i.e., recaptures of individuals a pulse other than the one in which they were banded) during the 4-yr MAWS pilot project. We banded the most birds at Ft. Bragg (5,873 individuals), followed by Ft. Chaffee (5,227), Ft. Benning (4,826), and Camp Robinson (4,536). The largest number of species was banded at Ft. Benning (57 species); the remaining installations had similar numbers of species captured and banded (45, 47, and 49 species at Ft. Chaffee, Camp Robinson, and Ft. Benning, respectively; Appendices 1-4). If we consider only bird species deemed to be 'winter residents' (i.e., not migrant or transient) at ≥ 1 station at an installation during at least one winter season, Ft. Benning still had the largest number of species captured and banded (44), followed by Ft. Bragg (41 species), Ft. Chaffee (39 species) and Camp Robinson (35 species; Appendices 1-4).

White-throated Sparrow was the most commonly captured species and accounted for 17% (3,469 individuals) of all birds banded. They were particularly common at the Arkansas installations, where the made up about one quarter of all birds banded (1,238 birds at Ft. Chaffee and 1,232 birds at Camp Robinson). We banded > 1,000 individuals of six other species during the MAWS pilot project: Song Sparrow (1,549), Field Sparrow (1,510), Ruby-crowned Kinglet (1,447), Dark-eyed (Slate-colored) Junco (1,395), Chipping Sparrow (1,159), and Yellow-rumped (Myrtle) Warbler (1,145). Although species composition of captures differed somewhat among installations (Appendices 1-4), all but one (Chipping Sparrow captured only at Fts. Bragg and Benning) of these top seven species was widely distributed among sites (banded at ≥ 22 stations).

Capture rates of all species pooled varied significantly among years at three of the four installations (Table 4). Capture rates were significantly higher in 2003-04 winter season than in other winter seasons at the Arkansas installations, and at Ft. Benning capture rates were significantly higher in 2004-05 than in 2005-06. We also found significant differences in capture rates among years for 10 species-installation combinations. These included Carolina Chickadee at Ft. Chaffee (2003-04 > 2006-06) and Camp Robinson (2003-04 > other years); Tufted Titmouse at Camp Robinson 2004-05 > 2005-06, 2006-07)and Ft. Bragg (2004-05 > 2006-07); Ruby-crowned Kinglet at Ft. Bragg (2003-04, 2004-05 > 2005-06, 2006-07); Song Sparrow at Ft. Chaffee (2003-04 > 2004-05 and 2005-06) and Camp Robinson (2003-04 > other years); White-throated Sparrow at Camp Robinson (2003-04 > 2004-05, 2006-07) and Ft. Benning (2004-05 > 2005-06, 2006-07); and Northern Cardinal at Ft. Chaffee (2003-04 > 2004-05, 2006-07).

Habitat

Summaries of 1-km radius NLCD land cover data and station-scale habitat variables indicated high variation in habitat structure within and among installations (Table 5; Fig. 1). The most striking differences were among installations. Forests at the Arkansas installations were primarily deciduous, while those at Ft. Benning tended to be mixed coniferous/deciduous and forests at Ft. Bragg were primarily coniferous (pine). All of the stations contained a mixture of forested, edge, and open habitats. Fort Chaffee represented, overall, the least forested set of stations, and Ft. Benning had the greatest land cover diversity, including substantial shrub/scrub and woody wetland. All stations had experienced at least some recent management activity, including ‘brush hogging’, bulldozing, silvicultural (pine) plantation, field mowing, and, especially, burning (both controlled burns and wildfires).

The principal components analysis successfully captured 52% of the variation in habitat data with the first three principal component axes. Varimax rotation revealed differentiation in habitat gradients represented by each axis (Table 6). Axis 1 was distinguished by having strong correlation (factor loading) with several variables that were not well-represented by the other axes. These included strong positive relationships between Axis 1 and land cover diversity (Shannon Index) and patchiness (negative loading for patch aggregation index), the number of evergreen forest patches, pasture/hay and crop cover (number of patches and edge), woody wetland cover (area, patches, edge), and station-scale deciduous forest cover. Variables that had strong loading in the same direction for both Axis 1 and 2 included negative loading for 1-km deciduous forest area and positive loading for evergreen forest edge and station-scale ground cover. Axis 1 was positively related to mixed forest and shrub/scrub variables, while Axis 2 was negatively related to these variables. Unique strong positive loadings for Axis 2 included developed open space (primarily lawn patches and edge), evergreen forest area, grassland/herbaceous edge, the number of emergent herbaceous wetland patches, and snags (canopy and subcanopy), and a negative relationship with deciduous forest edge. Unique negative loadings for Axis 2 included deciduous forest edge and pasture/hay edge. Axis 3 largely represented (from low to high) increasing water edge, urban development, and decreasing canopy cover. Stations at Ft. Benning tended to have high scores on Axis 1 (particularly VICK and YANK with their high heterogeneity of 1-km land cover classes and extensive shrub/scrub and woody wetland cover), while stations at Camp Robinson and (especially) Ft. Chaffee had low scores on this axis; Ft. Bragg stations had particularly high scores on Axis 2 (Fig. 2). There was greater heterogeneity among installations with respect to Axis 3, although CC03 at Ft. Benning.

Body Condition

As a preliminary to examining installation and habitat differences in body condition, we modeled body weight of individual captures and wing chord, time, and temperature variables. Selected models explained 23-45% of the variation in body weight for each focal species when considering birds of all ages combined; 26-46% of the variation in body weight when considering only birds aged as adult (AHY until Dec. 31; ASY after Dec. 31); and 31-44% of the variation in body weight when considering only young birds (HY until Dec. 31; AHY after Dec. 31; Table 7). For all focal species and age classes, wing chord was a highly significant (and typically the most important) predictor of body weight. Body weight significantly increased as a function of time of day for 9 of 10 species (all except Northern Cardinal; although relationship not significant for adult Field Sparrow). There was a significant quadratic relationship between day of season and weight for all species, with weight being lowest in November and March. Ambient temperature was an important predictor of body weight for at least one age class of 7 focal species. Five of these (Tufted Titmouse [all ages, adult, young], Field Sparrow [all ages, young], Song Sparrow [young], White-throated Sparrow [all ages, young], and Northern Cardinal [all ages]) had inverse relationships between ambient temperature and body weight, while two had positive relationships between ambient temperature and body weight (Ruby-crowned Kinglet [all ages, adult] and Hermit Thrush [adult]). Significant differences among seasons were found for all focal species except Swamp Sparrow. Seasonal differences were variable among species, although body weight tended to be lowest during the 2003-04 season for most.

We found significant differences in mean body condition among installations for each focal species (Figs. 3-5). Body condition tended to be lowest at Ft. Benning, and was typically highest at the Arkansas installations. The pattern was broadly similar for all birds (i.e., unknown aged birds, adults, and young; Fig. 3), birds aged as adults (Fig. 4), and young birds (Fig. 5).

Regression models that included 1-2 principal component habitat covariates described 30-58% of the variation in body condition for all birds, 19-62% of the variation in body condition for known adults only, and 25-66% of the variation for known young only (Table 8). At least one habitat variable was statistically significant for nine species (all but Hermit Thrush). Five species (for at least one of the age groupings) were negatively correlated with habitat axis 1, seven were negatively correlated with habitat axis 2 (for Ruby-crowned Kinglet only adults showed a linear relationship; the relationship was quadratic for all birds and for young). Two species were positively correlated with habitat axis 3, while one species was negatively correlated with axis 2.

Considering the mean body condition rank of the suite of 10 focal species and its relationship to individual habitat features, body condition was strongly positively related to the amount of grassland/herbaceous edge (1-km radius scale) and station-scale deciduous forest cover (up to about 50% cover; Fig. 6). Mean body condition rank was negatively correlated with various mixed forest characteristics (station-scale cover, landscape no. patches, and edge), woody wetland edge (up to about 10,000 m) landscape no. cultivated crop patches, station-scale ground cover, and landscape Shannon land cover diversity. Mean body condition rank was highest at stations with low evergreen forest area and edge, intermediate at stations with high evergreen forest area and edge, and lowest at stations with intermediate evergreen forest area and edge.

Apparent Survival-Rate Estimates

Analysis 1 (installation-scale): age, installation, and time effects
We found strong evidence of age effects on monthly apparent survival for six of the 10 focal species (Table 9). In each case, adult apparent (AHY/ASY) was higher than young (HY/SY) apparent survival (Table 10). As in earlier reports, installation effects were only strongly supported for Song Sparrow (Table 9). Over-wintering apparent survival was highest at Ft. Bragg for this species and lowest at Ft. Benning (Table 10). The over-summering, or between-year, apparent survival for Song Sparrow showed a contrasting pattern – it was highest at Ft. Benning and lowest at Ft. Bragg. Strong support for annual variation in apparent survival was only found for Carolina Chickadee (Table 9); winter apparent survival for this species was low during winters of 2003-04 and 2005-06 and high during winters of 2004-05 and 2006-07. We found strong evidence of age differences in recapture probability for two species (adult p < young p), year differences in recapture probability for five species, and installation differences in recapture probability for seven species (Table 9).

Analysis 2 (station-scale): age and habitat effects
We found strong support for age differences in apparent survival for the same six focal species as in the location-scale analysis (Table 11; again, all with adult survival > young survival). Strong support for habitat effects on apparent survival was found for three species. Tufted Titmouse apparent survival was significantly positively related to habitat axis 3 (slope from best model: $\hat{\beta}$ = 0.94; 95% CI = 0.37, 1.66). The effect, however, appears to have been limited to the over-summering (between-year) period (particularly for young [HY] birds; Fig. 7). Ruby-crowned Kinglet over-wintering apparent survival was positively related to Habitat axis 1 (slope from best model: $\hat{\beta}$ = 39.90; 95% CI = 4.10, 75.71; Fig. 8). For Song Sparrow, we found a significant season $\times$ habitat axis 1 interaction (slope from best model: $\hat{\beta}$ = - 0.88; 95% CI = - 1.56, - 0.21), such that over-wintering apparent survival was negatively related to axis 1 and over-summering apparent survival was positively related to axis 1 (Fig. 9). As for Analysis 1, we found strong support for age effects on recapture probability for Tufted Titmouse and White-throated Sparrow. We found habitat effects on recapture probability for four species (axes and directions of relationships inconsistent).

Behavioral observations

We collected 257 behavioral observations on 211 individuals in 657 hours of observation effort at the two Arkansas installations. Only 66 aggressive interactions involving 44 focal individuals were noted. Too few data were recorded to include aggressive interactions into models of apparent survival or body condition. Our largest sample size was for White-throated Sparrow (23 individuals), followed by Song Sparrow, and Dark-eyed Junco (9). Most interactions (72%) were between conspecifics, and most interspecific interactions (53%) involved one of the three focal species.

Feeding rates varied significantly among stations for each of the three focal species (Table 12). For Song Sparrow ($F_{10,52}$ = 2.83; P = 0.007), feeding rate was highest at NEWB at Camp Robinson, which differed significantly from ZONO at Ft. Chaffee. For White-throated Sparrow ($F_{11,146}$ = 9.72; P < 0.0001), feeding rate was significantly higher at ZONO than at any other station except SPIZ and JUNC (also at Ft. Chaffee). The only other statistically-significant difference for White-throated Sparrow was significantly lower feeding rate at PIPI (Ft. Chaffee) than at BUCK

(Camp Robinson). For Dark-eyed Junco ($F_{6,31}$ = 4.84; P = 0.0014), feeding rate was highest at PASS (Ft. Chaffee), which was significantly higher than ZONO (Tukey's HSD test).

Despite small sample sizes (numbers of foraging observations, birds handled to measure body condition, and numbers of stations), we found significant negative correlation between body condition and feeding rate for White-throated Sparrow (r = - 0.61; N = 12; P = 0.0341). Correlation was non-significant for the other two species (r = - 0.34; N = 10; P = 0.34 for Song Sparrow and r = 0.28; N = 7; P = 0.54 for Dark-eyed Junco).

DISCUSSION

Through four years of the pilot MAWS project we have met or exceeded all mist-netting effort goals for each of the four southeastern DoD installations. This effort has yielded more than 20,000 banded birds of 70 species and more than 6,000 between-pulse recaptures. These data are lending important insights into avian population dynamics and habitat quality for over-wintering birds in the southeastern United States. Our analyses of MAWS banding data indicate high variation in abundance (as indexed by capture rates), body condition, and apparent survival (site persistence and site fidelity) of birds among geographic areas (installations) and years.

For the suite of focal species considered in this report, body condition was typically highest at the Arkansas installations and lowest at Fort Benning. Because we corrected our body condition metric for temporal effects (time of day, day of season, year) and at least one non-habitat related variable (ambient temperature), this finding suggests that the generally low body condition at Ft. Benning may have been habitat-related. Although we did not control for location (installation) effects in our analysis of habitat effects on body condition (primarily because overlap in habitat gradients among installations was low; see Fig. 2), body condition was highly correlated with many of the landscape and local habitat variables that we considered. In general, body condition increased as a function of increased patch size, decreased patch diversity, greater deciduous cover, decreased mixed and evergreen forest, greater grassland/herbaceous edge and decreased numbers of cultivated crop patches.

Although patterns in body condition suggested low habitat quality at Ft. Benning compared to the other installations (particularly the Arkansas bases), this pattern was not (entirely) borne out by the survival analysis. We found strong evidence of variation among installations in apparent survival for just one of our 10 focal species. Over-wintering survival for this species, Song Sparrow, was lowest at Ft. Benning, which supports the finding of the body condition analysis; however, over-summering, or between-year, survival for this species was, in fact, *higher* at Ft. Benning than at the other installations. The reason for this non-intuitive result is not clear; however, it could simply reflect normal patterns of non-breeding season movements, rather than patterns of habitat quality. For example, Ft. Benning might not be reached by large numbers of over-wintering individuals until late in the over-wintering period when winter conditions become severe farther north. Individuals that do arrive there may also leave sooner in spring due to earlier spring conditions that allow efficient pre-migratory fattening. Application of alternative capture-recapture models (e.g., robust design or reverse-time models) to of the current data set could aid in better understanding patterns of recruitment and apparent survival of different species and age classes at the four installations.

Our habitat analysis of apparent survival indicated strong habitat effects for three species: Tufted Titmouse, Ruby-crowned Kinglet, and Song Sparrow. The pattern of over-wintering apparent survival for Song Sparrow closely matched the pattern found for body condition – both metrics were significantly negatively related to habitat axis 1. Yet, as indicated above, over-summering apparent survival did not follow the same pattern (at least for young). Apparent survival rates of Tufted Titmouse and Ruby-crowned Kinglet were significantly related to different habitat axes than their body condition was. Between-year apparent survival of Tufted Titmouse (particularly young birds) tended to be greater at sites with relatively high urban development (possibly due to increased feeders or cover around developments). Ruby-crowned Kinglet over-wintering apparent survival appeared to be greater at sites with greater habitat heterogeneity, including mixed and evergreen forest, shrub/scrub, and woody wetlands. Surprisingly, we did not find strong support for habitat effects in Field Sparrow, a species for which we had found strong habitat effects in the past. This could reflect the extraordinarily strong age effects found for this species in the current analysis; failure to model year effects on recapture probability (which were suggested important in the installation-scale survival analysis); or the expansion in the spatial resolution of the habitat data (only local variables were included in the previous report) such that the features to which Field Sparrows were responding may have been occluded.

Although we did not specifically examine the effect of dedicating observers to collect resighting data during the last three pulses of the 2006-07 MAWS season, these data did contribute substantial numbers of resightings of the three focal species at the Arkansas installations. These additional data undoubtedly contributed to our ability to detect strong installation effects on recapture probability in the installation-scale survival analyses. Another interesting result deriving from the observational data collected on resighted birds was that feeding rates of White-crowned Sparrow, the species for which we had the most data, was highest at stations where body condition was low. Thus, it appears that birds in poor condition are expending greater energy in foraging. Although our attention in this report is focused on identifying habitat effects, weather also affects body condition and survival. This was clear from strong ambient temperature effects on body weight that we found for most focal species. Interestingly, body weight of insectivores such as Ruby-crowned Kinglet and Hermit Thrush (which also relies on fruit, at least at some sites) was positively related to ambient temperature, probably reflecting lowered insect activity and abundance at low temperatures, while highly granivorous species such as the sparrows, increased in weight with declining temperatures, suggesting that, perhaps due to a more consistent food supply, they were better able to respond to drops in temperature.

Management Implications, Guidelines, and Future Directions

The development of habitat models explaining physical condition and over-wintering apparent survival and physical condition from the MAWS program on DoD installations complements ongoing efforts to implement avian management guidelines on DoD installations based on landscape-level models of productivity, adult population size, and probability of breeding from the MAPS Program. Indeed, the work reported here fulfills the recent request by researchers and land managers throughout the PIF and NABCI network for work to be initiated on the wintering grounds of migratory birds to complement work on their breeding grounds.

Based on the suite of focal species and metrics considered, habitat quality appeared generally to increase as a function of increased patch size, decreased patch diversity, greater deciduous cover, decreased mixed and evergreen forest, greater grassland/herbaceous edge and decreased numbers of cultivated crop patches. Certain species (e.g., as suggested by Dark-eyed Junco body condition and Tufted Titmouse between-year apparent survival) may also benefit from certain forms of low-level urban development (perhaps due to greater shrub/edge cover or bird feeders). And yet other species, such as Ruby-crowned Kinglet, may benefit from greater habitat heterogeneity, including mixed and evergreen forest and woody wetlands.

Overall, greater emphasis on maintaining larger habitat patches of certain types (e.g., deciduous forest, grassland/herbaceous) would appear to be beneficial to the bulk of species considered here. Nevertheless, a degree of caution should be exercised in the interpretation of our bird-habitat models. First, there was little overlap in habitats among the four installations. Because these installations (at least the Arkansas installations v. Fts. Bragg and Benning), were separated by large geographic gaps, and because they contained different sets of habitats that may differ in the timing of the arrival of over-wintering birds (and under what weather conditions the arrive) , it is unclear whether the habitat effects we found were simply artifacts of regional differences. An expanded MAWS program that provides adequate replication across broad habitat gradients within relatively small geographic regions (e.g., such as Partners in Flight Physiographic Areas or North American Bird Conservation Regions) would offer the opportunity to better distinguish spatial from habitat-related differences in the quality of different sites for overwintering birds.

Second, our habitat analyses were limited both in the spatial scales considered (1-km radius and station-scales) and the degree to which we had to aggregate the data (accross the spatial scales and across 47 individual habitat characteristics). This degree of simplification was necessary because of the limited numbers of station (maximum of 24 for any species). A larger set of MAWS staions would allow greater flexibility in modeling MAWS data.

Third, the focal species that we considered were widespread among installations. Each of the four installations had species that were common but not well-represented at the other installations and may provide quality habitat for those species. For example, habitats (at least the ones sampled) at Ft. Benning may not be especially good for our focal species, but that installation did have the highest diversity of winter birds, many of which are also declining or rare. Those unique species must also be considered when making management decisions.

A final caution, and one that could potentially explain differences between body condition and survival responses, is that birds may have been responding to management applications that were not included in habitat models. For example, all of the stations experience some sort of burning regime (typically a 3-year cycle but variable among installations/stations), and several stations were burned during the at least one of the MAWS banding seasons. Winter bird populations undoubtedly respond to whether (White et al. 1996), how often (Duncan et al. 2004), and in what season (King et al. 1998) their habitats burn. A variety of responses to burning could be expected. For example, burning could expose new resources for some species (e.g., uncovering buried seeds) but destroy resources for others (burning of seeds/insects). Because fire is a ubiquitous management practice on southeast U.S. military installations, we recommend that additional MAWS stations be sited in such a way as to test specifically for burning effects (e.g., frequencies or timing of burns) on winter bird populations.

Benefits to the Military

DoD military lands represent a crucial network of important habitats for many declining species of landbirds. These species are sensitive indicators of ecosystem health and little is known regarding their habitat needs during the non-breeding season. Wise stewardship of DoD lands can allow mission activities and natural resource conservation to coexist, and the DoD has become a major cooperating partner in the Neotropical Migratory Bird Conservation Initiative, Partners in Flight (PIF), and in the North American Bird Conservation Initiative (NABCI). The opportunity to enhance both the military mission and natural resource conservation is especially pronounced with respect to the grassland, shrubland, and edge habitats that are often created and maintained as part of the training missions of DoD installations and used by many overwintering landbirds.

Goals of the DoD's PIF and NABCI efforts are threefold: (1) to implement research and monitoring projects aimed at determining the causes of population declines in migratory birds, (2) the identification of management actions aimed at reversing the declines; and (3) the implementation of management to benefit declining bird populations. The MAWS Program on DoD installations in southeastern United States contributes significantly to these goals. First, it provides critical information on the manner in which habitat conditions resulting from land-management decisions (e.g., successional stage, amount of shrubland cover and edge, degree of fragmentation) affect over-wintering apparent survival and late-winter physical condition of declining landbird species that winter on the installations. Over-wintering survival and late-winter physical condition appear to be key factors in driving the population declines of many migratory species. Thus, information on relationships between these factors and habitat conditions is exactly what is needed to make land-management decisions that balance military mission activities and natural resource conservation.

Models and avian management guidelines resulting from this project will also provide important information to assist in the development of Integrated Natural Resources Management Plans (INRMP) for each installation. These are important management tools that aim to ensure that military operations and natural resources conservation are integrated and consistent with stewardship and legal requirements. Integration of the avian management guidelines that will result from this work with the INRMP planning process will enhance the installations' ability to conduct landscape-based natural resource management that is compatible with maintaining the military mission.

ACKNOWLEDGMENTS

We thank the personnel on each of the four military installations who provided enthusiastic support for and logistic help with the MAWS Program on the installation: on Fort Chaffee, these were Natural & Cultural Resource Manager Sabrina Kirkpatrick, Biologist Beth Phillips, and Environmental Program Manager Daniel T. Farrer; on Camp Robinson, these were Natural & Cultural Resource Managers Carla Greisen and Brian Mitchell; on Fort Bragg, these were Jessie Schillaci and Janice Patten of the Endangered Species Branch, and John Doss of Range Control; and on Fort Benning, these were Mark Thornton and Michael Fuller of the Environmental Management Division, and SEMP Host Site Coordinator Hugh Westbury. We are extremely grateful to these persons for their excellent and enthusiastic support. We also thank Chris Eberly, DoD Partners in Flight Coordinator, for helpful information and support throughout the study.

Field training and supervision of field work was provided by Keith Doran, Bernadette Emmons, Denise Jones, Amy McAndrews, Blanca Roldan, Matt Schapp, Ron Taylor, and Kerry Wilcox. Field biologist interns included: Rich Aracil, Jeff Beauchamp, Ashley Buchanan, Corinne Campbell, Kristin Comolli, Noel Dodge, Peter Doherty, Kristin Dybala, Kate Eldridge, Daniel Farrar, Amy Finfera, Leah Finity, Maren Gimpel, Joanna Hubbard, Amber Jonker, James Juda, Sara Kennedy; Janet Lapierre, Andrea Lindsay, Jenny McCabe, Chris McClure, Jasmine McConnell, Margaret Muenich, Kendra Noyes, Rachel Rabinovitz, Reed Schneider, Annie Schultz, John Siekierski, Dan Small, Ted Snyder, Brett Tryon, Melissa Vanderlinden, Ellen Welti, Sabrina West, Melissa Wolfe, Andrea Wuenschel, and Anne Wynne. Office support was provided by Kelly Gordon, Denise Jones, Sara Martin, and Ron Taylor. Teryk Morris ran the Fragstats analysis to produce landscape habitat variables.

Finally, we thank the Legacy Resources Management Program for funding of the work reported here, and Jane Mallory, Peter Boice, Pamela Behm, and Pedro Morales at the DoD Legacy

Resources Management Program and Suzanne Murdoch and George Sledge at the U.S. Army Corp of Engineers, Huntsville Center, for excellent logistical support. This is Contribution No. 334 of The Institute for Bird Populations.

LITERATURE CITED

Brennan, L. A., and W. P. Kuvlesky, Jr. 2005. North American grassland birds: an unfolding conservation crisis? Journal of Wildlife Management 69:1-13.

Burnham, K.P., and D.R. Anderson. 1998. Model Selection and Inference: a Practical Information Theoretic Approach. Springer-Verlag, New York, NY

Cawthorne, R. A., and J. H. Marchant. The effects of the 1978/79 winter on British bird populations. Bird Study 27:163-172.

Cooch, E., and G. White. 2002. Program MARK, Analysis of Data from Marked Individuals: "A Gentle Introduction," 2nd edition. www.phidot.org/software/mark/docs/book/

Crone, E. E. 2001. Is survivorship a better fitness surrogate than fecundity? Evolution 55:2611-2614.

DeSante, D.F., K.M. Burton, J.F. Saracco, and B.L. Walker. 1995. Productivity indices and survival rate estimates from MAPS, a continent-wide programme of constant-effort mist netting in North America. Journal Applied Statistics 22:935-947.

DeSante, D.F., M.P. Nott, and D.R. O'Grady. 2001. Identifying the proximate demographic cause(s) of population change by modelling spatial variation in productivity, survivorship, and population trends. Ardea 89 (special issue): 185-207.

DeSante, D.F. and D.K. Rosenberg. 1998. What do we need to monitor in order to manage landbirds? Pp. 93-106 in Marzluff, J.M., and R. Sallabanks, eds. Avian Conservation: Research and Management. Island Press, Washington, DC.

DeSante, D. F., and D. R. Kaschube. 2004. Modeling over-wintering survival of declining landbirds: the 2003-04 annual report of the Monitoring Avian Winter Survival (MAWS) program on four DoD installations in southeastern United States. Technical report submitted to the DoD Legacy Resources Management Program. The Institute for Bird Populations, Point Reyes Station, CA. 71 pp.

DeSante, D. F., J. F. Saracco, D. R. O'Grady, K. M. Burton, and B. L. Walker. 2004. Some methodological considerations of the Monitoring Avian Productivity and Survivorship Program. Studies in Avian Biology 29:28-45.

DeSante, D. F., M. P. Nott, and D. R. Kaschube. 2005a. Monitoring, modeling, and management: Why base avian monitoring on vital rates and how should it be done? Pages 795-804 *in* C. J. Ralph and T. D. Rich, editors. Bird Conservation Implementation and Integration in the Americas. U.S. Forest Service General Technical Report PSW-GTR-191.

DeSante, D. F., T. S. Sillett, R. B. Siegel, J. F. Saracco, C. A. Romo, S. Morales, A. Cerezo, D. Kaschube, B. Milá, and M. Grosselet. 2005b. MoSI (Monitoreo de Sobrevivencia Invernal): Assessing habitat-specific over-wintering survival of neotropical migratory landbirds. Pp. 926-936 In: Bird Conservation Implementation and Integration in the Americas (C. J. Ralph and T. D. Rich, Editors). USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

DeSante, D. F., J. F. Saracco, and D. R. Kaschube. 2005c. Modeling over-wintering survival of declining landbirds: the 2004-05 annual report of the Monitoring Avian Winter Survival (MAWS) program on four DoD installations in southeastern United States. Technical report submitted to the DoD Legacy Resources Management Program. The Institute for Bird Populations, Point Reyes Station, CA. 82 pp.

Duncan, L., J. Dilustro, and B. Collins. 2004. Avian response to forest management and military training activities at Fort Benning, Georgia. Georgia Journal of Science 62:95-103.

Hines, J.E., W.L. Kendall, and J.D. Nichols. 2003. On the use of the robust design with transient capture-recapture models. Auk 120:1151-1158.

Homer, C., J. Dewitz, J. Fry, M. Coan, N. Hossain, C. Larson, N. Herold, A. McKerrow, J. N. VanDriel, and J. Wickham. 2007. Completion of the 2001 National Land cover Database for the Conterminous United States. Photogrammetric Engineering and Remote Sensing 73:337-341.

King, T. G., M. A. Howell, B. R. Chapman, K. V. MIller, and R. A. Schorr. 1998. Comparisons of wintering bird communities in mature pine stands managed by prescribed burning. Wilson Bulletin 110:570-574.

Latta, S.C. and J. Faaborg. 2002. Demographic and population responses of Cape May Warblers wintering in multiple habitats. Ecology 83:2502-2515.

Lebreton, J,-D., K.P. Burnham, J. Clobert, and D.R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecological Monographs 62:67-118.

Legendre, P. and L. Legendre. 1998. Numerical Ecology. Second Ed. Elsevier, New York.

Marra, P.P., K.A. Hobson, and R.T. Holmes. 1998. Linking winter and summer events in a migratory bird by using stable-carbon isotopes. Science 282:1884-1886.

McGarigal, K., and B. J. Marks. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. USDA For. Serv. Gen. Tech. Rep. PNW-351.

Newton, I. 1998. Population Limitation in Birds. Academic Press. San Diego, CA, USA.

Nott, M.P., and D. F. DeSante. 2002. Demographic monitoring and the identification of transients in mark-recapture models. Pp. 727-736 *in:* J. M. Scott, P. Heglund, et al. (Eds.). Predicting Species Occurrences: Issues of Scale and Accuracy. Island Press, NY.

Nott, M.P., D.F. DeSante, R.B. Siegel, and P. Pyle. 2002. Influences of the El Niño/Southern Oscillation and the North Atlantic Oscillation on avian productivity in forests of the Pacific Northwest of North America. Global Ecology and Biogeography 11:333-342.

Piper, W. H. 1990. Site tenacity and dominance in wintering White-throated Sparrows *Zonotrichia albicollis* (Passeriformes: Emberizidae). Ethology 85:114-122.

Piper, W. H., and R. H. Wiley. 1990. The relationship between social dominance, subcutaneous fat, and annual survival in wintering white-throated sparrows. Behavioral Ecology and Sociobiology 26:201-208.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs, No. 107.

Pyle, P. 1997. Identification Guide to North American Birds, Part 1. Slate Creek Press, Bolinas, CA.

Ritters, K. H., R. V. O'Neill, C. T. Hunsaker, J. D. Wickham, D. H. Yankee, S. P. Timmins, K. B. Jones, and B. L. Jackson. 1995. A factor analysis of landscape pattern and structure metrics. Landscape Ecology 10:23-40.

Sæther, B.-E., and Ø. Bakke. 2000. Avian life history variation and contribution of demographic traits to the population growth rate. Ecology 81:642-653.

Sandercock, B. K., and A. Jaramillo. 2002. Annual survival rates of wintering sparrows: assessing demographic consequences of migration. Auk 119:149-165.

Saracco, J. F., D. F. DeSante, and D. R. Kaschube. 2006. Modeling overwintering survival of declining landbirds: the 2005-06 Annual Report of the Monitoring Avian Winter Survival (MAWS) program on four DoD Installations in southeastern United States. Technical report submitted to the DoD Legacy Resources Management Program. The Institute for Bird Populations, Point Reyes Station, CA. 50 pp.

Sauer, J. R., J. E. Hines, and J. Fallon. 2006. The North American Breeding Bird Survey, Results and Analysis 1966-2005. Version 6.2. 2006. USGS Patuxent Wildlife Research Center, Laurel, MD.

Siegel, R.B., R.L. Wilkerson, D.F. DeSante, D.R. Kaschube, and T.S. Sillett. 2004. Survival rates of landbirds on U.S. Naval Station Guantanamo Bay, Cuba. Unpubl. report. The Institute for Bird Populations, Point Reyes Station, CA.129 pp.

Sillett, T. S., R. T. Holmes, and T. W. Sherry. 2000. Impacts of a global climate cycle on population dynamics of a migratory songbird. Science 288:2040-2042.

Sokal, R. R., F. J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. W. H. Freeman and Co., New York.

White, D. H., C. B. Kepler, J. S. Hatfield, P. W. Sikes, Jr., and J. T. Seginak. 1996. Habitat associations of birds in the Georgia piedmont during winter. Journal of Field Ornithology 67:159-166.

White, G.C., and K.P. Burnham. 1999. Program Mark: survival estimation from populations of marked animals. Bird Study 46(suppl.): 120-138.

Table 1. Locations and average elevations for 24 MAWS stations operated on Southeastern DoD installations from November-March 2003-04, 2004-05, and 2006-07.

Installation	Station name	Station code	Location	Elev. (m)
Fort Chaffee	Junco	JUNC	35° 15’ 32” N, 94° 12’ 21” W	220
	Melospiza	MELO	35° 11’ 08” N, 94° 04’ 42” W	160
	Passerella	PASS	35° 16’ 00” N, 94° 07’ 43” W	140
	Pipilo	PIPI	35° 11’ 38” N, 94° 02’ 44” W	200
	Spizella	SPIZ	35° 18’ 46” N, 94° 14’ 59” W	130
	Zonotrichia	ZONO	35° 18’ 07” N, 94° 15’ 28” W	130
Camp Robinson	Buck	BUCK	34° 55’ 23” N, 92° 19’ 12” W	96
	Mini Forest	MIFO	34° 54’ 44” N, 92° 16’ 11” W	101
	New Bird	NEWB	34° 57’ 01” N, 92° 22’ 19” W	85
	Pee Dee	PEED	34° 57’ 04” N, 92° 20’ 21” W	96
	POW Camp	POWC	34° 51’ 49” N, 92° 17’ 59” W	116
	Siamese	SIAM	34° 56’ 37” N, 92° 19’ 22” W	101
Fort Bragg	Deer Pen Lake	DEER	35° 14’ 29” N, 78° 59’ 47” W	59
	Dove Field	DOFI	35° 11’ 47” N, 79° 13’ 58” W	94
	Golf Course	GCOU	35° 12’ 56” N, 79° 02’ 27” W	75
	Holland Lake	HOLA	35° 10’ 24” N, 79° 17’ 36” W	106
	Wildfire	WIFI	35° 10’ 02” N, 79° 08’ 14” W	68
	Wolf Pit Creek	WOCR	35° 06’ 24” N, 79° 20’ 45” W	57
Fort Benning	Charlie Charlie 2	CC02	32° 16’ 27” N, 84° 52’ 31” W	278
	Charlie Charlie 3	CC03	32° 19’ 20” N, 84° 59’ 21” W	240
	Molnar Range	MOLE	32° 17’ 03” N, 84° 55’ 50” W	223
	Victor 1	VICK	32° 20’ 52” N, 85° 00’ 42” W	341
	X-ray 5	XRAY	32° 14’ 51” N, 84° 57’ 14” W	269
	Yankee 2	YANK	32° 17’ 18” N, 84° 56’ 49” W	223

Table 2. North American Breeding Bird Survey (BBS) survey-wide trends, capture-recapture summary, and winter habitat associations for 10 focal species sampled by the 4-year MAWS pilot project on four southeastern DoD military installations (see Appendices 1-4 for scientific names and installation-specific capture-recapture data).

Species	BBS trend[1]	Stations	Banded	Pulse-unique recaps	Habitat[2]
Black-capped Chickadee	-0.72**	24	543	368	Forest, woodland, suburban areas
Tufted Titmouse	0.87**	24	721	345	Deciduous/mixed forest
Ruby-crowned Kinglet	-1.02**	24	1,447	529	Forest
Hermit Thrush	1.12**	24	729	614	Forest with shrub/understorey
Field Sparrow	-2.86**	23	1,510	391	Oldfield/open areas, forest edge, hedgerows
Song Sparrow	-0.54**	24	1,545	513	Oldfield, shrubland, young forest, suburban areas, edge
Swamp Sparrow	1.36**	22	950	344	Water edge, wetlands
White-throated Sparrow	-0.65*	24	3,469	1,318	Oldfield, shrubland, suburban areas, edge
Dark-eyed Junco	-1.33**	22	1,395	280	Oldfield, forest edge
Northern Cardinal	0.15	24	882	293	Oldfield, edge, shrubby areas (incl. forest)

[1] Estimating equations trend from Sauer et al. (2006); * = $P < 0.01$; ** = $P < 0.001$.
[2] Habitat descriptions generalized from Birds of North America (BNA) accounts (http://bna.birds.cornell.edu/bna)

Table 3. Operation details for 24 MAWS stations (see Table 1 for station details) operated during the winters of 2003-04, 2004-05, 2005-06, and 2006-07.

	2003-04		2004-05		2005-06		2006-07	
Station code	No. pulses	Net-hours	No. pulses	Net-hours	No. pulses	Net-hours	No. pulses	Net-hours
Fort Chaffee								
JUNC	5	665.83	5	817.17	5	820.33	5	1,120.67
MELO	5	687.00	5	949.00	5	697.00	5	1,145.83
PASS	5	638.83	5	1,039.67	5	732.50	5	1,150.67
PIPI	5	848.50	5	1,069.83	5	779.17	5	1,137.83
SPIZ	5	753.00	5	1,279.33	5	880.17	5	1,046.67
ZONO	5	915.83	5	1,067.83	5	862.50	5	1,043.00
Camp Robinson								
BUCK	3	298.17	5	1,235.33	5	796.50	5	1,290.17
MIFO	3	194.17	5	1,067.17	5	625.83	5	1,162.83
NEWB	2	47.50	5	888.17	5	718.67	5	1,167.83
PEED	3	282.00	5	1,155.50	5	697.33	5	1,248.33
POWC	4	98.83	5	1,022.83	5	842.50	5	1,180.67
SIAM	3	258.33	5	1,006.67	5	963.00	5	1,168.17

Table 3 continued.

Station code	2003-04		2004-05		2005-06		2006-07	
	No. pulses	Net-hours	No. pulses	Net-hours	No. pulses	Net-hours	No. pulses	Net-hours
Fort Bragg								
DEER	2	157.00	5	689.33	5	829.83	5	1,065.83
DOFI	5	517.00	5	773.67	5	731.17	5	1,046.33
GCOU	5	347.83	5	769.67	5	746.00	5	1,000.33
HOLA	5	608.00	5	966.00	5	1,079.00	5	1,203.17
WIFI	5	570.17	5	921.33	5	903.83	5	1,216.33
WOCR	5	708.67	5	1,099.00	5	1,172.00	5	1,146.50
Fort Benning								
CC02	3	387.00	5	1,291.00	5	945.50	5	1,250.33
CC03	5	566.17	5	1,125.67	5	1,227.67	5	1,012.00
MOLE	5	464.83	5	1,169.67	5	865.50	5	907.17
VICK	5	709.67	5	1,375.00	5	1,157.00	5	1,138.00
XRAY	5	573.17	5	1,049.17	5	979.17	5	871.67
YANK	3	380.17	5	1,207.67	5	1,073.00	5	902.17

Table 4. Annual capture rates (pulse-unique captures*100 net-hours-1) for ten focal species and for all species combined. Letters indicate means that are statistically-significant (P < 0.05; Tukey's HSD) for one-way ANOVAs testing for year differences in capture rate for a species at an installation.

			2003-04		2004-05		2005-06		2006-07	
Species	Installation	No. sta.	mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)
Carolina Chickadee	CHAF	6	2.04[a]	(0.30)	1.68[ab]	(0.18)	1.22[ab]	(0.16)	0.87[b]	(0.19)
	ROBI	6	4.44[a]	(0.84)	1.38[b]	(0.15)	1.38[b]	(0.28)	1.28[b]	(0.26)
	BRGG	6	0.77	(0.21)	0.96	(0.18)	0.96	(0.13)	0.48	(0.14)
	BENN	6	0.59	(0.17)	0.65	(0.24)	0.54	(0.24)	0.60	(0.23)
Tufted Titmouse	CHAF	6	2.04	(0.69)	1.45	(0.36)	1.40	(0.27)	0.60	(0.25)
	ROBI	6	3.49[ab]	(0.56)	5.02[a]	(1.27)	1.45[b]	(0.17)	1.37[b]	(0.18)
	BRGG	6	0.43[ab]	(0.25)	1.04[a]	(0.25)	0.48[ab]	(0.08)	0.24[b]	(0.11)
	BENN	6	0.74	(0.21)	0.41	(0.11)	0.39	(0.17)	0.64	(0.24)
Ruby-crowned Kinglet	CHAF	6	0.84	(0.23)	1.21	(0.16)	1.05	(0.23)	1.24	(0.32)
	ROBI	6	2.45	(0.70)	1.92	(0.48)	2.22	(0.37)	1.04	(0.32)
	BRGG	6	6.31[a]	(1.54)	6.37[a]	(1.33)	2.58[b]	(0.38)	3.02[b]	(0.49)
	BENN	6	0.61	(0.23)	1.98	(0.50)	1.72	(0.42)	2.68	(0.78)
Hermit Thrush	CHAF	6	1.91	(0.24)	1.54	(0.13)	2.31	(0.45)	2.11	(0.34)
	ROBI	6	2.58	(0.74)	2.26	(0.62)	2.70	(0.64)	2.91	(0.56)

Table 4 continued.

			2003-04		2004-05		2005-06		2006-07	
Species	Installation	No. sta.	mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)
Hermit Thrush	BRGG	6	1.08	(0.41)	1.46	(0.42)	0.86	(0.38)	1.20	(0.38)
	BENN	6	0.26	(0.11)	0.62	(0.20)	0.17	(0.08)	0.97	(0.36)
Field Sparrow	CHAF	6	4.37	(1.68)	1.09	(0.26)	1.62	(0.48)	1.89	(0.71)
	ROBI	6	2.44	(1.20)	1.71	(0.58)	1.43	(0.54)	1.35	(0.70)
	BRGG	5	5.35	(2.12)	5.06	(2.13)	4.45	(1.72)	3.07	(1.46)
	BENN	6	3.22	(1.23)	3.20	(1.07)	1.32	(0.37)	1.72	(0.46)
Song Sparrow	CHAF	6	3.89[a]	(0.93)	0.70[b]	(0.25)	0.94[b]	(0.18)	2.28[ab]	(0.72)
	ROBI	6	9.38[a]	(3.42)	1.16[b]	(0.31)	1.23[b]	(0.36)	1.42[b]	(0.41)
	BRGG	6	4.20	(1.50)	5.18	(2.78)	2.93	(0.90)	2.48	(0.90)
	BENN	6	3.02	(0.62)	3.26	(0.79)	1.44	(0.24)	2.67	(0.83)
Swamp Sparrow	CHAF	6	0.78	(0.29)	0.41	(0.19)	0.15	(0.07)	1.32	(0.72)
	ROBI	4	6.92	(5.44)	0.89	(0.79)	0.14	(0.10)	0.15	(0.10)
	BRGG	6	2.50	(0.86)	3.24	(1.63)	2.48	(1.05)	1.71	(0.85)
	BENN	6	3.25	(0.79)	4.12	(1.74)	1.90	(0.35)	1.84	(0.75)
White-throated Sparrow	CHAF	6	8.85	(0.95)	5.42	(0.62)	4.93	(1.18)	9.08	(2.26)

Table 4 continued.

			2003-04		2004-05		2005-06		2006-07	
Species	Installation	No. sta.	mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)
White-throated Sparrow	ROBI	6	24.60[a]	(5.86)	5.78[b]	(0.41)	11.49[ab]	(2.83)	6.53[b]	(1.59)
	BRGG	6	3.57	(1.08)	2.17	(0.55)	2.06	(0.75)	4.45	(0.62)
	BENN	6	2.37[ab]	(0.57)	4.79[a]	(1.11)	1.68[b]	(0.34)	1.78[b]	(0.72)
Slate-colored Junco	CHAF	6	4.64	(1.66)	1.17	(0.25)	4.16	(2.40)	2.98	(0.19)
	ROBI	6	1.90	(1.09)	0.27	(0.09)	0.64	(0.44)	0.57	(0.31)
	BRGG	6	5.82	(2.33)	4.27	(2.32)	1.07	(0.46)	4.87	(2.20)
	BENN	4	0.93	(0.61)	1.27	(0.67)	0.23	(0.21)	0.38	(0.05)
Northern Cardinal	CHAF	6	3.23[a]	(0.48)	1.45[b]	(0.24)	1.78[ab]	(0.55)	1.44[b]	(0.23)
	ROBI	6	4.80	(1.68)	1.54	(0.34)	2.16	(0.38)	1.61	(0.34)
	BRGG	6	1.10	(0.48)	0.96	(0.17)	0.54	(0.12)	0.61	(0.22)
	BENN	6	0.85	(0.16)	1.37	(0.27)	0.85	(0.20)	0.80	(0.19)
ALL SPECIES	**CHAF**	**6**	**42.48**[a]	**(2.94)**	**22.49**[c]	**(1.97)**	**25.15**[c]	**(1.63)**	**33.35**[b]	**(0.97)**
	ROBI	**6**	**73.69**[a]	**(11.88)**	**28.01**[b]	**(0.41)**	**34.10**[b]	**(2.62)**	**25.05**[b]	**(2.67)**
	BRGG	**6**	**47.05**	**(9.72)**	**44.93**	**(7.89)**	**28.63**	**(5.10)**	**32.33**	**(7.40)**
	BENN	**6**	**28.88**[ab]	**(2.50)**	**37.19**[a]	**(5.33)**	**16.40**[b]	**(2.05)**	**25.30**[ab]	**(4.34)**

Table 5. Summary of 47 habitat variables for MAWS stations (6 per installation) on four southeastern DoD installations. Variables from 1-km radius circles centered on stations were extracted from the 30-m resolution 2001 National Land cover Database (Homer et al. 2007) set on Camp Robinson, AR. Station variables were derived from field data collected during Feb. 2005, 2006, and 2007.

	Ft. Chaffee		Camp Robinson		Ft. Bragg		Ft. Benning	
Variable	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
<u>1-km landscape variables</u>								
Shannon diversity index	1.3	(0.1)	1.0	(0.1)	1.4	(0.1)	1.7	(0.1)
Patch aggregation index	76.7	(1.7)	82.8	(1.3)	75.6	(1.1)	72.6	(2.6)
<u>1-km class variables</u>								
Water edge	605.0	(593.1)	0.0	(0.0)	530.0	(214.9)	1825.0	(865.6)
Developed open space area	15.1	(1.2)	18.6	(3.6)	25.9	(8.8)	25.7	(17.3)
Developed open space patches	24.5	(3.3)	35.7	(7.6)	44.5	(17.3)	18.0	(4.4)
Developed open space edge	10865.0	(919.4)	13425.0	(2530.3)	15195.0	(4164.6)	7970.0	(2239.7)
Developed area	5.2	(3.2)	0.3	(0.3)	2.5	(0.9)	3.9	(3.9)
Developed patches	4.0	(2.4)	1.2	(1.2)	6.7	(2.8)	6.3	(6.3)
Developed edge	2450.0	(1224.4)	225.0	(225.0)	1935.0	(673.3)	2070.0	(2070.0)
Deciduous forest area	143.4	(8.3)	221.8	(14.7)	17.9	(5.6)	121.0	(21.2)
Deciduous forest patches	47.2	(4.1)	25.8	(3.3)	32.7	(4.9)	44.0	(6.7)
Deciduous forest edge	37135.0	(2260.6)	32530.0	(1821.1)	10320.0	(2400.5)	32570.0	(2938.5)

Table 5 continued.

Variable	Ft. Chaffee		Camp Robinson		Ft. Bragg		Ft. Benning	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Evergreen forest area	2.3	(1.3)	14.4	(3.4)	171.1	(15.2)	51.1	(9.4)
Evergreen forest patches	5.8	(2.8)	16.8	(3.9)	37.7	(4.8)	38.8	(9.1)
Evergreen forest edge	1520.0	(754.6)	6700.0	(1512.3)	37665.0	(1618.9)	18740.0	(2520.5)
Mixed forest area	13.5	(3.3)	2.0	(1.0)	3.6	(1.2)	33.4	(8.9)
Mixed forest patches	31.0	(7.0)	6.3	(3.8)	11.8	(4.2)	68.7	(9.6)
Mixed forest edge	8720.0	(1973.5)	1560.0	(884.4)	2895.0	(926.1)	20880.0	(4463.8)
Shrub/scrub area	10.4	(2.1)	0.0	(0.0)	2.2	(0.7)	22.3	(9.7)
Shrub/scrub patches	29.0	(4.4)	0.0	(0.0)	8.0	(2.5)	28.3	(10.2)
Shrub/scrub edge	7165.0	(1235.0)	0.0	(0.0)	1670.0	(478.7)	11570.0	(4864.6)
Grassland/herbaceous area	79.8	(25.2)	32.7	(8.0)	38.6	(10.7)	11.4	(7.9)
Grassland/herbaceous patches	41.5	(7.0)	32.8	(7.7)	50.5	(5.5)	14.2	(5.2)
Grassland/herbaceous edge	24325.0	(5112.4)	15370.0	(3580.9)	18285.0	(2636.1)	4365.0	(1892.9)
Pasture/hay area	40.0	(25.5)	4.8	(2.5)	1.8	(1.2)	11.3	(5.4)
Pasture/hay patches	5.5	(3.3)	5.3	(2.7)	5.0	(2.8)	18.2	(6.3)
Pasture/hay edge	6915.0	(4479.5)	2480.0	(1273.1)	1290.0	(783.5)	6330.0	(2629.4)

Table 5 continued.

Variable	Ft. Chaffee		Camp Robinson		Ft. Bragg		Ft. Benning	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Cultivated crop area	0.2	(0.2)	9.9	(9.8)	1.4	(0.8)	4.8	(1.9)
Cultivated crop patches	0.3	(0.3)	0.7	(0.5)	2.5	(1.2)	7.3	(2.1)
Cultivated crop edge	150.0	(150.0)	875.0	(761.3)	820.0	(461.2)	2560.0	(920.2)
Woody wetland area	1.0	(0.8)	8.4	(8.4)	36.8	(6.0)	20.7	(5.8)
Woody wetland patches	3.7	(2.6)	1.2	(1.2)	17.2	(3.0)	26.5	(10.8)
Woody wetland edge	715.0	(515.8)	990.0	(990.0)	12475.0	(1335.9)	10315.0	(3066.3)
Emergent herbaceous wetland area	0.0	(0.0)	1.5	(1.5)	1.1	(0.8)	0.3	(0.2)
Emergent herb. wetland patches	0.2	(0.2)	0.5	(0.5)	2.8	(1.4)	0.7	(0.5)
Emergent herbaceous wetland edge	25.0	(25.0)	335.0	(335.0)	770.0	(481.1)	215.0	(151.1)
Station variables								
Deciduous forest	25.3	(4.8)	31.9	(12.3)	6.4	(3.2)	0.0	(0.0)
Evergreen forest	0.0	(0.0)	10.3	(6.5)	25.5	(10.7)	13.5	(12.2)
Mixed forest	5.0	(3.2)	8.7	(4.4)	25.0	(6.4)	27.6	(9.3)
Shrub/scrub	33.0	(8.8)	37.8	(11.1)	9.4	(4.7)	25.8	(11.7)
Open/grassland/herbaceous	36.8	(12.7)	11.2	(4.3)	33.7	(15.7)	33.0	(9.9)

Table 5 continued.

	Ft. Chaffee		Camp Robinson		Ft. Bragg		Ft. Benning	
Variable	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Canopy cover	23.7	(2.4)	35.6	(6.9)	25.7	(5.3)	22.1	(5.4)
Canopy snags	1.0	(0.1)	1.3	(0.3)	1.3	(0.3)	0.8	(0.3)
Subcanopy cover	10.6	(1.6)	11.4	(2.3)	13.0	(3.0)	10.8	(3.6)
Subcanopy snags	0.6	(0.1)	0.5	(0.1)	1.6	(0.3)	0.9	(0.2)
Shrub cover	56.4	(1.2)	37.1	(5.3)	43.5	(7.7)	39.8	(6.9)
Ground cover	54.7	(2.8)	62.5	(2.7)	81.5	(2.5)	76.6	(2.7)

Table 6. Factor loadings for habitat variables included in a principal components analysis and varimax rotation on three principal components axes. Forty-seven variables were included in the analyses; only those variables (34) that contributed strongly to one of the axes (> |0.50|) are shown. High factor loadings (> 0.50) are bolded to highlight important axis descriptors; These three axes described 52% of the variation in the habitat data.

Variable	Axis 1	Axis 2	Axis 3
1-km landscape variables			
Shannon diversity index	**0.84**	0.00	0.28
Patch aggregation index	**-0.81**	0.13	-0.22
1-km class variables			
Water edge	0.35	0.02	**0.64**
Developed open space area	-0.06	0.39	**0.66**
Developed open space patches	-0.22	**0.57**	-0.00
Developed open space edge	-0.29	**0.61**	0.27
Developed area	0.02	0.09	**0.83**
Developed patches	0.03	0.33	**0.80**
Developed edge	0.03	0.22	**0.88**
Deciduous forest area	**-0.60**	**-0.52**	-0.22
Deciduous forest edge	-0.24	**-0.84**	-0.02
Evergreen forest area	0.42	**0.71**	-0.08
Evergreen forest patches	**0.77**	0.28	-0.10
Evergreen forest edge	**0.61**	**0.68**	-0.09
Mixed forest area	**0.55**	-0.46	-0.01
Mixed forest patches	**0.67**	**-0.57**	-0.04
Mixed forest edge	**0.59**	**-0.51**	-0.04
Shrub/scrub area	**0.69**	**-0.52**	0.20
Shrub/scrub patches	**0.57**	**-0.56**	0.39

Table 6 continued.

Variable	Axis 1	Axis 2	Axis 3
Shrub/scrub edge	**0.68**	**-0.54**	0.24
Grassland/herbaceous edge	-0.30	**0.51**	0.34
Pasture/hay patches	**0.51**	-0.38	-0.33
Pasture/hay edge	0.22	**-0.51**	-0.29
Cultivated crop patches	**0.78**	-0.16	0.04
Cultivated crop edge	**0.59**	-0.18	-0.09
Woody wetland area	**0.65**	0.56	-0.32
Woody wetland patches	**0.90**	-0.04	-0.02
Woody wetland edge	**0.89**	0.33	-0.18
Emergent herbaceous wetland patches	0.44	**0.51**	-0.07
Station variables			
Canopy cover	-0.28	0.22	**-0.55**
Ground cover	**0.58**	**0.54**	-0.05
Subcanopy snags	0.32	**0.76**	-0.02
Canopy snags	-0.11	**0.53**	-0.34
Deciduous forest	**-0.57**	-0.14	-0.13

Table 7. Models describing relationship between body weight of individual captures and wing chord length, time of day, season, and temperature. Only variables deemed significant ($P < 0.05$) in backward stepwise regression were included in models.

		All birds		Adults (AHY/ASY)		Young (HY/SY)	
Species	Variable[1]	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2
Carolina Chickadee	Wing	+ 0.52****	0.45	+ 0.54****	0.46	+ 0.46****	0.44
	Time of day	+ 0.17****		+ 0.15****		+ 0.16****	
	04,05 < 06,07	+ 0.05*		—		—	
	04 < 05	+ 0.10**		—		—	
	04 < 05,06,07	—		—		+ 0.14*	
Tufted Titmouse	Wing	+ 0.79****	0.33	+ 0.84****	0.41	+ 0.79****	0.39
	Time of day	+ 0.24****		+ 0.18**		+ 0.23****	
	Day of season	- 0.08*		—		—	
	Temperature	- 0.20****		- 0.18**		- 0.04****	
	04 < 05,06,07	+ 0.13*		—		—	
	04,05 < 06,07	—		+ 0.15*		—	

Table 7 continued.

		All birds		Adults (AHY/ASY)		Young (HY/SY)	
Species	Variable[1]	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2
Ruby-crowned Kinglet	Wing	+ 0.22****	0.23	+ 0.23****	0.28	+ 0.23****	0.23
	Time of day	+ 0.09****		+ 0.10****		+ 0.10****	
	Day of season	+ 0.07****		+ 0.07****		—	
	(Day of season)^2	- 0.05****		- 0.08****		—	
	Temperature	+ 0.06****		+ 0.07****		—	
	05,06 < 04,07	—		+ 0.03*		—	
Hermit Thrush	Wing	+ 0.81****	0.30	+ 0.56****	0.36	+ 0.91****	0.33
	Time of day	+ 0.33****		+ 0.49****		+ 0.27***	
	Day of season	+ 0.63****		+ 0.72****		+ 0.58****	
	(Day of season)^2	- 0.99****		- 1.33****		- 0.94****	
	Temperature	—		+ 0.26*			
	05 < 04,06,07	+ 0.27****		—		+ 0.43****	
	04,07 < 06	+ 0.16*		—			
	05,07 < 04,06	—		+ 0.26*			

Table 7 continued.

		All birds		Adults (AHY/ASY)		Young (HY/SY)	
Species	Variable	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2
Field Sparrow	Wing	+ 0.49****	0.27	+ 0.45****	0.26	+ 0.45****	0.30
	Time of day	+ 0.12****		—		+ 0.13***	
	Day of season	+ 0.08**		+ 0.06		—	
	(Day of season)^2	- 0.133****		- 0.25****		—	
	Temperature	- 0.07**		—		- 0.18****	
	04 < 05,06,07	+ 0.09***		—		+ 0.20****	
	07 < 05,06	+ 0.05*		—		—	
	04,07 < 05,06	—		+ 0.14****		—	
	07 < 04	—		+ 0.16**		—	
Song Sparrow	Wing	+ 0.73****	0.37	+ 0.83****	0.39	+ 0.63****	0.36
	Time of day	+ 0.19****		+ 0.20**		+ 0.17**	
	Day of season	+ 0.71****		+ 0.71****		0.67****	
	(Day of season)^2	- 0.54****		- 0.72****		- 0.54****	
	Temperature	—		—		- 0.14*	
	04 < 05,06,07	+ 0.10*		—		—	
	04,06 < 05,07	—		—		+ 0.17**	

Table 7 continued.

		All birds		Adults (AHY/ASY)		Young (HY/SY)	
Species	Variable	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2	$\hat{\beta}^2$	Model R^2
Swamp Sparrow	Wing	+ 0.70****	0.39	+ 0.73****	0.44	+ 0.64****	0.39
	Time of day	+ 0.15****		+ 0.23****		+ 0.15****	
	Day of season	+ 0.44****		+ 0.41****		+ 0.41****	
	(Day of season)^2	- 0.55****		- 0.66****		- 0.50****	
White-throated Sparrow	Wing	+ 1.14****	0.39	+ 1.17****	0.43	+ 1.02****	
	Time of day	+ 0.35****		+ 0.29****		+ 0.39****	
	Day of season	+ 0.57****		+ 0.56****		+ 0.42****	
	(Day of season)^2	- 0.59****		- 0.92****		- 0.52****	
	Temperature	- 0.13****		—		- 0.15**	
	04,07 < 05,06	+ 0.22****		—		+ 0.38****	
	07 < 04	+ 0.13**		—		—	
	04,05,07 < 06	—		+ 0.19**		—	
	04,07 < 05	—		+ 0.15**		—	
	05 < 06	—		—		+ 0.18*	

Table 7 continued.

		All birds		Adults (AHY/ASY)		Young (HY/SY)	
Species	Variable	$\hat{\beta}$ [2]	Model R^2	$\hat{\beta}$ [2]	Model R^2	$\hat{\beta}$ [2]	Model R^2
Dark-eyed (Slate-colored) Junco	Wing	+ 0.52****	0.35	+ 0.56****	0.46	+ 0.45****	0.33
	Time of day	+ 0.23****		+ 0.23****		+ 0.23****	
	Day of season	+ 0.40****		+ 0.41****		+ 0.20****	
	(Day of season)^2	- 0.35****		- 0.40****		- 0.36****	
	04,06 < 05,07	+ 0.07*		—		+ 0.12**	
	07 < 05	+ 0.09*		—		—	
Northern Cardinal	Wing	+ 1.52****	0.25	+ 1.25****	0.32	+ 1.24****	0.31
	Day of season	+ 0.10		+ 0.46		0.15	
	(Day of season)^2	- 0.39**		- 1.14***		- 1.45***	
	Temperature	- 0.43****		—		—	
	04,05,07 < 06	+ 0.29**		—		—	
	05,07 < 06	—		- 0.97**		—	
	07 < 04,05,06	—		—		+ 0.78**	

[1] Variables included in backward stepwise regression procedure (prob. to leave = 0.05). Wing = wing chord length; Time of day is in minutes (to the nearest 10 min.); Day of season is numeric continuous variable beginning on the first day of the MoSI season; Temperature is mean temperature (°C) on banding day; remaining variables describe year differences with the 2003-04 MAWS season represented by “04”, the 2004-05 MAWS season represented by “05”, etc.

[2] Slope parameter estimates. * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; **** = $P < 0.0001$.

Table 8. Models describing relationship between mean station-scale body condition and three composite habitat axes derived from a principal components analysis on 47 habitat variables (see Tables 5 and 6). Only axes deemed significant ($P < 0.05$) in backward stepwise regression were included in models.

		All birds		Adults (AHY/ASY)		Young (HY/SY)	
Species	Variable	$\hat{\beta}$ [1]	Model R^2	$\hat{\beta}$ [1]	Model R^2	$\hat{\beta}$ [1]	Model R^2
Carolina Chickadee	Axis 1	- 0.17*	0.58	- 0.23*	0.47	- 0.16*	0.47
	Axis 2	- 0.22****		- 0.21**		- 0.17**	
Tufted Titmouse	Axis 1	- 0.21**	0.52	—	0.19	—	0.26
	Axis 2	- 0.22**		- 0.17*		- 0.25*	
Ruby-crowned Kinglet	Axis 2	- 0.04*	0.46	- 0.06**	0.40	- 0.08**	0.40
	(Axis 2) [2]	+ 0.06**		—		+ 0.07*	
	Axis 3	—		- 0.04*			
Hermit Thrush	No variables significant						
Field Sparrow	Axis 1	- 0.24**	0.59	- 0.30****	0.62	- 0.18**	0.66
	Axis 2	- 0.26***		- 0.25**		- 0.32****	
Song Sparrow	Axis 1	- 0.22**	0.39	- 0.26*	0.25	- 0.19**	0.27
Swamp Sparrow	Axis 1	- 0.20**	0.37	—	0.00	- 0.21	0.48
White-throated Sparrow	Axis 2	- 0.29*	0.25	- 0.51**	0.36	—	0.00
Dark-eyed (Slate-colored) Junco	Axis 3	+ 0.18**	0.30	+ 0.28**	0.42	+ 0.17*	0.25

Table 8 continued.

		All birds		Adults (AHY/ASY)		Young (HY/SY)	
Species	Variable	$\hat{\beta}$	Model R^2	$\hat{\beta}$	Model R^2	$\hat{\beta}$	Model R^2
Northern Cardinal	Axis 2	- 0.71**	0.38	- 1.16**	0.54	—	0.00
	Axis 3	—		+ 0.58*			

[1] Slope parameter estimates. * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; **** = $P < 0.0001$.

Table 9. Model selection (QAICc weights, w_i) for age, installation, and year effects on monthly apparent survival-rate (ϕ) and recapture probability (*p)* for ten focal species (see text) for the four MAWS seasons 2003-04, 2004-05, 2005-06, and 2006-07 for the analysis of the effects of age and installation on survival. Strong effects ($w_i > 0.4$) are shown in bold, moderate effects ($0.4 \geq w_i > 0.3$) are underlined, and weak effects ($0.3 \geq w_i > 0.2$) are shown in italics.

	Age effects		Year effects		Installation effects	
Species	ϕ	*p*	ϕ	*p*	ϕ	*p*
Carolina Chickadee	0.144	*0.244*	**0.452**	0.074	0.012	0.156
Tufted Titmouse	**0.730**	**0.772**	0.142	0.039	0.196	0.045
Ruby-crowned Kinglet	0.188	0.095	0.047	**0.403**	*0.295*	**0.654**
Hermit Thrush	*0.255*	0.055	0.047	0.007	0.042	**0.996**
Field Sparrow	**0.736**	0.006	0.028	**0.869**	0.016	**0.999**
Song Sparrow	**0.560**	0.001	0.004	**1.000**	**0.997**	**0.996**
Swamp Sparrow	**0.954**	0.057	0.021	**0.850**	0.052	**0.713**
White-throated Sparrow	**0.998**	**1.000**	0.024	**1.000**	0.005	**1.000**
Dark-eyed Junco	0.124	0.193	0.028	0.032	0.097	**0.523**
Northern Cardinal	**0.422**	<u>0.341</u>	0.017	0.097	0.007	0.070

Table 10. Model-averaged time-constant monthly apparent survival-rate estimates and standard errors (SEs) for the over-wintering (W) and over-summering (S) periods (November 2003 - March 2007) for ten target species by installation and age.

		Fort Chaffee				Camp Robinson				Fort Bragg				Fort Benning			
		Adult		Young		Adult		Young		Adult		Young		Adult		Young	
Species	Seas.[1]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]
Carolina Chickadee	W04	0.956	0.059	0.960	0.060	0.957	0.059	0.960	0.060	0.957	0.059	0.961	0.060	0.957	0.059	0.961	0.060
	S04	0.926	0.036	0.921	0.040	0.925	0.036	0.920	0.040	0.926	0.036	0.921	0.040	0.926	0.036	0.921	0.040
	W05	0.992	0.025	0.995	0.021	0.992	0.025	0.996	0.021	0.992	0.025	0.996	0.020	0.992	0.024	0.996	0.020
	S05	0.889	0.021	0.884	0.020	0.889	0.021	0.884	0.020	0.889	0.021	0.884	0.020	0.889	0.021	0.884	0.020
	W06	0.963	0.049	0.967	0.049	0.964	0.049	0.967	0.049	0.964	0.049	0.967	0.049	0.964	0.048	0.967	0.049
	S06	0.902	0.020	0.898	0.022	0.902	0.021	0.897	0.023	0.902	0.020	0.897	0.022	0.903	0.020	0.898	0.022
	W07	0.992	0.025	0.995	0.021	0.992	0.025	0.996	0.021	0.992	0.024	0.996	0.020	0.992	0.024	0.996	0.020
Tufted Titmouse	W04	0.933	0.063	0.911	0.068	0.909	0.066	0.914	0.067	0.920	0.078	0.910	0.083	0.920	0.070	0.898	0.084
	S04	0.909	0.036	0.862	0.053	0.913	0.042	0.824	0.093	0.900	0.056	0.875	0.067	0.919	0.043	0.861	0.058
	W05	0.932	0.059	0.911	0.063	0.908	0.061	0.914	0.063	0.919	0.075	0.910	0.080	0.919	0.065	0.897	0.081
	S05	0.891	0.041	0.845	0.040	0.896	0.047	0.806	0.079	0.882	0.056	0.857	0.061	0.901	0.051	0.843	0.046
	W06	0.945	0.062	0.923	0.072	0.921	0.069	0.926	0.071	0.933	0.080	0.922	0.087	0.933	0.071	0.910	0.090
	S06	0.901	0.032	0.855	0.043	0.905	0.039	0.816	0.085	0.892	0.052	0.867	0.061	0.911	0.042	0.853	0.048
	W07	0.944	0.062	0.923	0.071	0.920	0.069	0.926	0.070	0.931	0.080	0.922	0.086	0.931	0.071	0.909	0.089

Table 10 continued.

		Fort Chaffee				Camp Robinson				Fort Bragg				Fort Benning			
		Adult		Young		Adult		Young		Adult		Young		Adult		Young	
Species	Seas.[1]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]
Ruby-crown. Kinglet	W04	0.679	0.057	0.669	0.064	0.651	0.060	0.640	0.065	0.675	0.048	0.665	0.056	0.677	0.046	0.666	0.054
	S04	0.973	0.034	0.967	1.743	0.977	0.389	0.972	1.786	0.948	0.531	0.942	1.822	0.977	0.028	0.972	1.743
	W05	0.672	0.052	0.662	0.058	0.644	0.052	0.633	0.055	0.668	0.041	0.658	0.048	0.670	0.039	0.659	0.047
	S05	0.975	0.029	0.970	0.036	0.979	0.022	0.974	0.030	0.950	0.041	0.945	0.044	0.979	0.022	0.974	0.030
	W06	0.676	0.050	0.665	0.057	0.648	0.052	0.637	0.056	0.672	0.039	0.662	0.047	0.674	0.037	0.663	0.046
	S06	0.976	0.030	0.971	0.036	0.980	0.022	0.976	0.031	0.951	0.042	0.946	0.044	0.980	0.022	0.976	0.031
	W07	0.677	0.050	0.666	0.058	0.649	0.053	0.637	0.057	0.673	0.040	0.662	0.048	0.675	0.037	0.664	0.046
Hermit Thrush	W04	0.820	0.030	0.824	0.028	0.821	0.028	0.820	0.028	0.820	0.029	0.820	0.030	0.821	0.034	0.821	0.034
	S04	0.936	0.016	0.944	0.015	0.944	0.015	0.936	0.015	0.943	0.017	0.936	0.016	0.945	0.020	0.938	0.020
	W05	0.816	0.026	0.819	0.025	0.817	0.024	0.816	0.024	0.816	0.026	0.816	0.026	0.817	0.031	0.816	0.031
	S05	0.935	0.016	0.943	0.015	0.943	0.016	0.936	0.015	0.943	0.017	0.935	0.016	0.944	0.020	0.937	0.020
	W06	0.819	0.026	0.822	0.024	0.819	0.024	0.819	0.024	0.819	0.026	0.819	0.026	0.820	0.031	0.819	0.031
	S06	0.937	0.016	0.945	0.015	0.944	0.015	0.937	0.015	0.944	0.016	0.937	0.016	0.946	0.019	0.938	0.020
	W07	0.817	0.025	0.821	0.024	0.818	0.023	0.817	0.023	0.817	0.025	0.817	0.025	0.818	0.030	0.818	0.031

Table 10 continued.

		Fort Chaffee				Camp Robinson				Fort Bragg				Fort Benning			
		Adult		Young		Adult		Young		Adult		Young		Adult		Young	
Species	Seas.[1]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]	$\hat{\phi}^2$	SE[3]
Field Sparrow	W04	0.910	0.053	0.816	0.064	0.912	0.054	0.819	0.068	0.915	0.052	0.822	0.071	0.911	0.051	0.817	0.064
	S04	0.935	0.025	0.925	0.032	0.934	0.026	0.923	0.032	0.932	0.026	0.921	0.031	0.935	0.024	0.924	0.031
	W05	0.910	0.052	0.815	0.064	0.912	0.053	0.818	0.068	0.915	0.051	0.821	0.071	0.911	0.050	0.817	0.064
	S05	0.935	0.025	0.924	0.032	0.933	0.026	0.923	0.032	0.931	0.026	0.921	0.032	0.934	0.024	0.924	0.031
	W06	0.912	0.052	0.817	0.068	0.914	0.053	0.820	0.072	0.917	0.052	0.823	0.075	0.913	0.051	0.818	0.068
	S06	0.935	0.025	0.922	2.801	0.933	0.026	0.920	2.801	0.931	0.026	0.918	2.801	0.934	0.024	0.921	2.801
	W07	0.908	0.057	0.814	0.066	0.910	0.057	0.816	0.070	0.913	0.056	0.819	0.073	0.909	0.055	0.815	0.066
Song Sparrow	W04	0.900	0.062	0.791	0.104	0.887	0.061	0.852	0.095	0.999	0.070	0.999	0.012	0.751	0.057	0.686	0.061
	S04	0.919	0.031	0.883	0.052	0.972	0.030	0.937	0.049	0.766	0.083	0.750	0.051	0.974	0.033	0.968	0.036
	W05	0.901	0.062	0.792	0.105	0.886	0.059	0.851	0.094	0.999	0.070	0.999	0.013	0.750	0.056	0.686	0.059
	S05	0.919	0.031	0.883	0.086	0.972	0.030	0.937	0.049	0.766	0.049	0.750	0.067	0.974	0.033	0.968	0.036
	W06	0.902	0.061	0.792	0.105	0.886	0.059	0.852	0.094	0.998	0.071	0.999	0.020	0.750	0.056	0.686	0.059
	S06	0.919	0.031	0.883	0.052	0.972	0.029	0.937	0.049	0.766	0.049	0.750	0.052	0.974	0.033	0.968	0.036
	W07	0.901	0.061	0.792	0.104	0.887	0.059	0.852	0.094	0.997	0.075	0.998	0.031	0.750	0.057	0.685	0.059

Table 10 continued.

		Fort Chaffee				Camp Robinson				Fort Bragg				Fort Benning			
		Adult		Young		Adult		Young		Adult		Young		Adult		Young	
Species	Seas.[1]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]
Swamp Sparrow	W04	0.869	0.048	0.760	0.060	0.869	0.058	0.760	0.071	0.864	0.046	0.754	0.050	0.861	0.044	0.754	0.047
	S04	0.942	0.028	0.889	0.033	0.931	5.754	0.865	8.482	0.940	0.031	0.890	0.029	0.942	0.028	0.891	0.029
	W05	0.869	0.048	0.760	0.061	0.868	0.059	0.758	0.071	0.865	0.044	0.754	0.050	0.861	0.044	0.753	0.046
	S05	0.940	0.030	0.888	0.033	0.932	0.054	0.866	6.232	0.938	0.032	0.888	0.029	0.940	0.028	0.889	0.029
	W06	0.872	0.049	0.762	0.065	0.872	0.060	0.761	0.075	0.868	0.046	0.757	0.055	0.864	0.047	0.756	0.053
	S06	0.941	0.028	0.888	0.035	0.930	8.666	0.864	—	0.938	0.031	0.888	0.031	0.941	0.028	0.889	0.031
	W07	0.869	0.048	0.759	0.063	0.866	0.780	0.755	0.781	0.864	0.048	0.752	0.052	0.860	0.047	0.752	0.049
White-thr. Sparrow	W04	0.945	0.024	0.832	0.027	0.945	0.025	0.832	0.027	0.944	0.026	0.831	0.028	0.945	0.024	0.831	0.028
	S04	0.945	0.011	0.941	0.012	0.945	0.011	0.941	0.012	0.945	0.012	0.941	0.013	0.945	0.012	0.941	0.013
	W05	0.944	0.022	0.833	0.027	0.944	0.022	0.833	0.027	0.944	0.024	0.833	0.028	0.944	0.023	0.832	0.028
	S05	0.944	0.011	0.940	0.013	0.944	0.011	0.940	0.013	0.944	0.011	0.940	0.014	0.944	0.011	0.940	0.013
	W06	0.947	0.022	0.833	0.030	0.947	0.022	0.833	0.029	0.946	0.023	0.833	0.030	0.947	0.022	0.833	0.030
	S06	0.945	0.011	0.940	0.013	0.945	0.011	0.940	0.013	0.945	0.011	0.940	0.014	0.945	0.011	0.941	0.014
	W07	0.946	0.022	0.832	0.028	0.947	0.022	0.832	0.027	0.946	0.024	0.832	0.028	0.946	0.022	0.831	0.028

Table 10 continued.

		Fort Chaffee				Camp Robinson				Fort Bragg				Fort Benning			
		Adult		Young		Adult		Young		Adult		Young		Adult		Young	
Species	Seas.[1]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]	$\hat{\phi}$[2]	SE[3]
Dark-eyed Junco	W04	0.906	0.061	0.899	0.063	0.914	0.071	0.907	0.073	0.912	0.065	0.905	0.067	0.886	0.092	0.879	0.092
	S04	0.878	0.027	0.879	0.027	0.881	0.033	0.882	0.032	0.873	0.033	0.874	0.032	0.890	0.044	0.891	0.043
	W05	0.905	0.060	0.898	0.062	0.912	0.069	0.905	0.072	0.910	0.064	0.903	0.066	0.884	0.091	0.877	0.090
	S05	0.878	0.028	0.879	0.027	0.881	0.033	0.882	0.032	0.873	0.033	0.873	0.033	0.889	0.044	0.890	0.044
	W06	0.906	0.060	0.898	0.062	0.913	0.070	0.906	0.072	0.911	0.064	0.904	0.066	0.885	0.091	0.878	0.091
	S06	0.880	0.028	0.881	0.028	0.883	0.034	0.884	0.033	0.875	0.034	0.876	0.034	0.892	0.044	0.893	0.044
	W07	0.903	0.060	0.896	0.062	0.911	0.070	0.904	0.072	0.909	0.064	0.902	0.066	0.883	0.091	0.876	0.090
Northern Cardinal	W04	0.905	—	0.875	0.083	0.905	—	0.875	0.083	0.905	—	0.875	0.084	0.906	—	0.875	0.084
	S04	0.950	—	0.924	0.048	0.950	—	0.924	0.048	0.949	—	0.924	0.048	0.949	—	0.924	0.048
	W05	0.906	0.064	0.876	0.080	0.906	0.064	0.876	0.080	0.906	0.065	0.875	0.081	0.906	0.064	0.876	0.080
	S05	0.951	0.034	0.926	0.046	0.951	0.035	0.925	0.046	0.950	2.671	0.925	0.047	0.951	0.035	0.925	0.046
	W06	0.907	0.064	0.877	0.081	0.907	0.065	0.877	0.081	0.907	0.066	0.877	0.081	0.908	0.065	0.877	0.081
	S06	0.951	0.035	0.926	0.046	0.951	0.035	0.925	0.047	0.951	2.671	0.926	0.047	0.951	0.035	0.925	0.047
	W07	0.905	0.065	0.875	0.081	0.905	0.065	0.875	0.081	0.905	0.067	0.875	0.081	0.906	0.065	0.875	0.081

[1] Season: W04 = winter 2003-04; S04 = over-summer 2004; W05 = winter 2004-05; S05 = over-summer 2005; W06 = winter 2005-06; S06 = over-summer 2006; W07 = winter 2006-07.
[2] Model-averaged monthly apparent survival-rate estimates derived from modified Cormack-Jolly-Seber models.
[3] Standard error. Cells with "—" entered had SE estimates > 10.

Table 11. Model selection (QAICc weights, w_i) for age and habitat effects on monthly apparent survival-rate (ϕ) and recapture probability (p) for 10 focal species for the four MAWS seasons 2003-04, 2004-05, 2005-06, and 2006-07 for the analysis of the effects of age and habitat on survival. Strong effects ($w_i > 0.4$) are bolded, moderate effects ($0.4 \geq w_i > 0.3$) are underlined, and weak effects ($0.3 \geq w_i > 0.2$) are italicized.

	Age effects		Habitat effects	
Species	ϕ	p	ϕ	p
Carolina Chickadee	*0.215*	0.199	*0.236*	0.151
Tufted Titmouse	**0.720**	**0.601**	**0.718**	<u>0.360</u>
Ruby-crowned Kinglet	0.014	0.115	**0.789**	**0.931**
Hermit Thrush	*0.244*	0.076	0.084	**0.987**
Field Sparrow	**0.730**	*0.234*	0.105	*0.268*
Song Sparrow	**0.999**	<u>0.395</u>	**0.851**	**0.513**
Swamp Sparrow	**0.976**	*0.255*	0.011	0.136
White-throated Sparrow	**0.966**	**0.964**	0.107	**0.998**
Dark-eyed Junco	0.117	*0.276*	0.191	*0.285*
Northern Cardinal	**0.434**	*0.286*	0.063	*0.293*

Table 12. Station-scale mean feeding rates (no. pecks/sec.; weighted by observation duration) and standard errors (SEs) from foraging observations collected at the Arkansas installations during January-March 2007.

	Song Sparrow			White-throated Sparrow			Dark-eyed Junco		
Station	N	mean	SE	N	mean	SE	N	mean	SE
Fort Chaffee									
JUNC	5	0.10	0.11	8	0.35	0.09	16	0.43	0.08
MELO	7	0.63	0.17	19	0.14	0.05	1	0.64	—
PASS	7	0.44	0.12	6	0.10	0.09	6	0.72	0.10
PIPI	2	0.44	0.54	30	0.16	0.03	2	0.00	0.00
SPIZ	3	0.08	0.07	5	0.42	0.11	—	—	—
ZONO	10	0.24	0.13	11	0.60	0.08	11	0.16	0.06
Camp Robinson									
BUCK	—	—	—	28	0.36	0.04	—	—	—
MIFO	5	0.00	0.00	8	0.20	0.06	—	—	—
NEWB	11	0.67	0.07	11	0.26	0.08	—	—	—
PEED	2	0.33	0.24	15	0.24	0.07	—	—	—
POWC	4	0.14	0.12	7	0.04	0.02	1	0.11	—
SIAM	7	0.18	0.06	10	0.19	0.05	1	0.00	—

Figure 1. 1-km radius landscapes centered on 24 MAWS stations on four southeastern DoD military installations. Mist-net locations are indicated by squares in the core area of landscapes. Four-letter station codes are defined in Table 1.

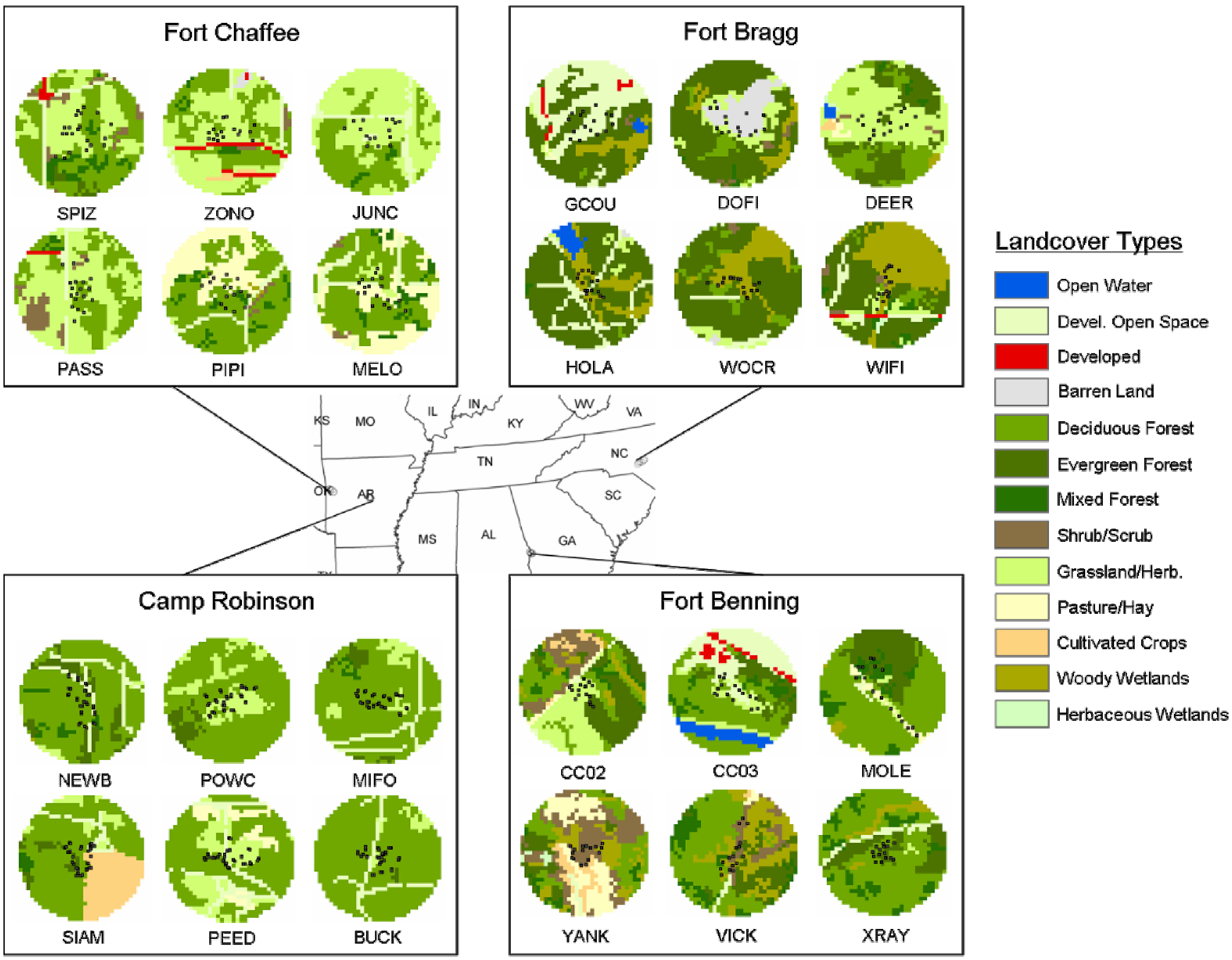


Figure 2. Biplots showing separation of MAWS stations along three principal components axes that describe habitat variation (see Table 5). Data points are labeled with station codes (see Table 1). Ft. Chaffee stations are shown by red circles; Camp Robinson stations are shown as blue exes; Ft. Bragg stations are shown as black diamonds; and Ft. Benning stations are shown as green squares.

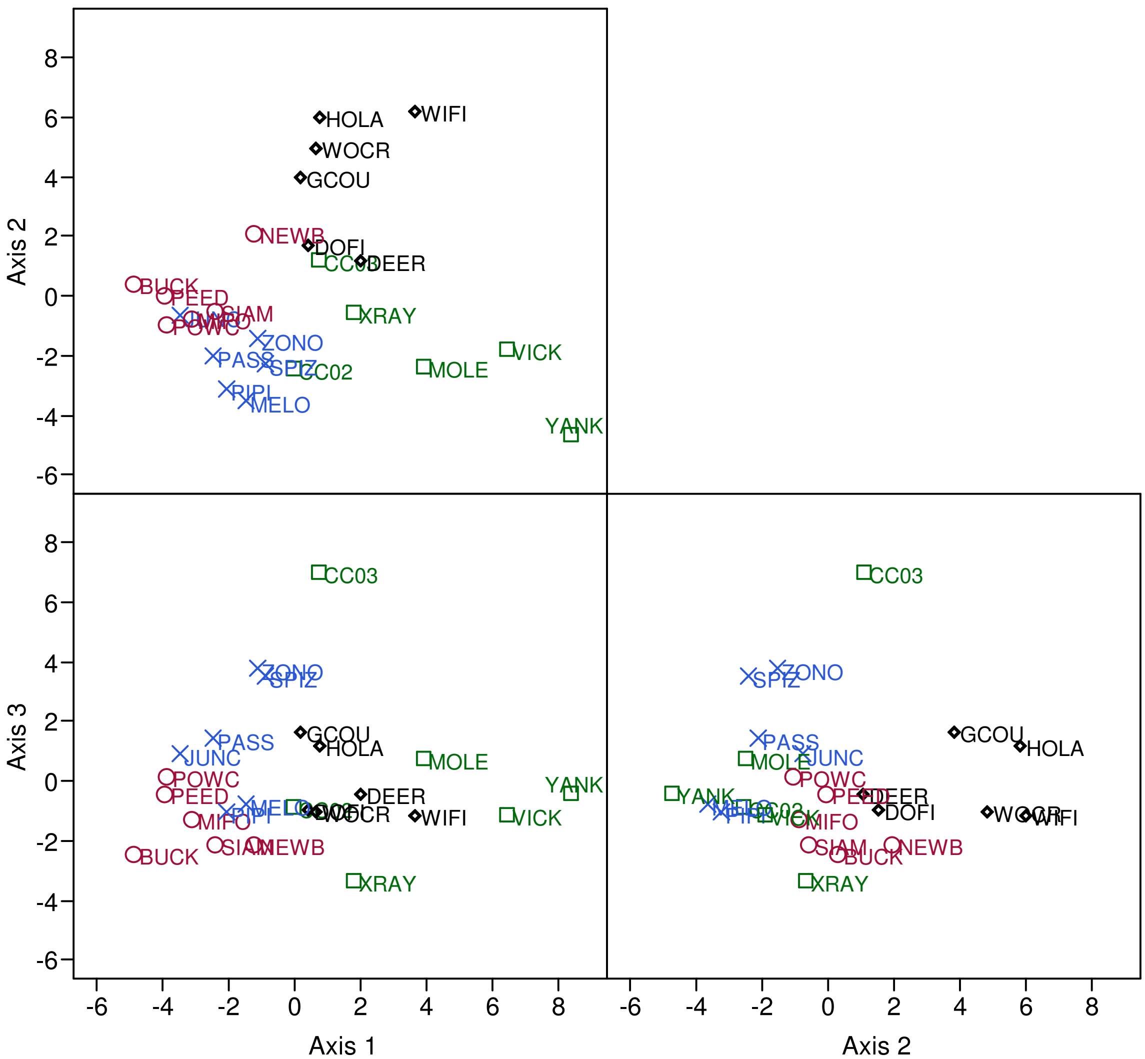


Figure 3. Body condition differences among locations using all ages (young, adult, unknown).

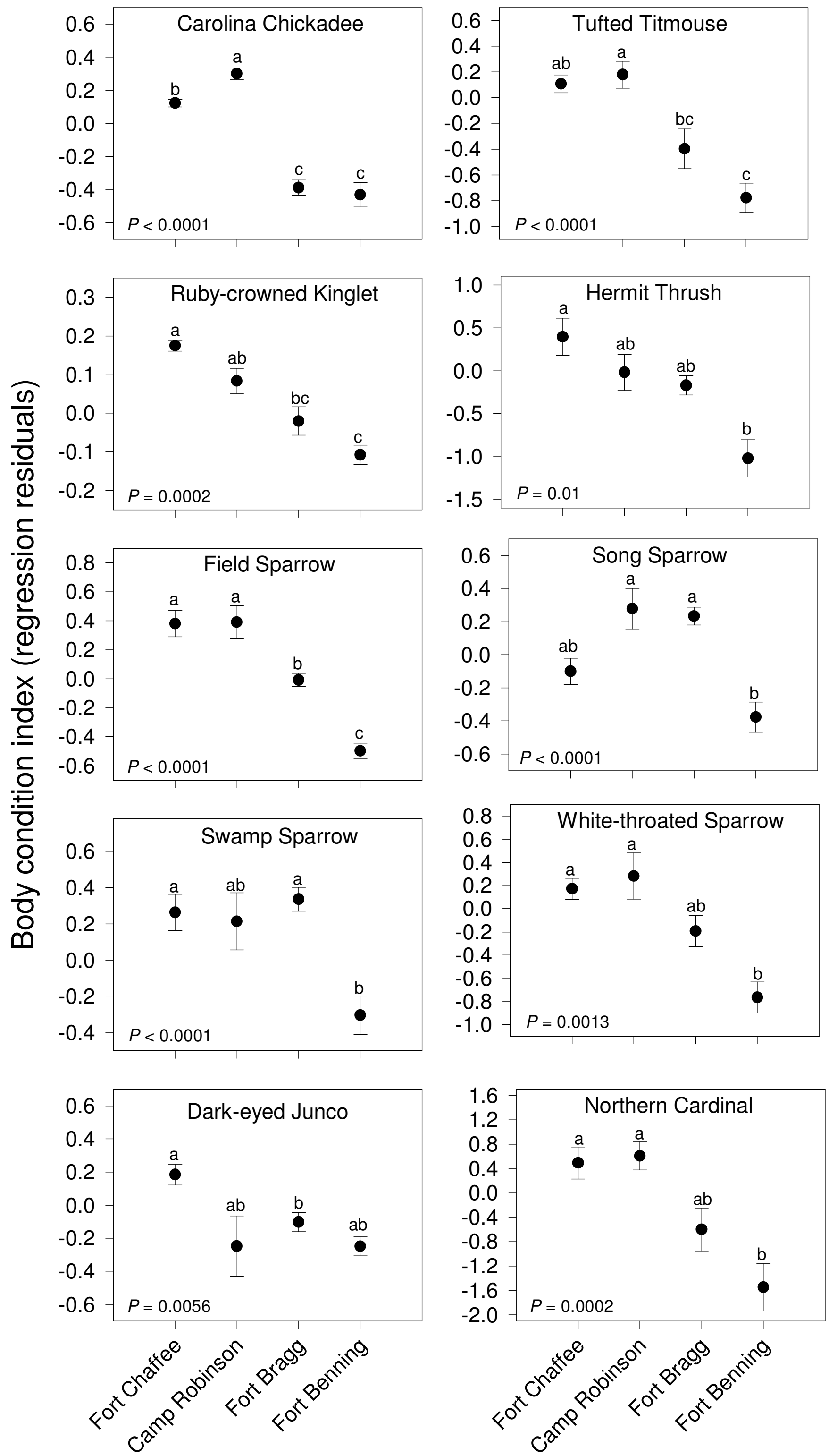


Figure 4. Body condition differences among locations for birds aged as adults (AHY/ASY).

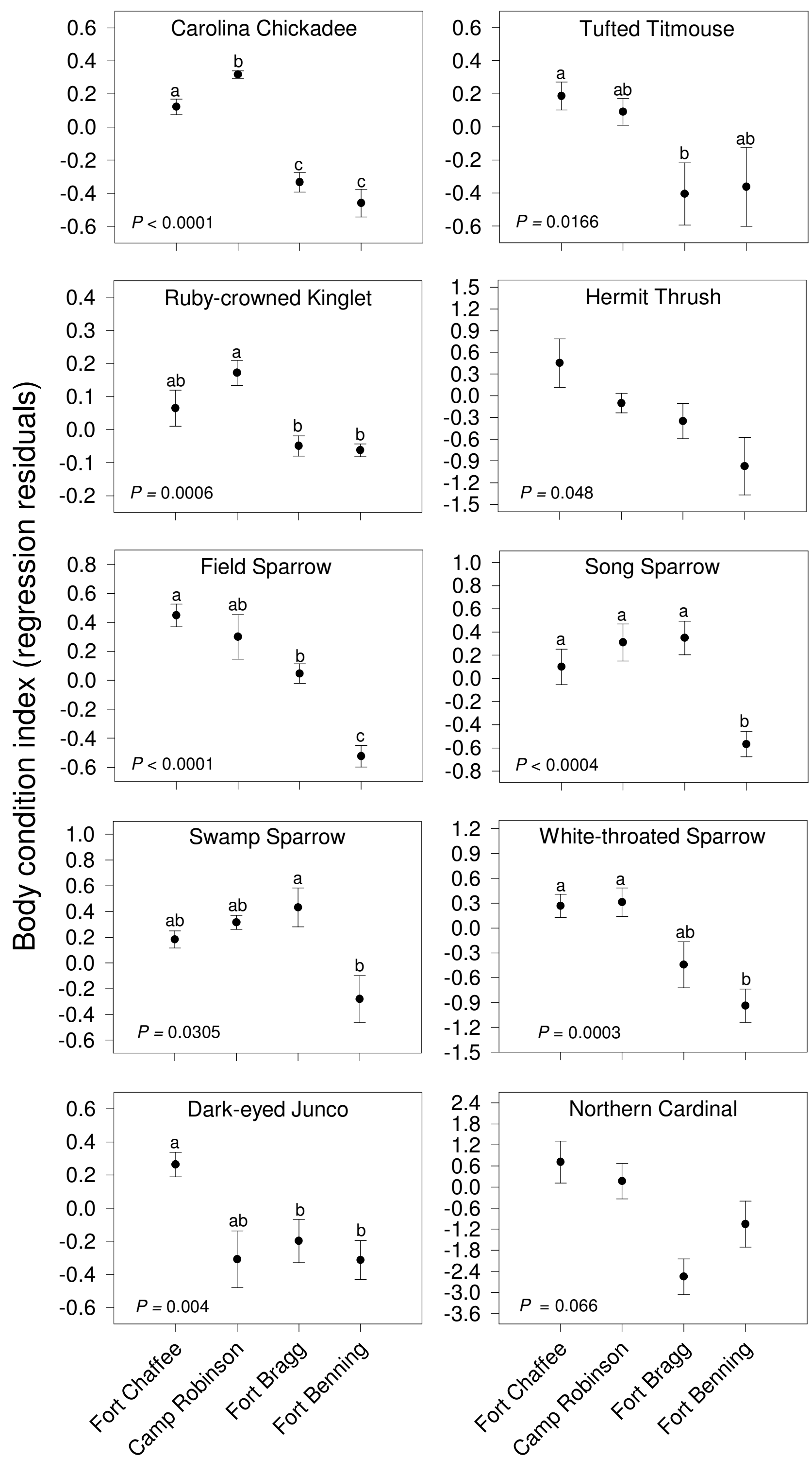


Figure 5. Body condition differences among locations for birds aged as young (HY/SY).

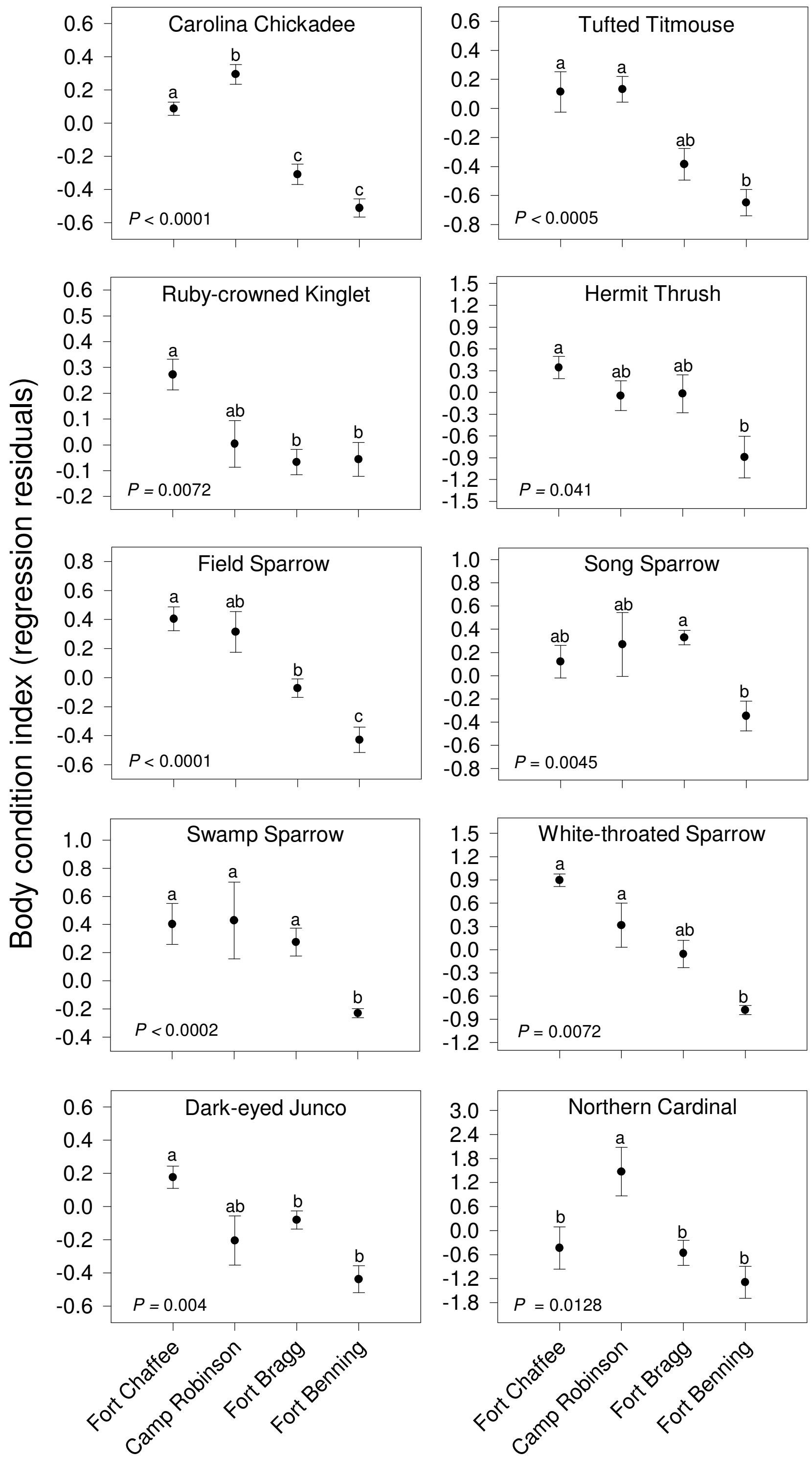


Figure 6. Relationships (linear or quadratic) between mean body condition rank for 10 focal species at 24 MAWS stations and individual habitat features. Only highly significant models (*P* < 0.01) are shown. Data points are labeled with station codes (see Table 1). Ft. Chaffee stations are indicated by blue exes; Camp Robinson stations are indicated by red circles; Ft. Bragg stations are indicated by black diamonds; and Ft. Benning stations are indicated by green squares.

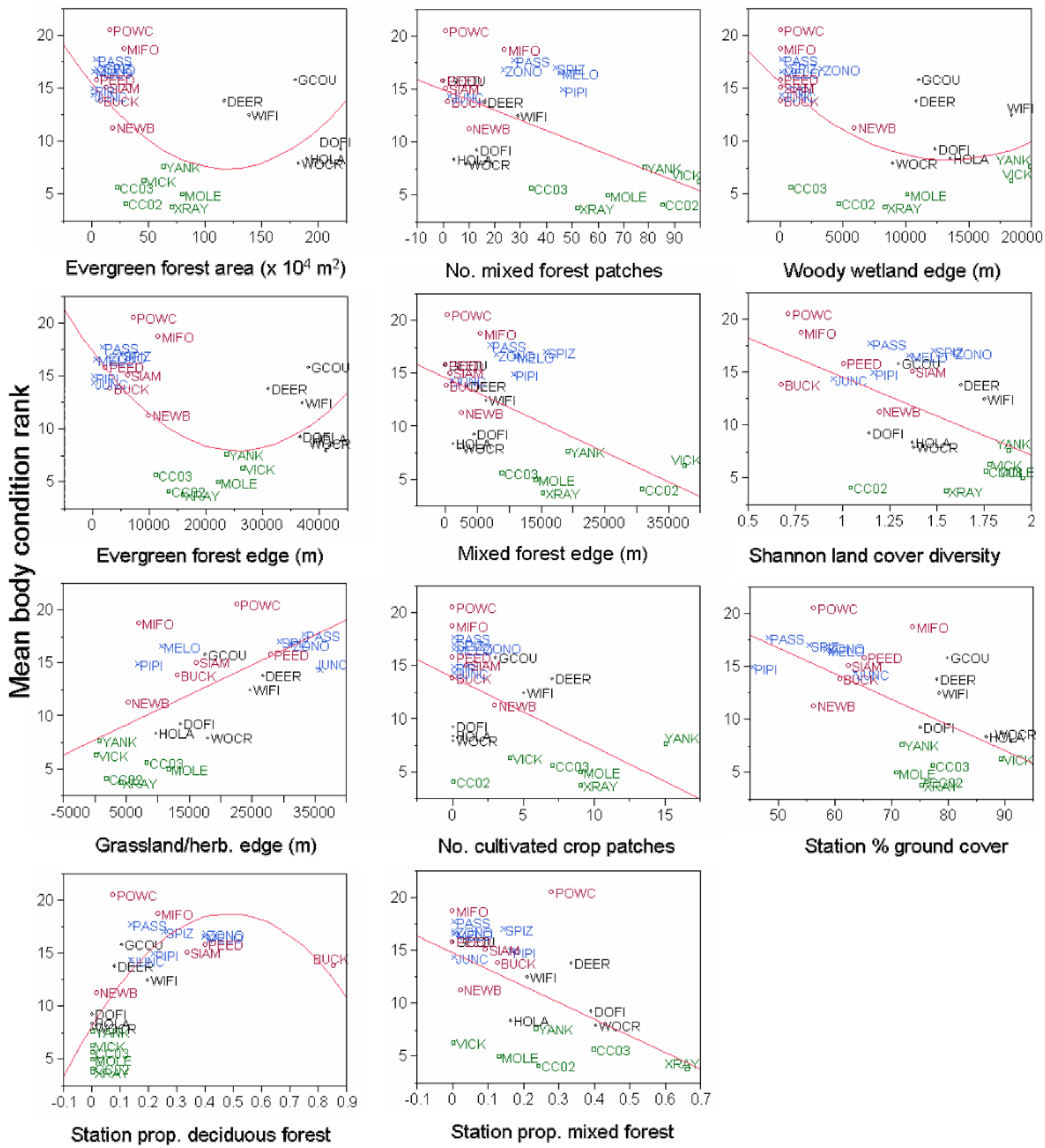


Figure 7. Relationship between habitat axis 3 and model-averaged estimates of apparent monthly over-wintering survival and apparent monthly over-summer (between-year) survival for two age classes of Tufted Titmouse at 24 southeastern MAWS stations. Survival estimates are 'time-constant' (i.e., averaged across months and years). Error bars represent 95% confidence intervals.

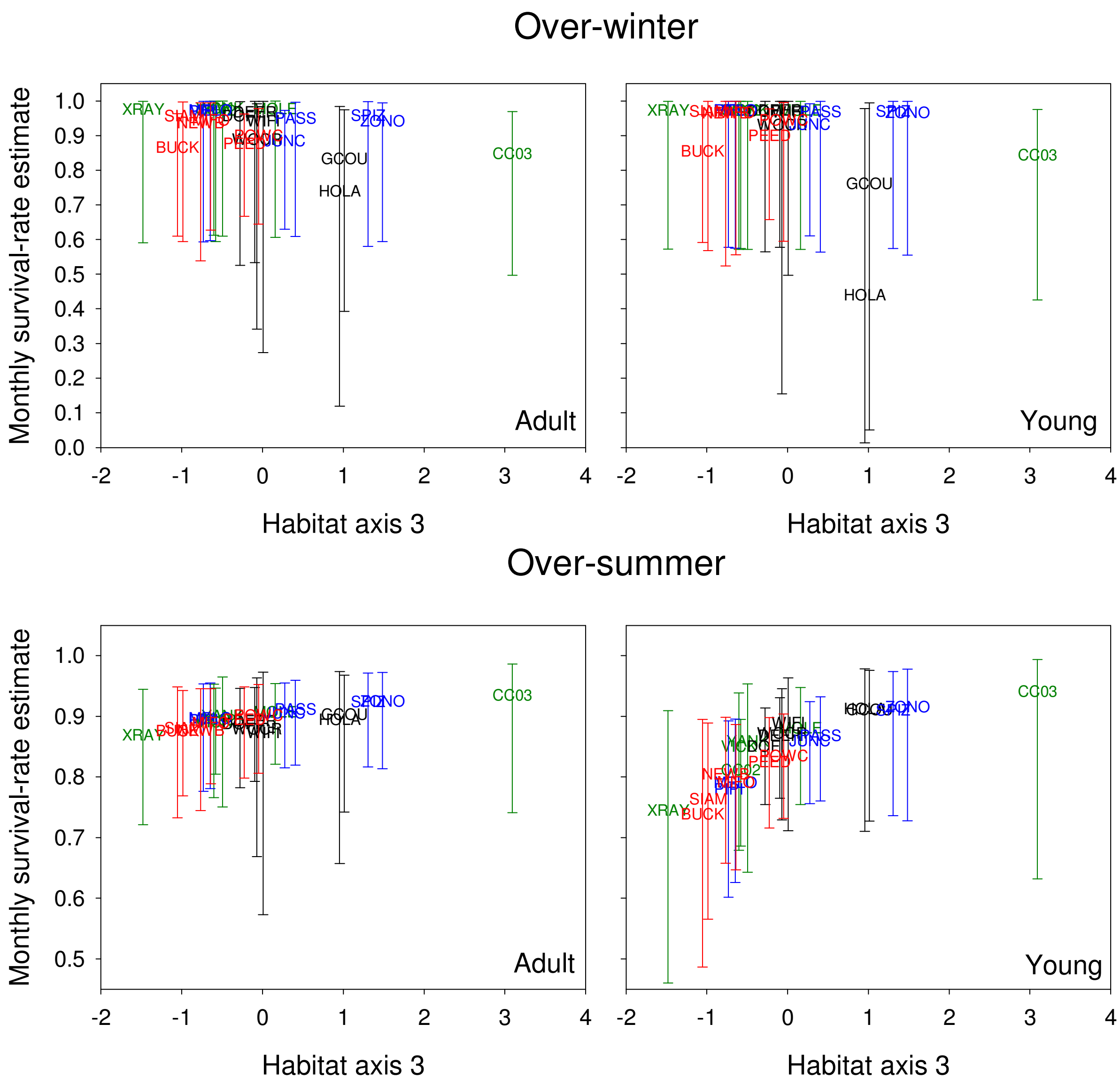


Figure 8. Relationship between habitat axis 1 and model-averaged estimates of apparent monthly over-wintering survival for Ruby-crowned Kinglet at 24 southeastern MAWS stations. There was virtually no statistical support for age-specific survival in this species. Over-summering or 'between-year' survival-rate estimates were unreliable (very large SEs or almost equal to 1). Survival estimates are 'time-constant' (i.e., averaged across months and years). Error bars represent 95% confidence intervals.

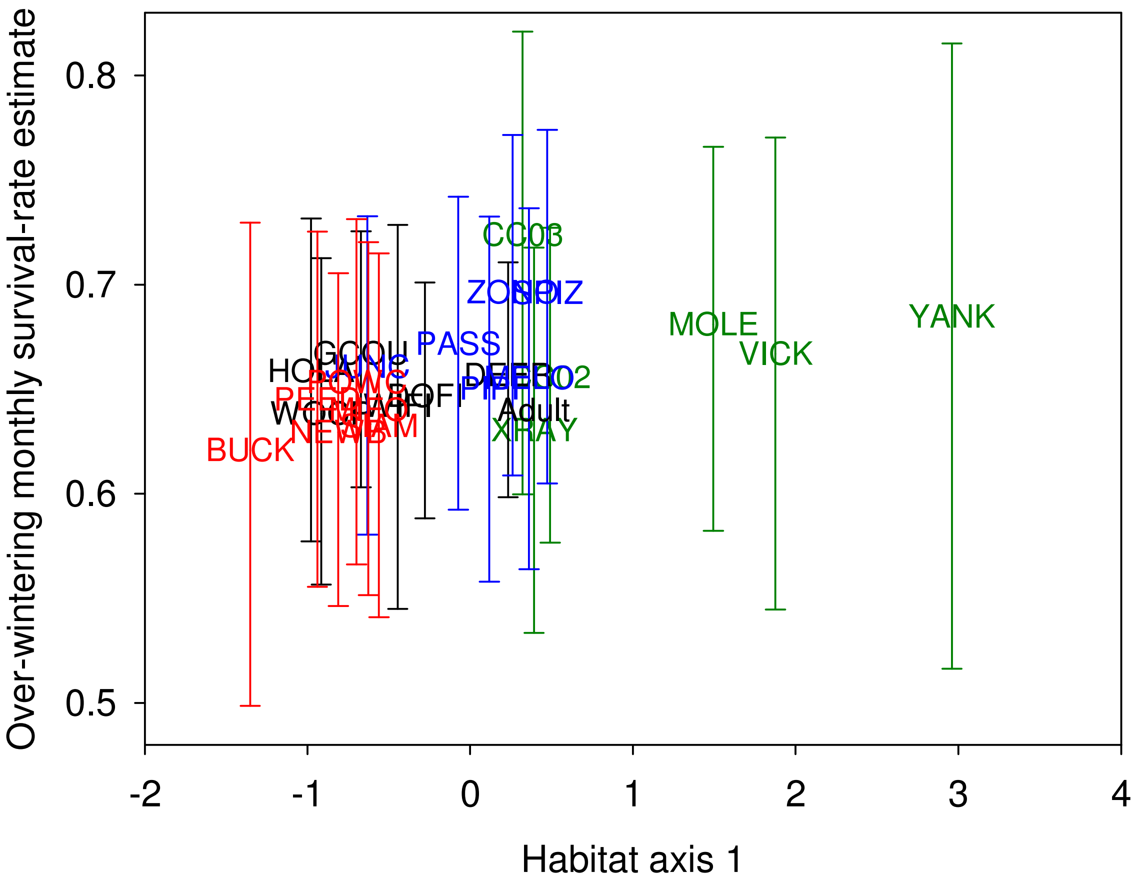
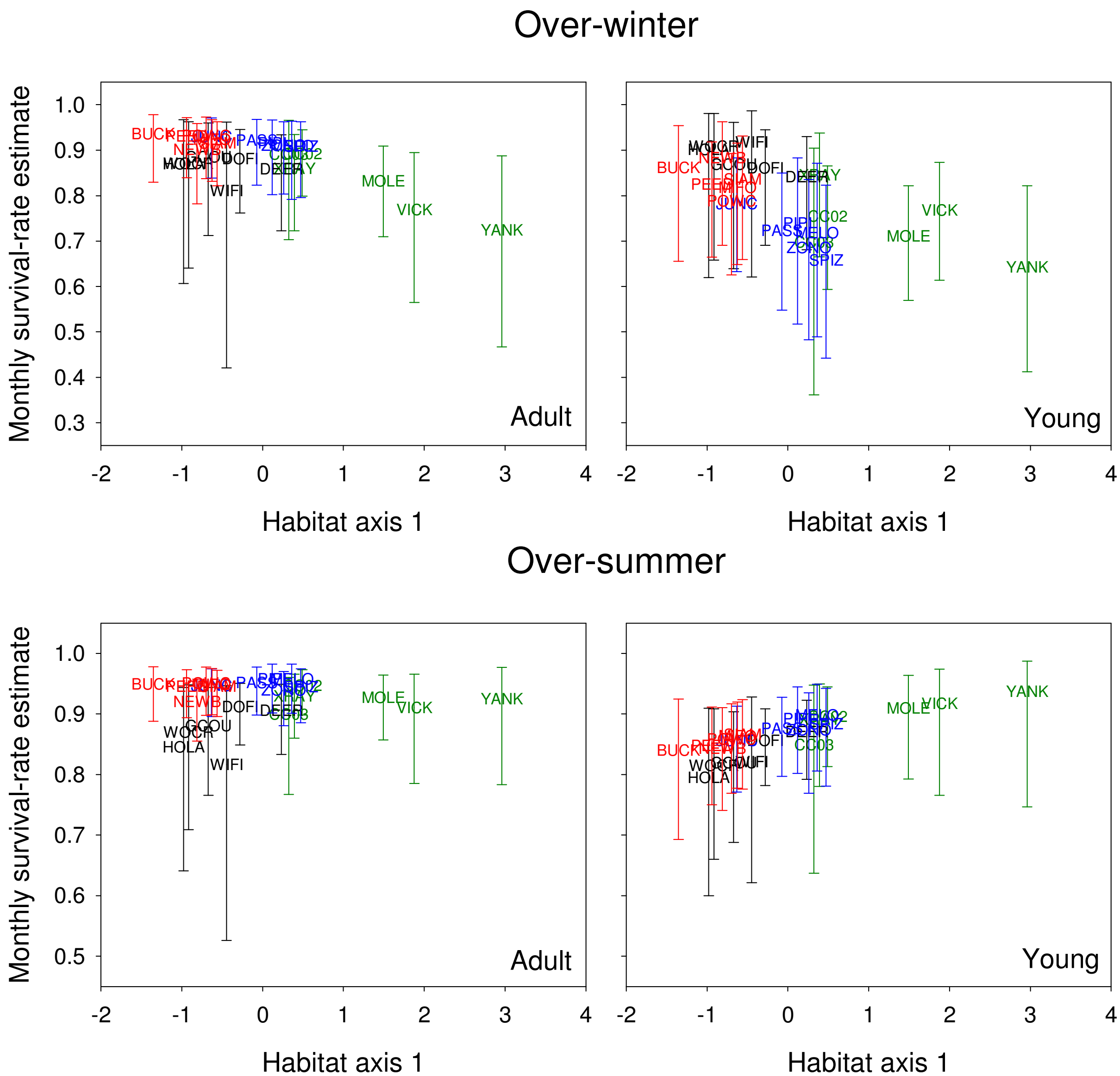


Figure 9. Relationship between habitat axis 1 and model-averaged estimates of apparent monthly over-wintering survival and apparent monthly over-summer (between-year) survival for two age classes of Song Sparrow at 24 southeastern MAWS stations. Survival estimates are 'time-constant' (i.e., averaged across months and years). Error bars represent 95% confidence intervals.



Appendix 1. Winter residency status and banding/recapture summary for 45 bird species (listed in taxonomic order) captured at six MAWS stations during four winter seasons (2003-04, 2004-05, 2005-06, and 2006-07) on Fort Chaffee, AR.

		Residency status[1]						Banded	
Common name	Scientific name	JUNC	MELO	PASS	PIPI	SPIZ	ZONO	Ind.	Pulse-specific recaps
Sharp-shinned Hawk	*Accipiter striatus*	OR	OR	TR	TR	OR	TR	7	0
Cooper's Hawk	*Accipiter cooperii*		OR	TR	OR	OR	TR	1	0
Red-bellied Woodpecker	*Melanerpes carolinus*	RR	RR	RR	RR	UR	RR	5	0
Yellow-bellied Sapsucker	*Sphyrapicus varius*	RR	UR	UR	OR	UR	RR	20	3
Downy Woodpecker	*Picoides pubescens*	RR	RR	RR	RR	RR	RR	17	4
Northern (Yellow-shafted) Flicker	*Colaptes auratus auratus*	RR	RR	RR	RR	RR	RR	8	0
Eastern Phoebe	*Sayornis phoebe*	TR	OR	OR	OR	RR	OR	18	1
Blue-headed Vireo	*Vireo solitarius*					TR		1	0
Blue Jay	*Cyanocitta cristata*	RR	RR	RR	RR	RR	RR	89	5
Carolina Chickadee	*Poecile carolinensis*	RR	RR	RR	RR	RR	RR	182	131
Tufted Titmouse	*Baeolophus bicolor*	RR	RR	RR	RR	RR	RR	191	97
White-breasted Nuthatch	*Sitta carolinensis*	TR	UR	RR	RR	UR	OR	1	0
Brown Creeper	*Certhia americana*			TR	OR	TR	TR	10	1
Carolina Wren	*Thryothorus ludovicianus*	RR	RR	RR	RR	RR	RR	67	42

Appendix 1 continued.

		Residency status[1]						Banded	
Common name	Scientific name	JUNC	MELO	PASS	PIPI	SPIZ	ZONO	Ind.	Pulse-specific recaps
House Wren	*Troglodytes aedon*	TR					TR	5	0
Winter Wren	*Troglodytes troglodytes*	TR	OR	TR	TR	OR	TR	8	1
Golden-crowned Kinglet	*Regulus satrapa*	OR	OR	UR	UR	OR	OR	57	4
Ruby-crowned Kinglet	*Regulus calendula*	RR	RR	RR	RR	RR	RR	170	80
Eastern Bluebird	*Sialia sialis*	RR	RR	RR	RR	RR	RR	99	6
Hermit Thrush	*Catharus guttatus*	RR	RR	RR	RR	RR	RR	217	215
American Robin	*Turdus migratorius*	RR	RR	RR	RR	RR	RR	105	0
Gray Catbird	*Dumetella carolinensis*			MI	MI	MI		2	0
Northern Mockingbird	*Mimus polyglottos*	RR	RR	RR	OR	RR	RR	59	22
Brown Thrasher	*Toxostoma rufum*	RR	UR	RR	RR	RR	RR	129	45
Cedar Waxwing	*Bombycilla cedrorum*	RR	UR	RR	UR	RR	UR	41	0
Orange-crowned Warbler	*Vermivora celata*		TR		TR	TR	TR	21	1
Yellow-rumped (Myrtle) Warbler	*Dendroica coronata coronata*	UR	UR	UR	UR	RR	UR	174	6
Spotted Towhee	*Pipilo maculatus*	TR			OR			3	0

Appendix 1 continued.

Common name	Scientific name	Residency status[1]						Banded	
		JUNC	MELO	PASS	PIPI	SPIZ	ZONO	Ind.	Pulse-specific recaps
Eastern Towhee	*Pipilo erythrophthalmus*	RR	RR	UR	RR	RR	RR	50	4
Field Sparrow	*Spizella pusilla*	RR	RR	RR	RR	RR	RR	385	90
Savannah Sparrow	*Passerculus sandwichensis*	TR		OR	TR	OR		6	0
Fox Sparrow	*Passerella iliaca*	RR	RR	RR	RR	RR	RR	312	72
Song Sparrow	*Melospiza melodia*	RR	RR	RR	RR	RR	RR	325	156
Lincoln's Sparrow	*Melospiza lincolnii*	TR		OR		TR	OR	12	0
Swamp Sparrow	*Melospiza georgiana*	OR	UR	RR	RR	RR	OR	101	57
White-throated Sparrow	*Zonotrichia albicollis*	RR	RR	RR	RR	RR	RR	1238	464
(Eastern) White-crowned Sparrow	*Zonotrichia leucophrys leucophrys*	TR		OR		OR	OR	12	0
Dark-eyed (Oregon) Junco	*Junco hyemalis oregonus*			TR	TR	TR		2	1
Dark-eyed (Slate-colored) Junco	*Junco hyemalis hyemalis*	RR	RR	RR	RR	RR	RR	581	141
Northern Cardinal	*Cardinalis cardinalis*	RR	RR	RR	RR	RR	RR	305	117
Eastern Meadowlark	*Sturnella magna*	RR	TR	UR	OR	OR	OR	3	0
Common Grackle	*Quiscalus quiscula*	RR	OR	RR	OR	RR	RR	5	0

Appendix 1 continued.

		Residency status[1]						Banded	
Common name	Scientific name	JUNC	MELO	PASS	PIPI	SPIZ	ZONO	Ind.	Pulse-specific recaps
Purple Finch	*Carpodacus purpureus*	OR	OR	OR	OR	OR	OR	34	0
House Finch	*Carpodacus mexicanus*	TR	TR	TR	TR	OR	OR	7	0
Pine Siskin	*Carduelis pinus*				TR			1	0
American Goldfinch	*Carduelis tristis*	RR	RR	RR	RR	RR	RR	144	3

[1] Winter residency codes (station codes presented in Table 1.): RR (regular resident) = resident during all winters sampled; UR (usual resident) = resident during 3 winters; OR (occasional resident) = resident during 1-2 winters; TR (transient) = observed during at least one winter and within wintering range but not resident; MI = passage migrant. See “Methods” for detail.

Appendix 2. Winter residency status and banding/recapture summary for 47 bird species (listed in taxonomic order) captured at six MAWS stations during four winter seasons (2003-04, 2004-05, 2005-06, and 2006-07) on Camp Robinson, Arkansas.

		Residency status[1]						Banded	
Common name	Scientific name	BUCK	MIFO	NEWB	PEED	POWC	SIAM	Ind.	Pulse-specific recaps
Sharp-shinned Hawk	*Accipiter striatus*	OR	TR	TR	TR	TR	TR	4	0
Cooper's Hawk	*Accipiter cooperii*	TR	TR	TR	TR	TR	TR	1	0
Red-bellied Woodpecker	*Melanerpes carolinus*	RR	OR	UR	OR	OR	UR	10	0
Yellow-bellied Sapsucker	*Sphyrapicus varius*	TR	TR	OR	OR		TR	6	0
Downy Woodpecker	*Picoides pubescens*	RR	UR	UR	UR	OR	RR	22	2
Northern (Yellow-shafted) Flicker	*Colaptes auratus auratus*	UR	UR	UR	UR	RR	UR	9	0
Eastern Phoebe	*Sayornis phoebe*	UR	TR	UR	UR	TR	TR	16	1
White-eyed Vireo	*Vireo griseus*						MI	1	0
Blue-headed Vireo	*Vireo solitarius*	TR	TR				TR	4	0
Blue Jay	*Cyanocitta cristata*	TR	RR	UR	RR	RR	UR	50	3
Carolina Chickadee	*Poecile carolinensis*	RR	RR	RR	RR	RR	RR	187	111
Tufted Titmouse	*Baeolophus bicolor*	RR	RR	RR	RR	RR	RR	363	183
White-breasted Nuthatch	*Sitta carolinensis*	OR	TR	OR	OR	TR	OR	1	0
Brown Creeper	*Certhia americana*	RR		OR	OR	TR	OR	36	5

Appendix 2 continued.

Common name	Scientific name	Residency status[1]						Banded	
		BUCK	MIFO	NEWB	PEED	POWC	SIAM	Ind.	Pulse-specific recaps
Carolina Wren	*Thryothorus ludovicianus*	RR	RR	RR	RR	RR	RR	119	76
Bewick's Wren	*Thryomanes bewickii*	TR	TR	OR	TR	OR	TR	18	10
House Wren	*Troglodytes aedon*			OR		TR	TR	6	0
Winter Wren	*Troglodytes troglodytes*	OR		RR	OR		TR	22	2
Golden-crowned Kinglet	*Regulus satrapa*	RR	RR	OR	RR	UR	RR	184	31
Ruby-crowned Kinglet	*Regulus calendula*	RR	RR	RR	RR	RR	RR	269	63
Eastern Bluebird	*Sialia sialis*	UR	UR	UR	RR	RR	UR	64	0
Hermit Thrush	*Catharus guttatus*	RR	RR	UR	RR	RR	RR	270	251
American Robin	*Turdus migratorius*	OR	RR	UR	RR	RR	RR	59	0
Gray Catbird	*Dumetella carolinensis*		MI			MI	MI	4	0
Northern Mockingbird	*Mimus polyglottos*	TR	RR		OR	OR		20	7
Brown Thrasher	*Toxostoma rufum*	RR	RR	OR	RR	UR	RR	130	48
Cedar Waxwing	*Bombycilla cedrorum*	TR	OR	OR	OR	OR	OR	5	0
Orange-crowned Warbler	*Vermivora celata*		TR			TR	TR	17	0

Appendix 2 continued.

		Residency status[1]						Banded	
Common name	Scientific name	BUCK	MIFO	NEWB	PEED	POWC	SIAM	Ind.	Pulse-specific recaps
Nashville Warbler	*Vermivora ruficapilla*					MI		3	0
Yellow-rumped (Myrtle) Warbler	*Dendroica coronata coronata*	OR	UR	OR	UR	OR	TR	163	3
Pine Warbler	*Dendroica pinus*	OR	TR	OR	OR	OR	OR	15	0
Black-and-white Warbler	*Mniotilta varia*	MI	MI	MI	MI	MI		1	0
Spotted Towhee	*Pipilo maculatus*		TR	TR	TR	TR	TR	5	0
Eastern Towhee	*Pipilo erythrophthalmus*	RR	RR	UR	RR	RR	RR	150	11
Chipping Sparrow	*Spizella passerina*			TR				3	0
Field Sparrow	*Spizella pusilla*	TR	RR	UR	UR	RR	RR	252	43
Fox Sparrow	*Passerella iliaca*	OR	UR	OR	OR	TR	UR	72	9
Song Sparrow	*Melospiza melodia*	OR	RR	RR	RR	RR	RR	251	101
Lincoln's Sparrow	*Melospiza lincolnii*					TR	TR	5	1
Swamp Sparrow	*Melospiza georgiana*	TR		RR	OR	OR		51	10
White-throated Sparrow	*Zonotrichia albicollis*	RR	RR	RR	RR	RR	RR	1232	601
(Eastern) White-crowned Sparrow	*Zonotrichia leucophrys leucophrys*				TR		TR	3	0

Appendix 2 continued.

		Residency status[1]						Banded	
Common name	Scientific name	BUCK	MIFO	NEWB	PEED	POWC	SIAM	Ind.	Pulse-specific recaps
Dark-eyed (Slate-colored) Junco	*Junco hyemalis hyemalis*	OR	TR	TR	OR	UR	UR	104	30
Northern Cardinal	*Cardinalis cardinalis*	RR	RR	RR	RR	RR	RR	290	87
Indigo Bunting	*Passerina cyanea*					MI		2	0
Purple Finch	*Carpodacus purpureus*	TR	TR	TR	TR	OR		5	0
American Goldfinch	*Carduelis tristis*	OR	RR	UR	OR	RR	UR	32	1

[1] Winter residecy codes (station codes presented in Table 1.): RR (regular resident) = resident during all winters sampled; UR (usual resident) = resident during 3 winters; OR (ocassional resident) = resident during 1-2 winters; TR (transient) = observed during at least one winter and within wintering range but not resident; MI = passage migrant. See "Methods" for detail.

Appendix 3. Winter residency status and banding/recapture summary for 49 bird species (listed in taxonomic order) captured at six MAWS stations during four winter seasons (2003-04, 2004-05, 2005-06, and 2006-07) on Fort Bragg, NC.

		Residency status[1]						Banded	
Common name	Scientific name	DEER	DOFI	GCOU	HOLA	WIFI	WOCR	Ind.	Pulse-specific recaps
Sharp-shinned Hawk	*Accipiter striatus*	TR	TR	TR	TR	TR	TR	1	0
Red-headed Woodpecker	*Melanerpes erythrocephalus*			OR		TR	TR	8	0
Red-bellied Woodpecker	*Melanerpes carolinus*	RR	RR	RR	OR	UR	RR	9	0
Yellow-bellied Sapsucker	*Sphyrapicus varius*	OR	UR	UR	OR	OR	UR	23	2
Downy Woodpecker	*Picoides pubescens*	OR	UR	RR	OR	RR	UR	14	0
Hairy Woodpecker	*Picoides villosus*	UR	OR	RR	OR	RR	OR	9	3
Yellow-shafted Flicker	*Colaptes a. auratus*	RR	RR	RR	UR	RR	UR	11	0
Yellow-bellied Flycatcher	*Empidonax flaviventris*	MI						1	0
Eastern Phoebe	*Sayornis phoebe*	OR	RR	UR	OR	OR	OR	43	6
White-eyed Vireo	*Vireo griseus*				MI		MI	2	0
Blue-headed Vireo	*Vireo solitarius*	OR	TR	TR		TR	OR	5	0
Blue Jay	*Cyanocitta cristata*	RR	RR	RR	RR	UR	RR	24	2
Carolina Chickadee	*Poecile carolinensis*	RR	RR	RR	RR	RR	RR	91	69
Tufted Titmouse	*Baeolophus bicolor*	RR	RR	UR	RR	RR	RR	79	32

Appendix 3 continued.

		Residency status[1]						Banded	
Common name	Scientific name	DEER	DOFI	GCOU	HOLA	WIFI	WOCR	Ind.	Pulse-specific recaps
Red-breasted Nuthatch	*Sitta canadensis*	OR	OR	OR	OR	OR	OR	2	0
White-breasted Nuthatch	*Sitta carolinensis*	UR	UR	RR	OR	RR	RR	5	0
Brown-headed Nuthatch	*Sitta pusilla*	RR	RR	RR	RR	RR	RR	13	1
Brown Creeper	*Certhia americana*	TR	OR	TR	OR	OR	UR	10	2
Carolina Wren	*Thryothorus ludovicianus*	RR	RR	RR	RR	RR	RR	103	56
House Wren	*Troglodytes aedon*	UR	TR	UR	OR	TR		24	5
Winter Wren	*Troglodytes troglodytes*			TR	UR	TR	RR	24	9
Golden-crowned Kinglet	*Regulus satrapa*	OR	RR	OR	RR	RR	RR	220	44
Ruby-crowned Kinglet	*Regulus calendula*	RR	RR	RR	RR	RR	RR	705	253
Eastern Bluebird	*Sialia sialis*	RR	RR	RR	UR	RR	RR	79	13
Hermit Thrush	*Catharus guttatus*	UR	OR	OR	RR	RR	RR	157	114
American Robin	*Turdus migratorius*	RR	RR	RR	RR	RR	UR	44	0
Gray Catbird	*Dumetella carolinensis*	UR	TR	TR	RR	OR	RR	35	19
Northern Mockingbird	*Mimus polyglottos*	RR	UR	OR				12	4

Appendix 3 continued.

		Residency status[1]						Banded	
Common name	Scientific name	DEER	DOFI	GCOU	HOLA	WIFI	WOCR	Ind.	Pulse-specific recaps
Brown Thrasher	*Toxostoma rufum*	RR	OR	UR	TR	OR	UR	33	9
Orange-crowned Warbler	*Vermivora celata*						TR	1	0
Yellow-rumped (Myrtle) Warbler	*Dendroica coronata coronata*	TR	RR	TR	OR	UR	TR	400	12
Pine Warbler	*Dendroica pinus*	UR	RR	UR	RR	RR	UR	145	8
(Yellow) Palm Warbler	*Dendroica palmarum hypochrysea*	TR	TR	TR				11	0
Common Yellowthroat	*Geothlypis trichas*	OR		OR	UR	OR	OR	18	8
Eastern Towhee	*Pipilo erythrophthalmus*	RR	RR	RR	RR	RR	RR	123	28
Chipping Sparrow	*Spizella passerina*	OR	RR	OR	OR	OR	TR	636	36
Field Sparrow	*Spizella pusilla*	RR	RR	RR	OR	OR		495	123
Savannah Sparrow	*Passerculus sandwichensis*		TR					1	0
Fox Sparrow	*Passerella iliaca*	OR	TR		TR	TR	OR	14	0
Song Sparrow	*Melospiza melodia*	RR	RR	RR	RR	RR	OR	537	114
Swamp Sparrow	*Melospiza georgiana*	UR	TR	RR	RR	RR	OR	361	102
White-throated Sparrow	*Zonotrichia albicollis*	RR	RR	RR	RR	OR	RR	529	97

Appendix 3 continued.

Common name	Scientific name	Residency status[1]						Banded	
		DEER	DOFI	GCOU	HOLA	WIFI	WOCR	Ind.	Pulse-specific recaps
Dark-eyed (Slate-colored) Junco	*Junco h. hyemalis*	RR	RR	RR	OR	RR	RR	612	98
Northern Cardinal	*Cardinalis cardinalis*	RR	RR	UR	RR	RR	RR	111	41
Red-winged Blackbird	*Agelaius phoeniceus*	UR	OR	OR	TR	OR	TR	5	0
Common Grackle	*Quiscalus quiscula*	OR	OR	OR	OR	OR	TR	3	0
Purple Finch	*Carpodacus purpureus*				TR			1	0
House Finch	*Carpodacus mexicanus*	TR	TR	TR	TR			2	0
American Goldfinch	*Carduelis tristis*	OR	RR	UR	RR	RR	RR	82	1

[1] Winter residecy codes (station codes presented in Table 1.): RR (regular resident) = resident during all winters sampled; UR (usual resident) = resident during 3 winters; OR (occasional resident) = resident during 1-2 winters; TR (transient) = observed during at least one winter and within wintering range but not resident; MI = passage migrant. See “Methods” for detail.

Appendix 4. Winter residency status and banding/recapture summary for 57 bird species (listed in taxonomic order) captured at six MAWS stations during four winter seasons (2003-04, 2004-05, 2005-06, and 2006-07) on Fort Benning, GA/AL.

		Residency status[1]						Banded	
Common name	Scientific name	CC02	CC03	MOLE	VICK	XRAY	YANK	Ind.	Pulse-specific recaps
Sharp-shinned Hawk	*Accipiter striatus*		TR	TR		TR	TR	2	0
Mourning Dove	*Zenaida macroura*	UR	UR	UR	UR	UR	OR	1	0
Common Ground-Dove	*Columbina passerina*			TR	TR	TR	TR	1	0
Red-headed Woodpecker	*Melanerpes erythrocephalus*	OR	OR	TR	UR	OR		5	0
Red-bellied Woodpecker	*Melanerpes carolinus*	UR	UR	UR	UR	UR	UR	6	0
Yellow-bellied Sapsucker	*Sphyrapicus varius*	OR	OR	OR	UR	UR	TR	10	2
Downy Woodpecker	*Picoides pubescens*	UR	OR	OR	UR	UR	OR	10	0
Hairy Woodpecker	*Picoides villosus*	TR	TR		TR	TR		2	0
Northern (Yellow-shafted) Flicker	*Colaptes auratus auratus*	RR	UR	UR	UR	UR	UR	2	0
Eastern Phoebe	*Sayornis phoebe*	UR	UR	RR	RR	RR	RR	66	3
White-eyed Vireo	*Vireo griseus*		TR	OR	OR	TR	OR	7	3
Blue-headed Vireo	*Vireo solitarius*	OR	TR	TR		OR	TR	5	0
Blue Jay	*Cyanocitta cristata*	UR	UR	OR	UR	OR	UR	14	1
Carolina Chickadee	*Poecile carolinensis*	RR	RR	RR	RR	RR	RR	83	57

Appendix 4 continued.

Common name	Scientific name	Residency status[1]						Banded	
		CC02	CC03	MOLE	VICK	XRAY	YANK	Ind.	Pulse-specific recaps
Tufted Titmouse	*Baeolophus bicolor*	RR	RR	RR	RR	RR	RR	88	33
White-breasted Nuthatch	*Sitta carolinensis*	OR	TR	OR	UR	TR		3	0
Brown-headed Nuthatch	*Sitta pusilla*	UR	UR	UR	UR	UR	OR	8	0
Carolina Wren	*Thryothorus ludovicianus*	RR	RR	RR	RR	RR	RR	139	84
House Wren	*Troglodytes aedon*	TR	OR	TR	TR	OR	TR	24	7
Winter Wren	*Troglodytes troglodytes*				TR			2	0
Golden-crowned Kinglet	*Regulus satrapa*	OR	OR	OR	OR	OR	OR	25	3
Ruby-crowned Kinglet	*Regulus calendula*	UR	UR	RR	UR	UR	UR	303	133
Eastern Bluebird	*Sialia sialis*	RR	UR	UR	UR	UR	OR	53	1
Hermit Thrush	*Catharus guttatus*	OR	UR	OR	OR	OR	OR	85	34
American Robin	*Turdus migratorius*	UR	RR	UR	UR	UR	UR	64	0
Gray Catbird	*Dumetella carolinensis*		TR	TR	TR	OR	UR	7	0
Northern Mockingbird	*Mimus polyglottos*		UR	OR	OR	OR	UR	24	14
Brown Thrasher	*Toxostoma rufum*		UR	OR	TR	OR	OR	25	7

Appendix 4 continued.

Common name	Scientific name	Residency status[1]						Banded	
		CC02	CC03	MOLE	VICK	XRAY	YANK	Ind.	Pulse-specific recaps
Cedar Waxwing	*Bombycilla cedrorum*	OR	TR	OR	OR	TR	TR	5	0
Tennessee Warbler	*Vermivora peregrina*		MI					1	0
Orange-crowned Warbler	*Vermivora celata*	TR	OR			TR	TR	20	5
Magnolia Warbler	*Dendroica magnolia*		MI	MI	MI			6	0
Myrtle Warbler	*Dendroica coronata coronata*	UR	OR	OR	UR	OR	OR	408	42
Black-throated Green Warbler	*Dendroica virens*		MI					1	0
Pine Warbler	*Dendroica pinus*	RR	RR	RR	RR	RR	TR	82	12
(Yellow) Palm Warbler	*Dendroica palmarum hypochrysea*		TR	TR	TR	OR	OR	29	1
Common Yellowthroat	*Geothlypis trichas*	RR	RR	RR	RR	RR	UR	115	58
Yellow-breasted Chat	*Icteria virens*			MI				1	0
Eastern Towhee	*Pipilo erythrophthalmus*	RR	RR	RR	RR	RR	RR	163	42
Bachman's Sparrow	*Aimophila aestivalis*		TR	OR	UR	TR	OR	9	1
Chipping Sparrow	*Spizella passerina*	UR	UR	OR	UR	OR	RR	520	8
Field Sparrow	*Spizella pusilla*	OR	UR	RR	RR	RR	RR	378	135

Appendix 4 continued.

		Residency status[1]						Banded	
Common name	Scientific name	CC02	CC03	MOLE	VICK	XRAY	YANK	Ind.	Pulse-specific recaps
Vesper Sparrow	*Pooecetes gramineus*			OR	TR		TR	8	1
Savannah Sparrow	*Passerculus sandwichensis*		OR	UR	TR		OR	215	47
Grasshopper Sparrow	*Ammodramus savannarum*		TR				TR	4	0
Henslow's Sparrow	*Ammodramus henslowii*				TR		TR	2	0
Fox Sparrow	*Passerella iliaca*	OR	TR		UR	OR	OR	52	4
Song Sparrow	*Melospiza melodia*	RR	UR	UR	UR	UR	RR	432	142
Lincoln's Sparrow	*Melospiza lincolnii*		TR		TR			2	0
Swamp Sparrow	*Melospiza georgiana*	UR	UR	UR	UR	OR	UR	437	175
White-throated Sparrow	*Zonotrichia albicollis*	RR	RR	RR	RR	RR	UR	470	156
Dark-eyed (Slate-colored) Junco	*Junco hyemalis hyemalis*	UR		TR	RR	OR	TR	98	11
Northern Cardinal	*Cardinalis cardinalis*	RR	RR	RR	RR	RR	RR	176	48
Indigo Bunting	*Passerina cyanea*			MI	MI	MI		11	0
Red-winged Blackbird	*Agelaius phoeniceus*	UR	RR	UR	UR	UR	UR	5	0
Purple Finch	*Carpodacus purpureus*	TR					TR	1	0

Appendix 4 continued.

		Residency status[1]						Banded	
Common name	Scientific name	CC02	CC03	MOLE	VICK	XRAY	YANK	Ind.	Pulse-specific recaps
American Goldfinch	*Carduelis tristis*	UR	UR	UR	UR	UR	OR	111	2

[1] Winter residency codes (station codes presented in Table 1.): RR (regular resident) = resident during all winters sampled; UR (usual resident) = resident during 3 winters; OR (occasional resident) = resident during 1-2 winters; TR (transient) = observed during at least one winter and within wintering range but not resident; MI = passage migrant. See "Methods" for detail.