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Grassland Bird Productivity on Military Airfields in the Mid-Atlantic and Northeast Regions - Interim Report.

KIMBERLY A. PETERS AND MICHAEL C. ALLEN
NEW JERSEY AUDUBON SOCIETY,
Cape May Court House, NJ

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EXECUTIVE SUMMARY

Grasslands associated with airfields in the northeastern United States (both military and civilian) often support large numbers of regionally rare grassland birds. As grassland habitat area in the region continues to decline, the role that that large airfields play in maintaining populations of these species is likely to increase. Despite this, relatively little is known regarding reproductive success in these habitats, and whether they act as population sources or sinks. This is a particular concern because vegetation management on airfields often involves regular mowing during the summer breeding season, a practice presumed to be harmful to nesting success. To obtain a general picture of grassland bird reproductive success on regional airfields, and to examine possible factors that may be affecting it (including mowing), we conducted a nest monitoring study in 2009 on three military airfields in the Mid-Atlantic and Northeast: Westover Air Reserve Base (Massachusetts), Joint Base McGuire-Dix-Lakehurst (New Jersey), and Patuxent River Naval Air Station (Maryland).

Nests of two target species (grasshopper sparrow and eastern meadowlark) and of other grassland-obligate species were located and monitored at regular intervals until success (fledging) or failure. We measured vegetation characteristics around each nest, and through direct observation and cooperation with mowing crews were able to determine: 1) if a nest was located in a regularly mowed area, 2) if a nest was directly mowed over while active, and 3) the condition of each nest immediately following a mow. We calculated daily nest survival rates (DSR), and examined the effects of various predictor variables using logistic modeling in program MARK.

In 2009 and 2010, we located and monitored 115 grasshopper sparrow nests, 86 Eastern meadowlark nests, and 86 nests of other grassland-obligate passerines across all three sites. We also processed and banded 141 grasshopper sparrow and 92 eastern meadowlark nestlings to assess future recruitment into each breeding population. Daily survival rates for grasshopper sparrow nests ranged from 0.96 at Lakehurst to 0.97 at Westover, while rates for eastern meadowlark ranged from 0.94 at Patuxent River to 0.97 at Lakehurst. DSR modeling did not reveal any strong predictors for grasshopper sparrow nesting success, although we did observe a potential relationship between DSR and the distance of nests from active runways at Westover Air Reserve Base and Patuxent River Naval Air Station. The direction of these relationships differed between sites. At Westover, nests located further from active runways appeared to be more successful, while at Patuxent River, nests closer to runways were more successful. The pattern observed at Westover Air Reserve Base may have been driven by management implementation, as grasslands within 300 ft of active airfield surfaces (including runways) were mowed to maintain vegetation height at 7-14 inches, whereas those beyond 300 ft were typically not mowed during the breeding season.

DSR models predicting eastern meadowlark nesting success were somewhat more consistent among sites. At Westover Air Reserve Base and Joint Base McGuire-Dix-Lakehurst, meadowlark nests in areas with less horizontal grass cover were more

successful than those with more cover. At Patuxent River Naval Air Station, success was positively associated with mean vegetation height. It may be that the habitat associations observed at all three sites were related to habitat heterogeneity, which has been linked to eastern meadowlark presence in other studies. However, it is not immediately clear by what mechanism increased vegetation height or decreased grass cover would translate into lower rates of nest failure.

Although we more than doubled our sample sizes in year 2 of the study, results should still be viewed as tentative because they are based on relatively low numbers of nests from each site. Mowing variables did not emerge as good predictors of nest survival for either target species, and DSR was not significantly lower for nests that were mowed over vs. those that were not (i.e., direct mowing effects), or for nests in mowed areas vs. those in unmowed areas (i.e., indirect mowing effects). Nevertheless, we did observe some direct mortality due to mowing. One grasshopper sparrow nest of the 14 that were mowed was directly destroyed by mowing. Eastern meadowlark nests were much more likely to be directly destroyed by the mowers. For this species, nearly half (46%) of nests in regularly mowed areas were mowed over, and close to one-third (29%) of mowed nests were directly destroyed by the mowers. We also documented some potential secondary mortality due to predation or abandonment (i.e., 1 additional grasshopper sparrow nest, and 6 additional meadowlark nests). We anticipate that data from a proposed third field season in 2012 will allow us to draw stronger conclusions regarding the effects of mowing and other factors on grassland bird nest survival on DoD airfields.

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BACKGROUND AND OBJECTIVES

The Department of Defense (DoD) is the steward of approximately 30 million acres of land in the United States, many of which contain threatened and endangered species as well as critical habitats. Programs that seek to protect and enhance natural resources on DoD lands acknowledge the importance of military lands to the conservation of species and habitats of concern (e.g., DoD Partners In Flight). It has been suggested that airfields in general, if properly managed, may be important for supporting stable breeding populations of grassland birds, a guild that has experienced steep and geographically widespread population declines (Askins 1993, 1996, Rich et al. 2004, Brennan and Kuvlesky 2005). Military airfields have also been specifically identified as important components in the conservation of rare grassland birds (Osborne and Peterson 1984).

Current Air Force policy includes provisions for the protection and conservation of state-listed species, so long as such actions do not interfere with the military mission (AFI 32-7064-2004). At the same time, aviation safety procedures dictate that grassland management methods on USAF airfields comply with Bird/Wildlife Aircraft Strike Hazard regulations (BASH, AFI 91-212-2004). Naval air stations also often follow Air Force BASH-recommended management strategies (K. Rambo, *personal comm.*), although draft Navy guidelines allow each installation the flexibility to develop its own site-appropriate mowing/management regime based on a Wildlife Hazard Assessment (CNIC M-BASH January 2010). BASH management generally consists of a strict mowing regime, with vegetation directly adjacent to runways consistently managed to 7-14 inches (AFI 91-212-2004). Other tools, such as mechanical shrub removal and prescribed burning, are also used on airfields to encourage homogenous vegetation conditions recommended by BASH guidelines. These techniques are currently in use on several military airfields, including the Lakehurst unit of Joint-Base McGuire-Dix-Lakehurst (LAKEHURST) in New Jersey and Westover Air Reserve Base (WARB) in Massachusetts. Recent findings from the Northeast region indicate that current Air Force BASH guidelines may not necessarily be optimal for reducing strike-risk, and that management standards should be assessed on a site-by-site basis (Peters and Allen 2010a). These findings also suggest that airfields may be maintained to provide habitat for small, low strike-risk grassland birds while simultaneously optimizing safety.

Several grassland bird species of regional and national concern breed on military airfields in the Mid-Atlantic and Northeast regions. These include upland sandpiper (UPSA, *Bartramia longicauda*), grasshopper sparrow (GRSP, *Ammodramus savannarum*), Henslow's sparrow (HESP, *A. henslowii*), eastern meadowlark (EAME, *Sturnella magna*), horned lark (HOLA, *Eremophila alpestris*), and field sparrow (FISP, *Spizella pusilla*), all of which are regarded as grassland obligates (UPSA, GRSP, HESP, EAME, HOLA) or associates (FISP) during the breeding season. For instance, WARB hosts the largest breeding population of UPSA and GRSP in Massachusetts (S. Melvin, *personal comm*), and LAKEHURST hosts the largest breeding population of UPSA, and second largest population of GRSP, in New Jersey (J. Joyce, *personal comm.*). Patuxent River Naval Air Station (PRNAS) in Maryland, also supports large breeding populations of GRSP and EAME. To date, monitoring data from these three sites conducted by NJ

Audubon indicate that the local densities of target grassland species are stable or increasing (Peters and Allen 2010a). However, based on these data alone it is difficult to assess whether these populations are in fact self-sustaining, successfully reproducing populations or are instead dependent upon outside immigration to maintain themselves. Grassland habitat is also increasingly rare in the heavily-developed Northeast and Mid-Atlantic regions, so a lack of alternative breeding habitat may be affecting site use (Melvin 1994, Askins 1996, Vickery and Dunwiddie 1997, Norment 2002).

It is widely accepted that avian abundance measures alone are not adequate for measuring habitat quality and, in particular, species response to anthropogenic habitat manipulation (Van Horne 1983). Several factors can make evaluating the effects of habitat changes on bird population status problematic, such as the potential influences of site fidelity and social interactions. An individual may return to a prior breeding site or to its natal site regardless of that habitat's characteristics or quality. Territorial behavior exhibited by dominant individuals may relegate subordinate individuals to suboptimal habitats, a process known as despotic distribution (Fretwell and Lucas 1969). Lack of alternative habitat also often forces individuals to use sites that are suboptimal (e.g., Perlut et al. 2006). In addition, some sites may function as ecological traps, where habitat cues are decoupled from (i.e., do not represent) actual habitat quality. Such cases may arise when altered, enhanced or created habitats are selected by individuals based on environmental cues. These cues, however, misrepresent the functional habitat quality of the sites, which ultimately act as population sinks. In such cases, lower quality habitats (i.e., those with lower reproductive rates) could exhibit greater bird densities than high quality habitats. For instance, Kershner and Bollinger (1996) found that EAME were attracted to Illinois airfields, although mandated mowing practices were responsible for 44% of nest failures.

Evidence also suggests that human-induced disturbance can directly reduce fitness in breeding bird colonies through displacement or increased nest predation (review in Carney and Sydeman 1999). Similar findings have recently been documented in great tit (*Parus major*), where traffic noise was shown to reduce clutch size and number of fledglings independent of clutch size (Halfwerk et al. 2010). These effects were identified as occurring primarily when the frequency band of traffic noise overlapped that of the lower frequency segment of the great tit song, indicating potential interference in intraspecific communication. Comparatively little is understood about the potential effects of disturbance on grassland birds. The few studies that have addressed the issue have produced unclear and sometimes conflicting results. For instance, Forman et al. (2004) reported that grassland bird nesting activity was affected by road traffic, but only above defined threshold traffic levels. Alternatively, military activity did not affect nest site selection or nesting success in EAME or GRSP on Fort Riley, KS (Hubbard et al. 2006).

In response to uncertainties about the suitability of human-altered habitats (e.g., airfield grasslands) for priority bird species, emphasis is now being placed on monitoring local demographic parameters (e.g., nest survival, fledging success, fecundity) as targets for management rather than on abundance parameters alone (Martin 1992, Conway and Martin 1999). We initiated the current project in spring 2009. Our primary goal was to expand our current avian monitoring program on LAKEHURST, WARB, and PRNAS (i.e., avian density monitoring, Peters and Allen 2010a) to include demographic parameters for breeding grassland birds (i.e., reproductive success). Target species were GRSP and EAME, both of which breed on all three sites. GRSP is listed as "threatened" in MA and NJ, "at risk" in MD, and of regional concern in need of "immediate management" in the Mid-Atlantic and Northeast regions (PIF BCR 30). EAME is considered a species of "special concern" in NJ, and "of management concern" in the Northeast (USFWS Region 5). EAME also serves as a good model for ground-nesting grassland birds as it is a relatively abundant species that has shown sharp and consistent population declines throughout much of its breeding range (Rich et al. 2004, Askins et al. 2007). The current study was designed to provide a clearer picture of the habitat-use and demographic dynamics of these species on LAKEHURST, WARB and PRNAS.

Findings from the first year of the study were based on relatively low sample sizes from each site, and nest survival modeling (daily survival rate, DSR) for all sites combined did not reveal any strong predictors for either target species. When sites were analyzed separately, percent grass cover around the nest, distance to active runway, and date of season all emerged as potential factors influencing nest DSR, but again, because of low sample size were considered only preliminary. Mowing variables did not emerge as good predictors of nest survival, and DSR was not significantly lower for nests that were mowed over vs. those that were not (i.e., direct mowing effects), or for nests in mowed areas vs. those in unmowed areas (i.e., indirect mowing effects). Nevertheless, we did observe some direct mortality due to mowing (4 of 20 mowed nests), and some potential secondary mortality due to scavenging or abandonment (3 additional nests).

Our primary goal in Year 2 was to increase sample size from each study site in order to strengthen our inferences about links among airfield management history, vegetation structure, and grassland bird nesting success. Our specific objectives were to: (1) continue to obtain nesting success measures for the target species, (2) relate nesting success to habitat characteristics, and (3) relate nesting success to restoration/enhancement and BASH management history. Particular emphasis was placed on determining how nests placed in intensively mowed areas (i.e., BASH management areas) fared compared to those placed outside of mowed areas, and how nests that were directly mowed over while active fared as compared to undisturbed (i.e., unmowed) nests.

STUDY SITES

Joint Base McGuire-Dix-Lakehurst (JBMDL)

The Lakehurst section of JBMDL (LAKEHURST) in Lakehurst, New Jersey, consists of 7,400 acres and is located within the Pinelands National Reserve. The mission of the LAKEHURST Environmental Department includes land management, forestry, threatened and endangered species management, and habitat improvement. Approximately 1,700 acres of the site is considered grassland habitat, 1,200-1,300 acres of which are actively managed (J. Joyce, *personal comm.*). Species of concern on the site include upland sandpiper (state endangered), and grasshopper sparrow (state threatened), both regarded as grassland obligates during the breeding season. Other grassland associates recently recommended for NJ state listing include horned lark (threatened, HOLA, *Eremophila alpestris*) and American kestrel (threatened, AMKE, *Falco sparverius*) (NJDEP Proposed Amendment: N.J.A.C. 7:25-4.17). LAKEHURST supports the largest known breeding population of upland sandpipers in New Jersey (10-12 pairs), and the second-largest known population of grasshopper sparrows in the state (after Atlantic City International Airport) (J. Joyce, *personal comm.*). Habitat improvement measures for grassland birds have been implemented over the last 13 years and have included controlled burns, mowing, and mechanical shrub-removal methods. Burn schedules currently run on a four-year basis, and affect 145-185 acres of the site per year. About 750 – 1,000 acres of the grasslands are mowed each year during late-winter. No mowing is currently performed during the grassland bird breeding season (April – August).

Westover Air Reserve Base (WARB)

Westover Air Reserve Base in Chicopee, Massachusetts contains approximately 2,511 acres of land in an area of the Connecticut River Valley characterized by gently sloping terrain of moderately fertile, sandy, well-drained loams. The base maintains the largest contiguous grasslands in the Connecticut River watershed (>1,200 ac). The grasslands contain over 100 species of plants but large areas are dominated by non-native vegetation. Westover's grasslands provide breeding habitat to New England's largest populations of three rare species: upland sandpiper, grasshopper sparrow, and Phyllira tiger moth (*Grammia phyllira*). The sandpiper and moth are listed by Massachusetts as endangered and the sparrow is state-listed as threatened. The 1987 populations of 25 upland sandpipers and 55 singing male grasshopper sparrows increased to 150 and 182, respectively, by 2003 (Melvin 1994). The U.S. Fish and Wildlife Service identified Westover as a Special Focus Area with "high" priority within the Silvio O. Conte National Fish and Wildlife Refuge. Mowing frequency for 523 acres of vegetation within 300 feet of runways and taxiways is determined by the time it takes vegetation to approach an average height of 14 inches (i.e., approximately once per month, A. Milroy, *personal comm.*). The remaining 690 ac is mowed after 1 August each year to avoid the grassland bird nesting season. Prescribed fire was introduced in 2002 (60 ac) with subsequent burns in 2004 (122 ac), 2006 (250 ac) and 2010 (169 ac). Westover is building toward a three to five-year return interval for burning the grasslands. The variability is due to uncertainties of weather, funding, and availability of qualified personnel. Recently, the base has begun integrated pest management of invasive plant species.

Patuxent River Naval Air Station (PRNAS)

The PRNAS is located in St. Mary's County, Maryland, and consists of approximately 6,300 acres along the western shore of Chesapeake Bay near its confluence with the Patuxent River. Another ~1,000 acres of Navy land occurs at a nearby outlying field known as Webster Field Annex. The mission of the PRNAS Environmental Department includes land management, forestry, threatened and endangered species management, and habitat improvement. Several hundred acres of the site are considered grassland habitat, with most of that subjected to regular mowing or some other form of active management (K. Rambo, *personal comm*.). Species of concern on the site include upland sandpiper and buff-breasted sandpiper (*Tryngites subruficollis*) during migration, and breeding populations of grasshopper sparrow, eastern meadowlark, and northern bobwhite (*Colinus virginianus*). The latter three are regarded as grassland obligates during the breeding season. Upland sandpiper is considered a species that is endangered (breeding population only) in Maryland and a "species of high concern" continentally (Brown et al. 2001). Buff-breasted sandpiper and grasshopper sparrow are considered species "at risk" in Maryland and globally (the former) or continentally (the latter; Brown et al. 2001, Rich et al. 2004). Concentrations of upland sandpipers at PRNAS typically reach into the 40s and 50s during migration and numbers of buff-breasted sandpipers often are in the 30s. These are some of the highest densities reported within the mid-Atlantic region (K. Rambo, *personal comm*.). Habitat improvement measures for grassland birds have been implemented over the last 5-10 years, including establishment of native warm-season grasses, regulated mowing heights and frequency, controlled burns, and various shrub-removal methods (mechanical, manual, and chemical).

METHODS

Nest searching and monitoring

Nest-searching blocks at each installation were selected prior to the field season based on scheduled mowing regimes (PRNAS, WARB) or available grassland habitat (LAKEHURST). Blocks provided relatively equal representation of areas on WARB that were (1) intensively mowed to 7-14 in during the breeding season, and (2) were not mowed during the breeding season. All blocks on PRNAS represented areas that were mowed to 7-14 inches, while no blocks on LAKEHURST were mowed. Blocks on LAKEHURST were located in three distinct areas: (1) around an active runway (Westfield Runways), (2) a primarily inactive runway (Test Site), or (3) an air drop area not associated with any runways (Jump Circle). Maps depicting search blocks established at each site are available in Appendix A. Each block was searched for approximately two hours once every one to two weeks.

Various methods of locating nests were implemented throughout the season (16 April - 15 July) including systematic area searches, behavioral observations, 'sticking' and rope-dragging. Specific methods were similar to those used by Nesbit and Robinson in the Illinois Natural History Survey (http://virtualbirder.com/vbirder/onLoc/onLocDirs/ILSUM/pa/Wilmington2.html). Systematic searches consisted of observers walking parallel transects within a study plot in order to flush adults off nests. Specific adult breeding behaviors noted included singing, calling, counter-calling, carrying nesting material or food, and defensive (i.e., agonistic) actions. "Sticking", or flushing adults off the nest by agitating vegetation with a 2-meter bamboo stick, was the primary method of searching at LAKEHURST, while rope-dragging (two observers dragging an approximately 20 m weighted rope) as well as sticking were used at PRNAS and WARB. Rope-dragging was not feasible at LAKEHURST due to abundant woody vegetation. An attempt was made to employ equal searching effort across all blocks within each site. Two blocks at LAKEHURST that were monitored in the first year of the study were not included in the 2010 sample frame because no nests were found there in 2009.

Mowing activities at PRNAS and WARB were tracked through communication with on-site management crews, and observers visited known active nests in targeted areas immediately prior to and after mowing. Nests at WARB were ultimately categorized as "not in mowing plan area", "in mowing plan area but not directly mowed over", or "directly mowed over". PRNAS nests were simply categorized as "mowed over" or "not mowed over". Nests that were directly mowed over were easily recognizable due to mower tracks, grass clippings and reduced vegetation height at and around the nest.

Once located, nests were monitored every 2-3 days through completion or termination. Based on conditions observed at and around nests, nest failures were categorized as depredated, abandoned, destroyed by mower, or unknown. Successful nests were defined as those that fledged at least one GRSP or EAME chick. Overall probability of nest success was based on a 20 day nesting cycle (including incubation) for GRSP (Vickery 1996), and a 24 day nesting cycle for EAME (Lanyon 1995). Similar methods were used to define success of other grassland breeding passerine nests monitored during the study.

The date of nest initiation (i.e., start of incubation) was estimated in most cases by back-dating from the known or estimated hatch date or fledge date. Incubation and nestling periods were assumed to be 12 and 8 days for GRSP, and 14 and 10 days for EAME, respectively (Lanyon 1995, Vickery 1996). The date of hatching or fledging (when not directly observed) was estimated as the mid-point between the two checks surrounding the event. Nests at which eggs were present for significantly longer than the expected incubation period were classified as abandoned. In these cases, the date of termination was assumed to have occurred mid-way between the last date at which parental activity was observed, and the subsequent check date.

At all sites, grasshopper sparrow and eastern meadowlark nestlings were marked when they were 4-6 or 7-9 days old, respectively, to examine future recruitment into the population. Due to logistical issues, four EAME were banded on day 6, and 9 GRSP were banded on day 7, at PRNAS. All nestlings were fitted with a USFWS aluminum leg band and batch-marked with a single site-specific color band (LAKEHURST, green; PRNAS, dark blue; WARB, pink) to uniquely identify the site at which they were banded. General morphometric measurements were also taken, including mass (Ohaus balance scale to 0.01 g), wing (wing rule to 0.5 mm), tail and tarsus (calipers to 0.5 mm). Fat scores were assigned based on visible subcutaneous fat stores, and keel scores were assigned based on the prominence of the sternal keel (Appendix B).

Vegetation Sampling

Vegetation around each nest was quantified within a 1 m^2 quadrat centered on the nest. Percent horizontal coverage (including overlap) of four cover types was visually estimated within the quadrat: grass, forb, bare ground, and shrub. Vegetation height at the time of nest discovery was measured as the maximum height at which vegetation touched a vertical pole, averaged over five sub-sample locations (the center and four corners of the quadrat). This measure was performed again on the last day a nest was visited. In 2010, during the final nest visit, we also measured litter depth (i.e., flattened, dead vegetation) at the same five sub-sample locations (to 1 cm). The extent of vegetation “clumpiness” in the general area around the nest (e.g., as formed by warm season grasses) was categorized as: 1) grass mostly even and homogeneous, 2) grass somewhat clumpy, and 3) grass mostly in clumps.

In 2010, from 15 to 23 June, we also collected vegetation data at randomly selected sites within each search block, in order to evaluate nest-site selection at the microhabitat scale. To select survey locations, we generated a list of multiple random points for each survey block in a GIS (ArcGIS 9.3). In the field, we visited the points in each block sequentially, and took vegetation measurements so long as a point did not fall on a road or other airfield infrastructure, and was greater than 50 m from a previously-sampled point. If either of these occurred, we moved to the next point on the list until we had completed the desired number of samples per block. At PRNAS and LAKEHURST, and at half of the blocks on WARB (n = 8), five samples were completed per block. At WARB blocks that straddled mowed and unmowed management areas (n = 8), we performed 10 measurements per block (5 per management zone). Measurements performed at random locations were identical to those taken at the nest quadrats.

Statistical Analyses

We modeled daily nest survival rate (DSR) of grasshopper sparrow, eastern meadowlark and ‘other’ grassland obligate species using the logistic nest survival model within the program MARK (v. 6.0; White and Burnham 1999, Dinsmore et al. 2002). ‘Other’ passerine species consisted of savannah sparrow (n = 51), bobolink (n = 8), and horned lark (n = 3) on WARB, and field sparrow (n = 23) and horned lark (n = 1) on LAKEHURST. Several non-passerine nests were also located and monitored, including 23 upland sandpiper nests at WARB, and 20 common nighthawk nests at LAKEHURST. Findings for these nests are reported elsewhere (Peters and Allen 2010b, Allen et al. 2009, respectively).

A set of 10-12 candidate models were evaluated for each of the three study sites. Distinct model sets were developed for each site because of substantial differences in management strategies, and because several habitat variables were confounded among sites. At each site, we first ran a null (intercept only) model and two temporal models – 'Year' and 'Julian' (i.e., day of season). If a temporal model substantially outperformed the null (greater than 2 Akaike Information Criterion units), it was included as a covariate in all subsequent models evaluated. This iterative modeling approach was adopted due to temporal variability noted in other studies of avian nesting success (Grant et al. 2005, Dinsmore and Dinsmore 2007). Because of sample size limitations, a maximum of one parameter (plus temporal variables, if applicable) was included per model. Models evaluated for each set are listed in Table 1. Two management models were included in the initial WARB model set, a 'Mowed Area' model, and a 'Nest Mowed' model. The 'Mowed Area' candidate modeled nest success based on whether or not a nest was located within a mowing plan area. The 'Nest Mowed' candidate modeled the success of nests that were directly mowed over vs. those that were not. For PRNAS data, we only included a 'Nest Mowed' model. No management models were included in the Lakehurst model set, as no mowing occurred there. 'Distance from Runway' (i.e., distance to nearest active runway) models were examined for PRNAS and WARB. Because several study areas on Lakehurst were not associated with active runways, we instead incorporated an 'Area' class variable (i.e., Jump Circle, Test Site, Westfield Runway, Appendix A). Daily survival rate (DSR) estimates and confidence intervals for groups of nests were generated using the appropriate corresponding model. The best performing model(s) were selected based on Akaike's Information Criterion adjusted for low sample sizes (AIC_c; Burnham and Anderson 2002). Models within ≤ 2 ΔAIC_c points were considered equally supported. Model fit was assessed using McFadden's pseudo R^2, which can be interpreted as an approximate variance in the outcome accounted for by the model (Long 1997). In general, this value tends to be smaller than R^2, and it is not recommended that they be interpreted independently or compared across datasets (UCLA 2011).

After examination of the individual site models, we developed several pooled-site models incorporating parameters that appeared to be related to DSR, to look for general effects and interactions among sites. These candidate models included a 'Julian' model, a 'Site' model, a 'Julian' + 'Site' model, a 'Grass Height' + 'Site' model with a 'Grass Height' x 'Site' interaction, and a 'Grass Cover' + 'Site' model with a 'Grass Cover' x 'Site' interaction. For PRNAS and WARB only, we also ran a 'Nest Mowed' + 'Site' model with a 'Nest Mowed' x 'Site' interaction, and a 'Distance to Runway' + 'Site' model with a 'Distance to Runway' x 'Site' interaction.

FINDINGS

Nest Site Characteristics

A total of 76 grasshopper sparrow and 41 eastern meadowlark nests were located in 2010, bringing our total nest counts to 117 and 89, respectively. Only data from 115 grasshopper sparrow, and 86 eastern meadowlark nests were used in subsequent DSR analyses due to missing data (e.g., exposure days). Maps of all monitored nests, by site and nest fate, can be viewed in Appendix A. Habitat structure around nests varied across sites for both species (Tables 2-4), and ANOVA analyses indicated that several of these habitat variables differed significantly among sites (Figure 1). This was the basis for our decision to run analyses separately for each military installation, to avoid problems associated with factors that were confounded with site.

We also examined vegetation data collected at random plots not affiliated with nests and compared them to our nest plots. Because random plot data were only available from one year (2010), these comparisons are primarily qualitative. At all sites, eastern meadowlarks, and to a lesser extent grasshopper sparrows, tended to nest in areas of the airfield that were characterized by less bare ground (Figure 2). Nests of both species also were in areas with fewer shrubs (Figure 2). PRNAS, in general, had greater grass and forb cover than did the other two sites at nest and random plots, reflecting the homogeneity of ground cover characteristic of the base. LAKEHURST, conversely, was much more likely to contain patches of bare ground in random plots, revealing the patchy nature of the warm-season grasses that dominate the site. Finally, nest sites for both species tended to be in shorter vegetation than was recorded at random plots at WARB (Figure 3); this pattern was not apparent at LAKEHURST or PRNAS. Summary statistics for vegetation measurements taken at random plots are provided in Table 5.

Nest Initiation Dates

Patterns of nest initiation dates at the three sites are illustrated in Figures 4-6. Nest initiations for grasshopper sparrow followed disparate patterns among sites, although all showed a peak in nesting activity during the latter part of May (Figure 4). At PRNAS, a bimodal pattern was apparent, suggesting two broods per season; one in late May and another in late June/early July. Nests monitored at WARB showed a more uniform pattern of initiation from late May through early July. A majority (> 60 %) of grasshopper sparrow nests monitored at LAKEHURST were estimated to have been initiated during the last ten days of May. Eastern meadowlarks apparently began nesting earlier than grasshopper sparrows at all sites, generally in late April at PRNAS and WARB, and in early May at LAKEHURST (Figure 5). Meadowlark nest initiations were also multimodal, with approximately monthly peaks in activity apparent at PRNAS and WARB. Sample size limitations likely precluded the identification of similar patterns at LAKEHURST. Initiation dates for savannah sparrow and field sparrow at WARB and LAKEHURST, respectively, were also characterized by what appear to be within-season cycles of nesting activity (Figure 6).

Nest Survival Rates

<u>Individual-site nest survival models</u>

Grasshopper sparrow

Grasshopper sparrow DSR was best predicted by Distance to Runway at WARB, while both the Distance to Runway and Nest Mowed models performed competitively at PRNAS (Table 6). Several models were identified as performing equally well at LAKEHURST, but none of these outperformed the Null model (Table 6). Although the Distance models performed relatively well for predicting DSR at WARB and PRNAS, patterns observed at the two bases were very different. At WARB, nests that were located further from active runways were more successful than those closer to runways (Table 7, Figures 7, A1). The opposite was true at PRNAS, where nests closer to runways tended to fare better (Table 7, Figures 8b, A5). All parameter estimate CIs from the LAKEHURST models also widely included "no effect", indicating that none of the factors measured were good predictors of DSR at this site (Table 7, Figure 9).

At PRNAS, nests that were mowed over while active actually were slightly more successful than those that weren't mowed; however, the 95% CI for the mow parameter estimate widely overlapped zero, or "no effect", so this finding may be spurious (Table 7, Figure 8a). Sample-size was likely a factor; only 9 nests were mowed over (1 failure), whereas 48 nests were not mowed (19 failures).

Although the WARB Mow Area model was slightly greater than 2.0 AIC_c points greater than the top-performing model (Table 6), it should be noted that due to the spatial layout of the mowing plan, the Mow Area parameter at this site was confounded with Distance to Runway; nests closer to the runway were generally within the mow plan area, while those further removed from the runway were not (Figures 10, A1). According to the Mow Area model, nests within the mow plan fared slightly worse overall (DSR = 0.949; CI 0.898 - 0.976) than did those outside of the mow plan (DSR = 0.985; CI 0.941-0.996, Table 8). However, the mow area parameter estimate overlapped zero (mow area vs. not in mow area; $\beta = -1.23$, SE = 0.81, 95% CI = -2.82 to 0.36), so this relationship is only weakly supported.

Overall, grasshopper sparrow DSRs among the three study sites were similar (Table 8). Based on DSR estimates, probability of nesting success for grasshopper sparrow was 51% at WARB (95% CI = 27-70%), 47% at LAKEHURST (CI = 27-64%), and 48% at PRNAS (CI = 32-62%).

Eastern meadowlark

Similar to preliminary findings from 2009, eastern meadowlark DSR was best predicted by percent grass cover at WARB and LAKEHURST (Table 9). At both sites, nests were more successful in areas with less grass cover (Table 10, Figures 11-12). The vegetation clumpiness model for LAKEHURST was also competitive, but gave imprecise parameter estimates (Table 10), likely as a result of the extremely low sample size obtained there (n = 7 nests). At PRNAS, DSR was best predicted by the vegetation height model (Table 9), wherein meadowlark nests were more successful in areas with higher vegetation (Table 10, Figure 13). A negative trend in success as the season progressed was also noted at PRNAS (Table 10, Figure 13).

Eastern meadowlark DSR was similar between WARB and PRNAS, but was somewhat higher at LAKEHURST, possibly due to the small sample size obtained there (Table 11). In general, meadowlark DSR was lower than that observed for grasshopper sparrow. Probability of nesting success for meadowlark was 31% at WARB (95% CI = 13-70%), 54% at LAKEHURST (CI = 15-82%), and 20% at PRNAS (CI = 10-32%).

Other grassland obligates

Nest survival models for other grassland passerines breeding at LAKEHURST and WARB are provided in Table 12. At WARB, nests that were mowed over actually fared better than those that were not mowed (Table 13, Figure 14). At LAKEHURST, all parameter estimates encompassed zero (Table 13). However, there appeared to be a moderate Year effect (i.e., 2009 nests were more successful than 2010 nests), and a negative relationship to grass cover (Table 13, Figure 15). Although the LAKEHURST 'Vegetation Clumpiness' model was also competitive, relationships according to this model were unclear (Table 13, Figure 15).

<u>Combined-site nest survival models</u>

Grasshopper sparrow

Combined-site vegetation structure models for grasshopper sparrow did not reveal any overall effects or interactions among study sites (Table 14). Although the best-performing model included a seasonal effect, the parameter estimate for this effect was nearly centered on zero, indicating that this was not a reliable factor for predicting DSR (Table 14). The combined management/spatial models for grasshopper sparrow at PRNAS and WARB, however, revealed a significant interaction between the two sites with respect to the distance nests were from active runways (Table 15). A clear distinction emerged, wherein nests located closer to runways were more successful at PRNAS, while those located further from runways were more successful at WARB (Figure 16).

Eastern meadowlark

For eastern meadowlark, the combined vegetation model revealed a strong grass-cover effect as well as a grass x site interaction (Table 16). There was a clear negative relationship between the amount of horizontal grass cover surrounding a nest and DSR. The interaction terms further indicated that this relationship was primarily driven by patterns observed at WARB and Lakehurst (Figure 17). Combined management/spatial models for eastern meadowlark at PRNAS and WARB did not reveal any effects or interactions with respect to mowing or nest placement (Table 17). A slight negative temporal pattern in DSR was noted (i.e., through a seasonal effect), but again, the 95% CI for this parameter estimate widely encompassed 'no effect'.

Nestling Morphometrics

In 2010, 111 grasshopper sparrow and 76 eastern meadowlark nestlings were processed and banded (Table 18). Measurements among sites were comparable, with the exception of fat and keel rating scores, which were subjectively assigned and may reflect observer differences rather than differences in chick condition. When 2009 (Lakehurst only, GRSP n = 33; EAME n = 16, Allen et al. 2009) and 2010 data were combined and examined by nestling age (days), grasshopper sparrow mass increase was nearly identical among sites (Figure 18a). Eastern meadowlark chicks were lighter at Lakehurst than the other two sites (Figure 18b). However, sample size at Lakehurst was low and represented 2009 data only, rendering it difficult to discern whether inter-annual or site differences were driving this pattern.

Direct Mowing Effects

At PRNAS, mowers passed over 26 of 52 active meadowlark nests and nine of 58 active grasshopper sparrow nests during both years of the study. Seven meadowlark nests (27% of those mowed) were directly destroyed by the mower (e.g., crushed by tires, killed by blades), while no grasshopper sparrow nests were directly destroyed. Two additional meadowlark nests were abandoned immediately after mowing (i.e., by the next check date), likely as a result of the disturbance. One of these was mowed during the egg-laying stage (a particularly sensitive period; Lanyon 1995), and the other experienced significant damage to the nest structure (the "roof" was removed). Another two meadowlark nests were suspected to have failed as a result of scavenging by predators soon after mowing, but it is unclear whether these failures were caused by the mowing or were simply natural predation events.

At WARB, 15 of 27 meadowlark nests and 14 of 26 grasshopper sparrow nests were located in areas that were mowed during the breeding season. Five active nests of each target species (i.e., EAME and GRSP) were mowed over at WARB, and one nest of each was directly destroyed as a result (i.e., 20% of those mowed). Two additional eastern meadowlark nests were abandoned immediately after being mowed, one of which was likely in the egg-laying stage (it contained only three eggs). One additional grasshopper sparrow nest also failed soon after being mowed, when the nestlings were apparently abandoned. Chicks in this nest survived the mow, but during the next visit we found one nestling dead and the others sitting outside the nest . The nest was ultimately classified as 'failed' when on subsequent checks the chicks, too young to have fledged, were not present in the vicinity.

DISCUSSION

Data from the first two years of this study have provided a great deal of information about grassland bird productivity on LAKEHURST, PRNAS, and WARB. Although sample sizes obtained for each site were limited in some instances (e.g., eastern meadowlarks at LAKEHURST), a clearer picture has continued to emerge regarding the implications of management actions on grassland bird breeding success on regional DoD airfields.

Grasshopper Sparrow, Nest Survival Models

The top-ranking models of daily nest survival rates (DSR) pointed to several potential factors affecting grasshopper sparrow DSR, though predictor variables and response patterns differed substantially among the three study sites. For grasshopper sparrow, the distance of a nest from the nearest active runway emerged as a potentially important predictor of DSR both at PRNAS and WARB. However, at WARB, proximity to runways appeared to be detrimental to survival, whereas at PRNAS, nests closer to runways appeared to fare better. Model selection at LAKEHURST did not reveal any strong predictors of grasshopper sparrow nest success.

It should be noted that parameter estimates from the 'distance to runway' models either overlapped zero (WARB) or nearly-overlapped zero (PRNAS), so they should be interpreted with caution. The top-ranked GRSP model at PRNAS also indicated that mowed-over nests fared better than those that did not, though this model had parameter estimates that widely overlapped zero. None of the candidate grasshopper sparrow DSR models appear to have fit exceptionally well, as evidenced by pseudo-R^2 values less than 0.10 (Table 6), although see Shaffer and Thompson (2007) for discussion of the limitations of deviance-based measures of DSR model-fit. While model performance was less than optimal in some cases, we feel it is relevant to further consider the potential implications of the mixed results observed, as they may reflect differences in management strategies, landscape context, or other factors among the sites.

To avoid potential conflicts among management goals, WARB consults with the Massachusetts Natural Heritage and Endangered Species Program (MNHESP) concerning the impacts of airfield mowing on species of conservation concern. As a result, the WARB Bird Hazard Working Group agreed to maintain grass at 7-14 inches only within 300 ft of airfield pavements (Appendix A), and to delay mowing of the remainder of the airfield until after 1 August each year when the majority of grassland bird nesting is completed (A. Milroy *personal comm*.). As a result, vegetation structure directly adjacent to runways is different from that further from the runways, and the 'Distance from Runway' parameter is confounded with management strategy (i.e., mow area vs. unmowed area). Because the "Mow Area" model at WARB, which performed nearly as well as the top-performing models (i.e., ΔAIC = 2.37), indicated that nests in mowed areas did not do as well as those in unmowed areas (estimated 35 vs. 75% survival), we feel that this issue deserves further attention. However, sample sizes of GRSP nests found in mowed and unmowed areas (14 and 12, respectively) were below the minimum of 20 nests recommended for reliable estimation of DSR (Hensler and Nichols 1981). Therefore, we anticipate that an additional year of data will increase the precision of our estimates and help clarify whether or not the distance effect observed at WARB is in fact management driven.

Alternatively, the positive relationship found between grasshopper sparrow DSR and distance to runways at WARB could be due to disturbance associated with aircraft activity. Disturbance from human activities is well-known to reduce fitness in several avian guilds (reviews in Hockin *et al*. 1992, Carney and Sydeman 1999), through increased rates of predation (Giese 1996), nest abandonment (Anderson and Keith 1980) or lowered nest attendance by adults (Verhulst et al. 2001). Grassland birds have also been documented to avoid breeding in areas near heavy road traffic (Forman et al. 2004). Interestingly, in some cases this lowered habitat use may be offset by increased breeding success associated with lower densities, as has been demonstrated with ground-nesting woodlarks (*Lullula arborea*, Mallord et al. 2007). There is also a possibility that runway placement resulted in negative edge-effects (i.e., increased predation near runway edges), although the evidence for use of paved surfaces as travel corridors by nest predators in grassland habitats is weak (Winter et al. 2000). At WARB, observers often noted coyote (*Canis latrans*) scat and that of other potential mammalian predators along perimeter roads paralleling the runways (MCA, *personal observ.*). Closer inspection of how habitat, aircraft disturbance, and predator dynamics differ with respect to distance from the runways at WARB will be necessary to clarify the processes behind these apparent spatial patterns in nest survival.

Conversely, at PRNAS, grasshopper sparrow nests closer to active runways appeared to be *more* successful than those farther away. This finding may be related to the landscape context in which the airfield is juxtaposed. PRNAS is bordered by coastal habitats (e.g., saltmarsh, coastal scrub), which are known to harbor mammalian predators such as raccoon (*Procyon lotor*) and Norway rat (*Rattus norvegicus*, Draud et al. 2004), so that nests near the airfield margin may have been subject to higher predation rates. Many fields on base are also bordered by woody vegetation, an edge type that has been linked to higher nest predation rates for grassland birds in other studies (Winter et al. 2000, Jensen and Finck 2004), although not in all cases (see Grant et al. 2006). Again, although the fit of our "distance to runways" model was relatively low, we feel that further inquiry into this potential effect is warranted, as a better understanding of the spatial dynamics of nest survival for grasshopper sparrows at PRNAS would ultimately benefit future management decisions for this species of conservation concern. Other spatially-explicit models may also be worth exploring, such as those relating grasshopper sparrow nest survival to the distance to nearest woodland edge.

Eastern Meadowlark, Nest Survival Models

A clearer picture emerged with respect to eastern meadowlark nesting success at the three study sites. At LAKEHURST and WARB, nests fared significantly better when placed in microhabitats with less horizontal grass cover. Nests at PRNAS, alternatively, were significantly more successful in areas characterized by taller vegetation. Further examination of the vegetation height variable at PRNAS confirmed that it was not correlated with horizontal grass cover ($R^2 = -0.02$, $P = 0.89$). The indication that grass cover was negatively related to meadowlark nesting success at two of our sites, and that vegetation height was positively related to success at the other, may be associated with habitat heterogeneity. Several studies have suggested that managers maintain grasslands for this species by providing a diversity of cover heights and densities, presumably with some shrub invasion (review in Lanyon 1995). Some nests at PRNAS were in fact placed under small cedars (*Juniperus sp.*, MCA *personal observ*., Figure 20). However, it is not immediately clear by what mechanism increased vegetation height or decreased grass cover would translate into lower rates of nest failure.

Effects of Mowing

Although mowing was a source of nest failure in our study, it did not emerge as a significant predictor of nest survival rates for either target species. It is important to note that even with two years of data, sample sizes for directly mowed nests were small for grasshopper sparrow, lowering the precision of DSR estimates and making comparisons difficult. Only 14 grasshopper sparrow nests were mowed during the course of the study, which is lower than the recommended sample size for comparing DSR among groups (e.g., 20 nests, Hensler and Nichols 1981), and this problem was exacerbated even further in the individual site models (PRNAS, n = 9 nests mowed; WARB, n = 5 nests mowed). Similarly, while sample sizes of meadowlark nests at PRNAS (n = 26 nests mowed) were above the recommended minimum, only 5 meadowlark nests at WARB were mowed over during the two years of the study.

Pooling data from both 'mowed' bases, we found that 19% of grasshopper sparrow nests located in mowed areas were passed over by a mower, but only one nest was directly destroyed by the mowing itself (7% of those mowed). Eastern meadowlark nests, however, were much more likely to be directly destroyed by the mowers. For this species, nearly half (46%) of nests in regularly mowed areas were mowed over, and close to one-third (29%) of mowed nests were directly destroyed by the mowers. There are several likely causes for the discrepancy we noted between species. First, eastern meadowlarks generally begin nesting earlier than grasshopper sparrows (late April vs. late May; Figure 4 and 5, Lanyon 1995, Vickery 1996), and were thus subject to more mowing events, which took place approximately once per month (Figure 19). Grasshopper sparrow nesting, on the other hand, took place later in the season and appeared to be shorter overall, so that they experienced fewer mowing events. Eastern meadowlark individual nesting cycles are also somewhat longer than grasshopper sparrow (ca. 24 days vs. 20 days, respectively), leaving them vulnerable for longer periods of time. Furthermore, grasshopper sparrow nests tended to have a lower height-profile than meadowlark nests, so that they were less susceptible to blade strikes and less likely to incur serious structural damage. The temporal patterns of nest initiations we observed at the three sites may be particularly informative, in that prior knowledge could allow managers to time mowing so as to minimize damage to targeted species such as grasshopper sparrow.

Mowing-induced mortality rates at our sites (both direct and indirect) were lower than expected based on the results of several previous studies (Bollinger et al. 1990, Kershner and Bollinger 1996, Perlut et al. 2006). In a study of bobolinks in New York, hay cutting (not including raking and baling) caused direct mortality of 51% of eggs and nestlings, plus an additional 24% through nest abandonment (Bollinger et al. 1990). On Illinois airports, Kershner and Bollinger (1996) found mowing to be the cause of 44% of all grassland bird nest mortality. Haying in late May / early June in Vermont (including raking and baling) resulted in the direct mortality of 78% of savannah sparrow and bobolink nests, while nearly all remaining nests were scavenged by predators (Perlut et al. 2006).

Several factors may have resulted in the comparatively lower mowing mortality rates in our study, including mowing height, mowing intensity, and timing. Fields at airports studied by Kershner and Bollinger (1996) had a fairly low average mowing height of 11 cm and a minimum of 5 cm, while all fields at WARB and most at PRNAS were cut at a height of 18 cm (7 inches, D. Milroy, *personal comm.*). This height difference, though not large, could have reduced the probability of direct damage to eggs or nestlings.

Studies involving hay cutting (Bollinger et al. 1990, Perlut et al. 2006) may have experienced higher mortality rates due to the larger and potentially more invasive machinery, especially in the case of Perlut et al. (2006) whose mortality rates also included additional passes by raking and baling machines. Timing could have also played a role in reducing the number of nests mowed, as mowing often began in mid- or late-May, perhaps after many EAME nests were already completed, but before the majority of GRSP nesting had begun.

We anticipate that a proposed increase in sample size, to be obtained during the 2012 breeding season, will enhance our ability to detect potential effects of mowing, either direct or indirect, on grassland bird breeding success. It seems likely that nests that are directly mowed over are at greater risk of failure, based on observations we made in 2009 of nests that were crushed or partially destroyed by mowers, and on results from similar studies (e.g., Kershner and Bollinger 1996). However, the results we have obtained thus far have shown no effect of mowing on survival rates, or in some cases a positive relationship to survival. We feel that these apparently spurious findings are likely a result of sample-size limitations. Also, because mowed areas generally have less concealing vegetation than unmowed areas, nests in these areas would be expected to be vulnerable to indirect effects including predation/scavenging (Bollinger et al. 1990, Perlut et al. 2006) and exposure to the elements (With and Webb 1993). A mowing-induced reduction in food resources could also reduce nest survival due to lowered provisioning rates (Zalilk and Strong 2008) and increase exposure as parents remain off the nest for longer periods of time in pursuit of food. The patterns we observed at WARB indicate that such indirect processes may be in effect at that site, but again, we feel that at least one additional year of data will be necessary for clarification. Alternatively, it may be that mowing regimes based on a 7-14" vegetation height requirement are less detrimental than management practices evaluated in other studies. If additional data support this possibility, recommendations for major alterations in management regimes may not be warranted.

Overall, nest survival rates at our three study sites in 2009-2010 were relatively high for both target species when compared with the literature. For grasshopper sparrow, pooled DSR estimates ranged from 0.96 at LAKEHURST and PRNAS to 0.97 at WARB, compared to a range of 0.91-0.96 from three other studies (only studies with > 20 nests included; Perkins et al. 2003, Galligan et al. 2006, Giocomo et al. 2008). For eastern meadowlark, estimates ranged from 0.94 at PRNAS to 0.97 at LAKEHURST, and from 0.93-0.95 in published reports (Galligan et al. 2006, Perkins and Vickery 2007, Giocomo et al. 2008). Given the nest survival rates we observed in 2009-2010, we have no immediate reason to believe that our three study sites are acting as “ecological traps” (Robertson and Hutto 2006), or population sinks in which birds are attracted to nest, but do not reproduce successfully. Furthermore, there is evidence that grasshopper sparrow, at least, can produce two broods at our sites (e.g., Figure 8 [PRNAS], Jones 2000 [WARB]), which would allow a higher annual productivity for pairs that do escape the mower. However, source-sink population dynamics depend not only on annual productivity, but also on factors more difficult to measure, such as juvenile and adult survival (Perlut et al. 2008). For example, poor fledgling survival due to mowing-related habitat alteration would have a negative effect on population health, similar to poor nest survival, but would be logistically difficult to assess in the current study.

Because airfields are thought to be of great importance to regional populations of declining grassland birds, and are likely to become more so in the future (Askins et al. 2007), it is imperative that good data on populations and demography at these sites are available. Given the somewhat conflicting results of our study with those from other airports (e.g., Kershner and Bollinger 1996), much uncertainty remains concerning the effects of airfield management and operations on grassland bird productivity. We have thus proposed a third year of the current study, in order to obtain adequate site-specific sample-sizes and identify any general response patterns for the region.

Benefits to the Military

Taken in conjunction with a parallel study currently being conducted on PRNAS, LAKEHURST, and WARB that focuses on management effects on bash-risk and conservation-priority species habitat use (Peters and Allen 2010a), findings from this research can be used to generate comprehensive management models for DoD airfields. In previous reports we made several suggestions for enhancing DoD management decisions regarding airfield safety and functionality, with the goal of minimizing the likelihood of problem species occurrence and maximizing positive effects on conservation concern species (Peters and Allen 2010a, 2010b). Data obtained in this study will further enhance confidence in model predictions about the effects of management practices on airfields, and will provide DoD airfield managers with an increased general understanding of how mowing and other management activities on their lands affect sensitive grassland bird populations. Results from this study also identified nesting microhabitat preferences of species of conservation concern on airfields, and provided site-specific information on the timing of nesting. If some of the generalized patterns we have observed thus far can be substantiated, data collected through this project can be used to develop best management practices (BMPs) that may serve as guidelines for airfield managers wishing to minimize impacts on sensitive grassland species. For instance, resource managers may be able to respond by altering mowing regimes (e.g., to avoid critical nesting periods), manipulating habitat to draw birds away from active runways (e.g., grasshopper sparrows at WARB), or increasing habitat heterogeneity (e.g., eastern meadowlarks in the Northeast region).

Ultimately, a clearer understanding of how airfield habitat management practices affect species of conservation concern will be essential to developing Integrated Natural Resources Management Plans for Navy, Air Force and Army bases. Additional data from these and other sites with varying management and operational activities will be valuable in elucidating the role that DoD and other airfields will play in the future population viability of grassland birds. We anticipate that the next step in this critical process will be to integrate findings from various monitoring studies into a Structured Decision Making (SDM) process (review in Peters and Allen 2010a) that recognizes all potential objectives, engages various stakeholders, and uses the best available science to determine optimal management plans for individual DoD airfields.

LITERATURE CITED

Allen, M. C., K. A. Peters, and L. Usyk. 2009. Avian Productivity on Lakehurst Naval Air Engineering Station, 2009. Report submitted to John Joyce, Natural/Cultural Resources Manager, Lakehurst Naval Air Engineering Station, Lakehurst, NJ.

Anderson, D. W. and J. O. Keith. 1980. The human influence on seabird nesting success: conservation implications. Biological Conservation 18:65–80.

Askins, R. A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. Current Ornithology 11:1-34.

Askins, R. A. 1996. History and conservation of grassland birds in the northeastern United States. In The ecology and conservation of grasslands and heathlands in the northeastern United States (P. D. Vickery, P. Dunwiddie, C. Griffin, Eds.). Massachusetts Audubon Society, Lincoln, MA.

Askins, R. A., F. Chavez-Ramirez B. C. Dale, C. A. Haas, J. R. Herkert, F. L. Knopf, and P. D. Vickery. 2007. Conservation of grassland birds in North America: Understanding ecological processes in different regions. Ornithological Monographs 64:1-46.

Bairlein, F. 1995. European-African songbird migration network manual of field methods. Institut für Vogelforschung, Wilhelmshaven, Germany.

Bollinger, E. K., P. B. Bollinger, and T. A. Gavin. 1990. Effects of Hay-Cropping on Eastern Populations of the Bobolink. Wildlife Society Bulletin 18:142-150.

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

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. The U.S. Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.

Burnham, K. P. and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach – 2nd ed. Springer Science & Business Media, Inc., New York, NY.

Carney, K. M. and W. J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22: 68-79.

Commander Navy Installations Command (CNIC) Air Operations Program Director, January 2010. DRAFT - Bird/Animal Aircraft Strike Hazard (BASH) Manual. www/public.navy.mil/navsafecen/Documents/aviation/operations (accessed 2/24/2011).

Conway, C. and T. E. Martin. 1999. The value of monitoring demographic parameters and associated habitat: the BBIRD program. *In* R. Bonney, D. N. Pashley, R. J. Cooper, L. Niles, eds., Strategies for bird conservation: the Partners in Flight planning process. Cornell Lab of Ornithology. <http://birds.cornell.edu/pifcapemay>

Dinsmore, S. J., G. C. White, and F. L. Knopf. 2002. Advanced techniques for modeling avian nest survival. Ecology 83:3476-3488.

Dinsmore, S. J., and J. J. Dinsmore. 2007. Modeling avian nest survival in program MARK. Studies in Avian Biology 34:73-83.

Draud, M. M. Bossert, and S. Zimnavoda. 2004. Predation on hatchling and juvenile diamondback terrapins (*Malaclemys trrapin*) by the Norway Rat (*Rattus norvegicus*). Journal of Herpetology 38:467–470.

Forman, R. T., B. Reineking, and A. M. Hersperger. 2004. Road traffic and nearby grassland bird patterns in a suburbanizing landscape. Environmental Management 29:782-800.

Fretwell, S. and H. J. Lucas, Jr. 1969. On territorial behaviour and other factors influencing habitat distribution in birds. I. Theoretical development. Acta Biotheoretica 19:16-36.

Galligan, E. W., T. L. Devault, and S. L. Lima. 2006. Nesting success of grassland and savanna birds on reclaimed surface coal mines of the Midwestern United States. Wilson Journal of Ornithology 118:537-546.

Giese, M. 1996. Effects of human activity on adelie penguin *Pygoscelis adeliae* breeding success. Biological Conservation 75, 157–164.

Giocomo, J. J., E. D. Moss, D. A. Buehler, and W. G. Minser. 2008. Nesting biology of grassland birds at Fort Campbell, Kentucky and Tennessee. Wilson Journal of Ornithology 120:111-119.

Grant, T. A., T. L. Shaffer, E. M. Madden, and P. J. Pietz. 2005. Time-specific variation in passerine nest survival: new insights into old questions. Auk 122:661-672.

Grant, T. A., E. M. Madden, T. L. Shaffer, P. J. Pietz, G. B. Berkey, and N. J. Kadrmas. 2006. Nest survival of clay-colored and vesper sparrows in relation to woodland edge in mixed-grass prairies. Journal of Wildlife Management 70:691-701.

Halfwerk, W., L. J. M. Holleman, C. M. Lessells, and H. Slabbekoorn. 2010. Negative impact of traffic noise on avian reproductive success. Journal of Applied Ecology 48(1):210-219.

Hensler, G. L. and J. D. Nichols. 1981. The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bulletin 93: 42-53.

Hockin, D., M. Ounsted, M. Gorman, D. Hill, V. Keller and M. A. Barker. 1992. Examination of the effects of disturbance on birds with reference to its importance in ecological assessments. Journal of Environmental Management 36:253–286.

Hubbard, R. D., D. P. Althoff, K. A. Blecha, B. A. Bruvold, and R. D. Japuntich. 2006. Nest site characteristics of eastern meadowlarks and grasshopper sparrows in tallgrass prairie at the Fort Riley military installation, Kansas. Transactions of the Kansas Academy of Science, 109:168-174.

Jensen, W. E. and E. J. Finck. 2004. Edge effects on nesting dickcissels (*Spiza americana*) in relation to edge type of remnant tallgrass prairie in Kansas. American Midland Naturalist 151:192-199.

Jones, A. L. 2000. Grasshopper sparrow (*Ammodramus savannarum*) metapopulation dynamics and conservation strategies in Massachusetts. Master of Science Thesis. University of Massachusetts Amherst, Department of Natural Resources Conservation.

Kershner, E. L., and E. K. Bollinger. 1996. Reproductive success of grassland birds at east-central Illinois airports. American Midland Naturalist 136:358-366.

Lanyon, W. E. 1995. Eastern Meadowlark (*Sturnella magna*). *In* The Birds of North America, No. 160 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Long, J. S. 1997. *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks: Sage Publications. pp104-106.

Mallord, J. W. P. M. Dolman, A. F. Brown, and W. J. Sutherland. 2007. Linking recreational disturbance to population size in a ground-nesting passerine. Journal of Applied Ecology 44:185–195.

Martin, T. E. 1992. Breeding productivity considerations: what are the appropriate habitat features for management? Pages 455-473 *in* J. M. Hagan and D. W. Johnston, eds. Ecology and Conservation of Neotropical Migrants. Smithsonian Institution Press, Washington, DC.

Melvin, S. M. 1994. Military bases provide habitat for rare grassland birds. National Heritage News, Massachusetts Division of Fish and Wildlife 4:3.

Norment, C. 2002. On grassland bird conservation in the Northeast. Auk 199:271-279.

Osborne, D. R. and A. T. Peterson. 1984. Decline of the upland sandpiper (*Bartramia longicauda*) in Ohio: an endangered species. Ohio Journal of Science 84:8-10.

Perkins, D. W. and P. D. Vickery. 2007. Nest Success of Grassland Birds in Florida Dry Prairie. Southeastern Naturalist 6:283-292.

Perlut, N. G., A. M. Strong, T. M. Donovan, and N. J. Buckley. 2006. Grassland songbirds in a dynamic management landscape: Behavioral responses and management strategies. Ecological Applications 16:2235-2247.

Perlut, N. G., A. M. Strong, T. M. Donovan, and N. J. Buckley. 2008. Grassland songbird survival and recruitment in agricultural landscapes: implications for source–sink demography. Ecology 89:1941-1952.

Peters, K. A. and M. C. Allen. 2010a. Avian response to grassland management around military airfields in the Mid-Atlantic and Northeast regions. Interim Report submitted to the DoD Legacy Resource Management Program.

Peters, K. A. and M. C. Allen. 2010b. Grassland bird nesting success and relative abundance on Westover Air Reserve Base (WARB), Massachusetts. Report submitted to Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Hadley, MA.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D.W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Robertson, B. A. and R. Hutto. 2006. A framework for understanding ecological traps and an evaluation of existing evidence. Ecology 87:1075-1085.

Schaffer, T. L. and F. R. Thompson III. 2007. Making meaningful estimates of nest survival with model-based methods. Studies in Avian Biology 34:84-95.

UCLA Academic Technology Services, Statistical Consulting Group. 2011. Introduction to SAS. from http://www.ats.ucla.edu/stat/sas/notes2/ (accessed February 26, 2011).

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Verhulst, S., Oosterbeek, K. and Ens, B. J. 2001. Experimental evidence for effects of human disturbance on foraging and parental care in oystercatchers. Biological Conservation 101:375–380.

Vickery, P. D. 1996. Grasshopper sparrow (Ammodramus savannarum). In The Birds of North America, No. 239 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, DC.

Vickery,P. D., and P. A. Dunwiddie, eds. 1997. Grasslands of Northeastern North America. Massachusetts Audubon Society, Lincoln, Massachusetts.

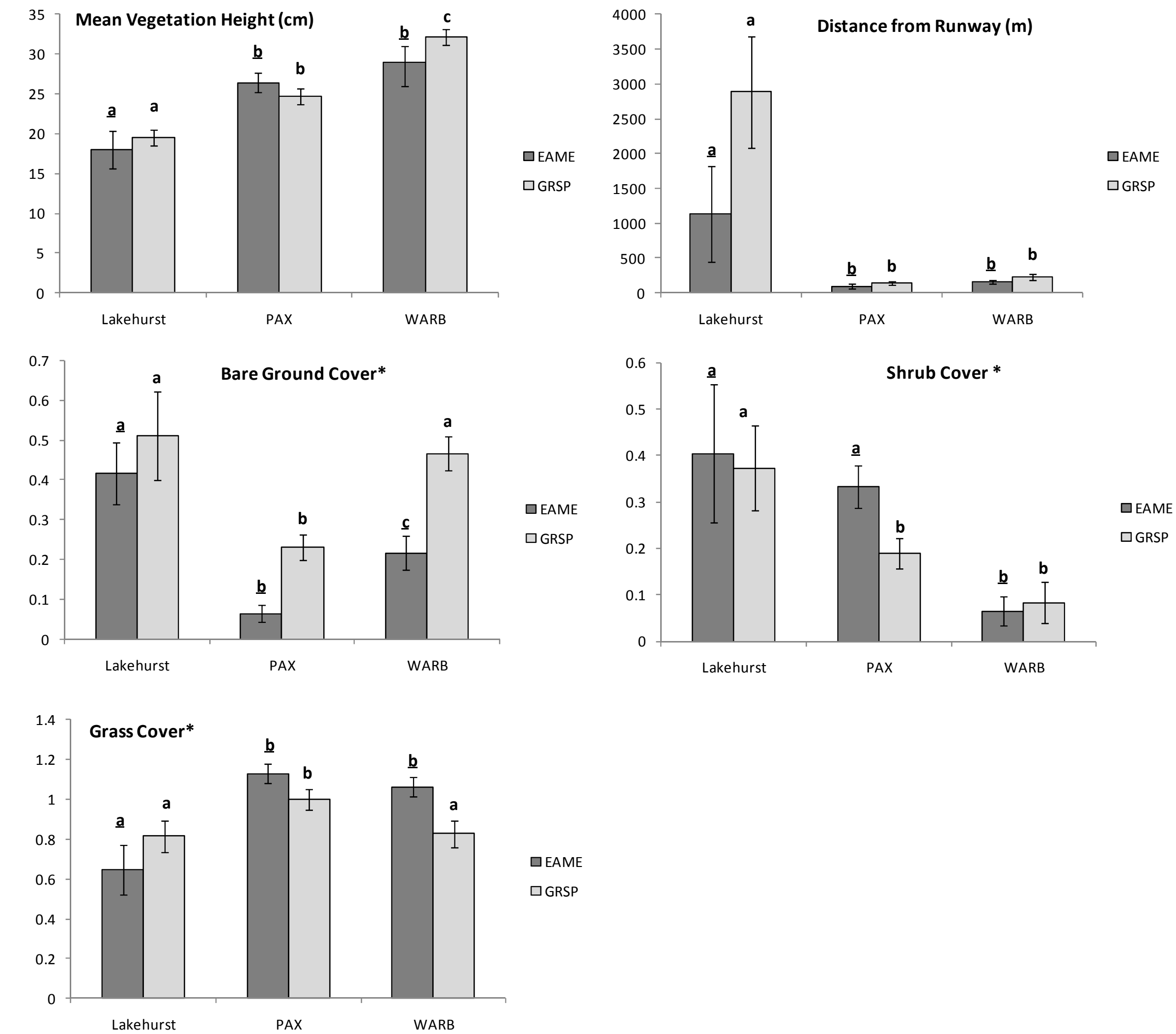
Walk, J. W., E. L. Kershner, T. J. Benson and R. E. Warner. 2010. Nesting success of grassland birds in small patches in an agricultural landscape. Auk 127:328-334.

White, G. C. and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46: 120-139.

Winter, M., D. H. Johnson, and J. Faaborg. 2000. Evidence for edge effects on multiple levels in tallgrass prairie. Condor 102:256-266.

With, K. A., and D. R. Webb. 1993. Microclimate of ground nests - the relative importance of radiative cover and wind breaks for 3 grassland species. Condor 95:401-413.

Zalilk, N. J. and A. M. Strong. 2008. Effects of hay cropping on invertebrate biomass and the breeding ecology of Savannah Sparrows (*Passerculus sandwichensis*). Auk 125:700-710.



*Percent cover, arcsine transformed.

Figure 1. Significant differences in mean (SE) habitat characteristics of 1-m^2 plots centered on grasshopper sparrow and eastern meadowlark nests among study sites, 2009-2010. Significance accepted at $P < 0.05$ (ANOVA, SAS v. 9.3).

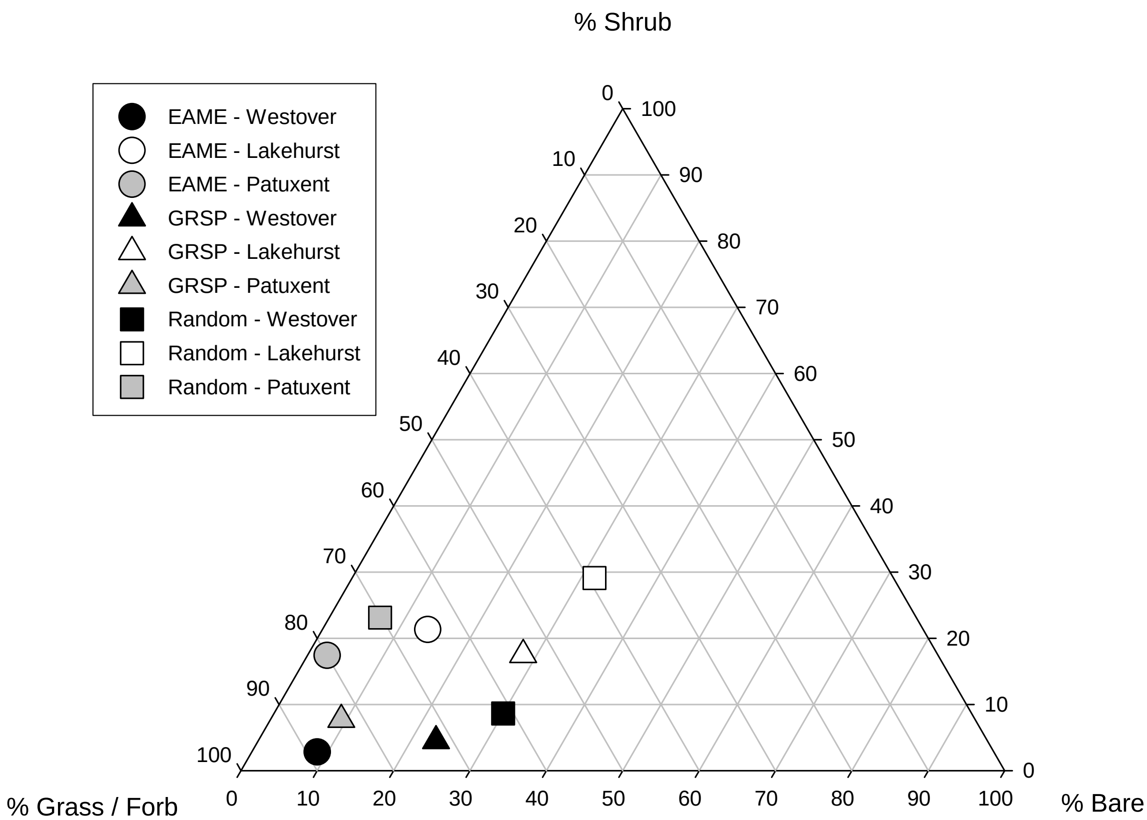


Figure 2. Horizontal cover profile of vegetation around nests and at random locations on the three study sites (Westover, Lakehurst, and Patuxent River).

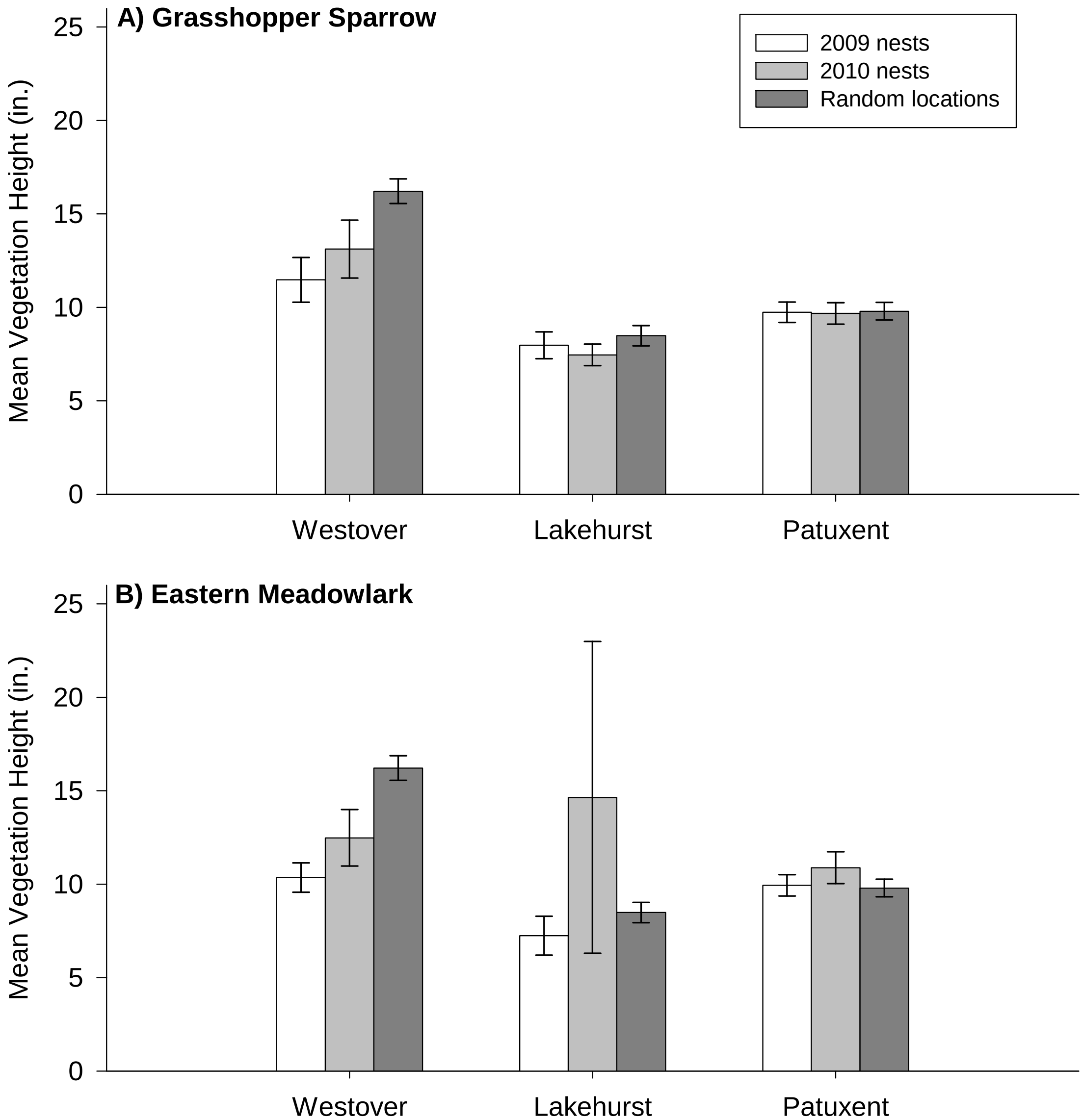


Figure 3. Mean (SE) vegetation height (in.) at eastern meadowlark and grasshopper sparrow nest sites and random locations at the three study sites (Westover, Lakehurst, and Patuxent River).

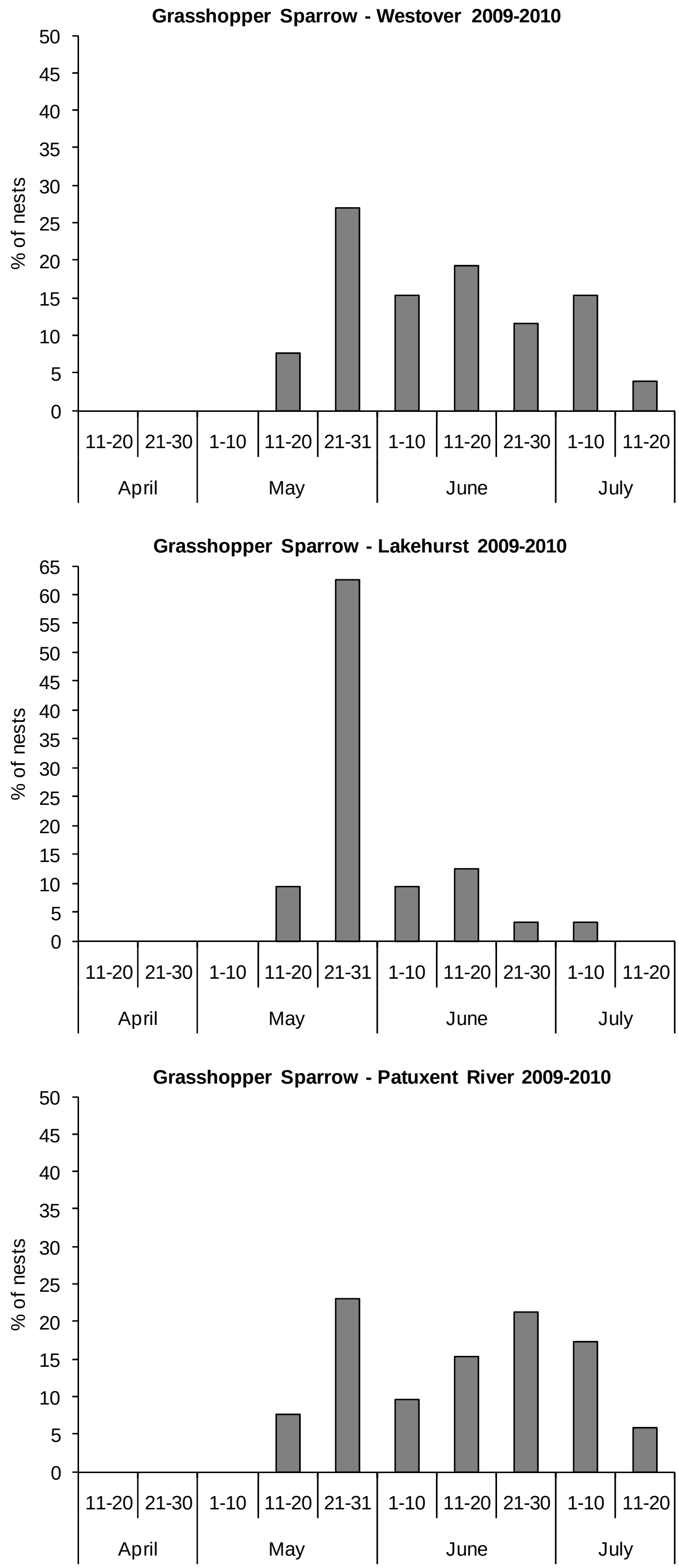


Figure 4. Estimated initiation dates (start of incubation) for grasshopper sparrow nests monitored during 2009 and 2010 at the Westover, Lakehurst, and Patuxent River sites.

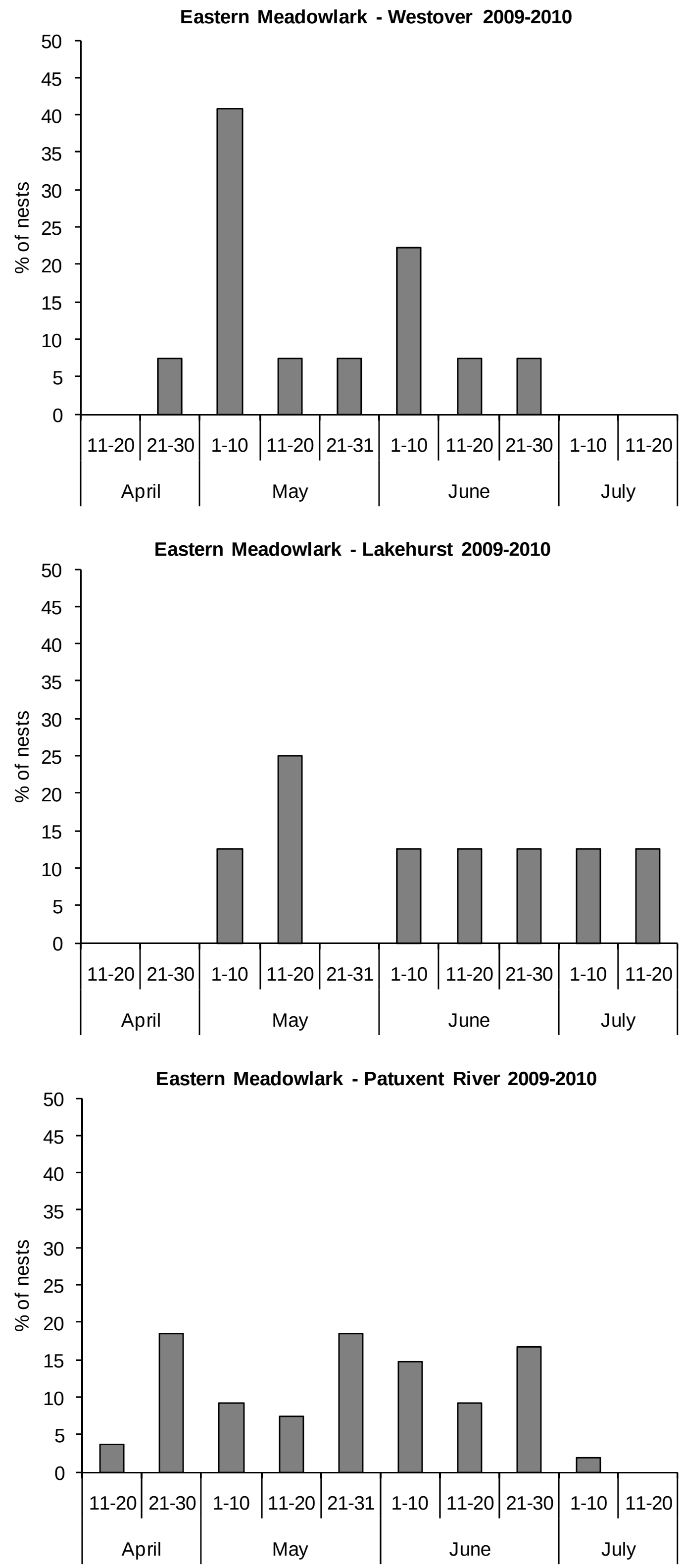


Figure 5. Estimated initiation dates (start of incubation) for eastern meadowlark nests monitored during 2009 and 2010 at the Westover, Lakehurst, and Patuxent River sites.

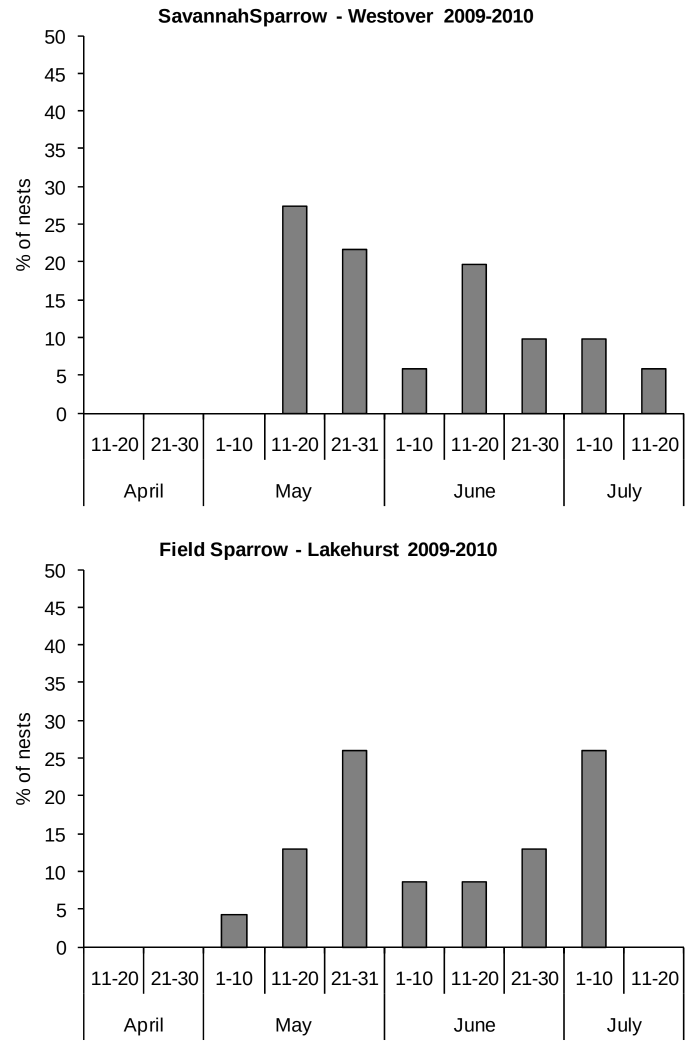


Figure 6. Estimated initiation dates (start of incubation) for savannah sparrow and field sparrow nests monitored at the Westover and Lakehurst sites, respectively, in 2009 and 2010.

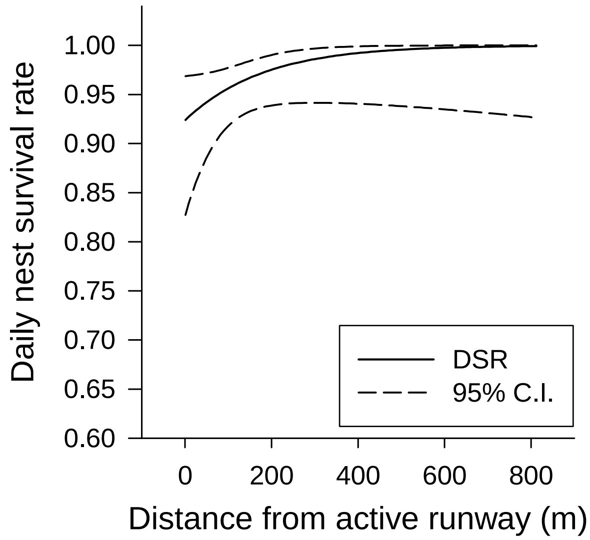


Figure 7. The best-performing model of daily survival rate for grasshopper sparrow nests at Westover Air Reserve Base, Chicopee, MA. Model is based on data from 26 nests monitored in 2009 and 2010.

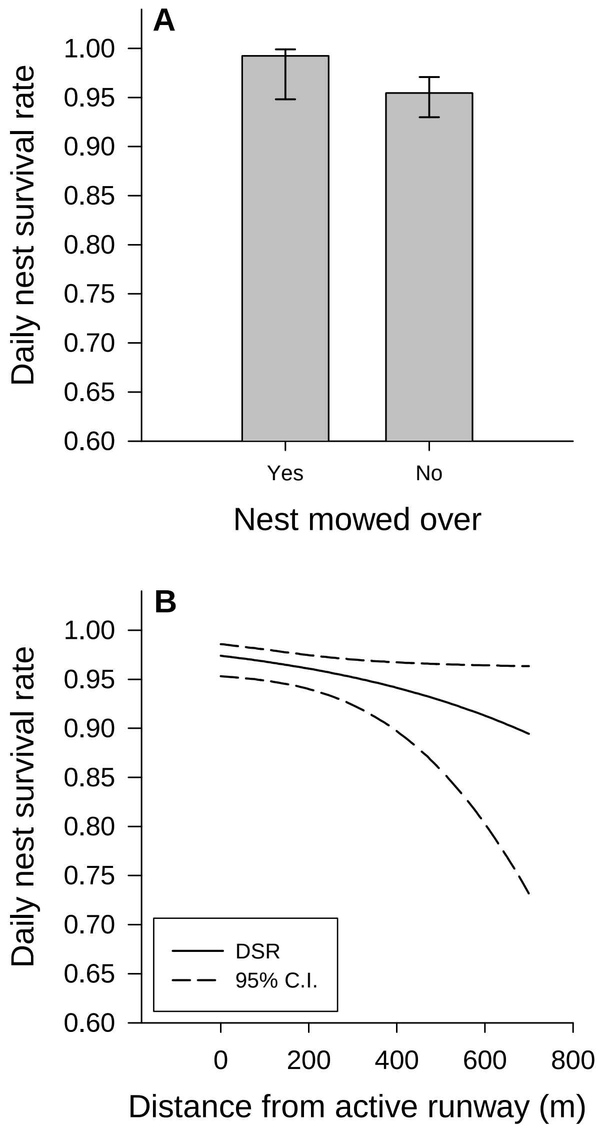


Figure 8. The best-performing models of daily survival rate for grasshopper sparrow nests at Patuxent River Naval Air Station, Patuxent River, MD. Models are based on data from 58 nests monitored in 2009 and 2010. Error bars show 95% confidence intervals.

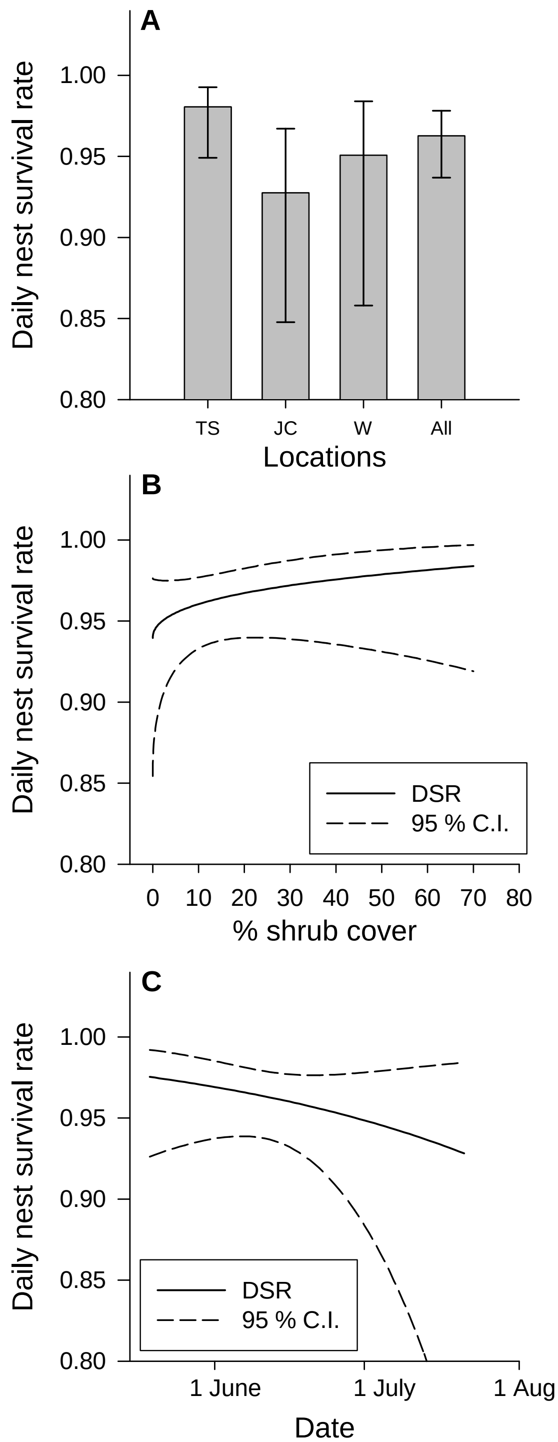


Figure 9. The best-performing models of daily survival rate for grasshopper sparrow nests at Joint Base McGuire-Dix-Lakehurst, Lakehurst, NJ. Models are based on data from 31 nests monitored in 2009 and 2010. TS – test site, JC – jump circle, W – west field, All – all nests pooled (null model). Error bars show 95% confidence intervals.

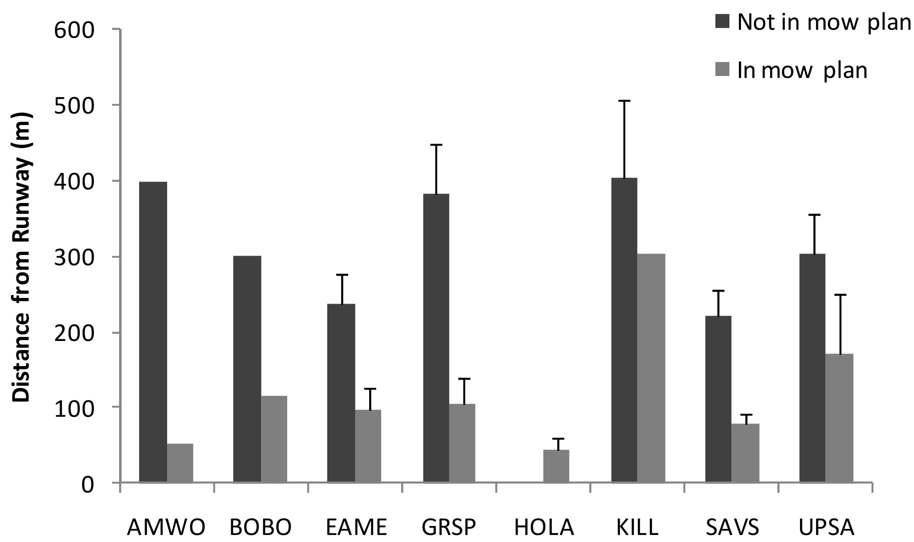


Figure 10. Distance (SE) from runway of nests of all grassland species found on Westover Air Reserve Base 2009-2010. Nests within the mow plan were generally closer to active runways than were those outside of the mow plan.

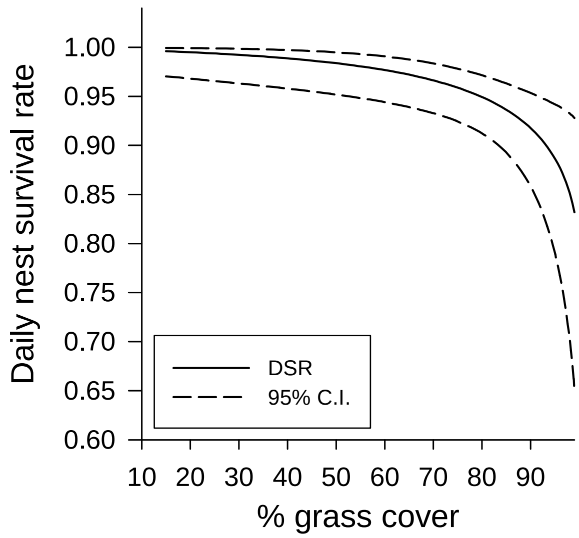


Figure 11. The best-performing model of daily survival rate for eastern meadowlark nests at Westover Air Reserve Base, Chicopee, MA. Model is based on data from 27 nests monitored in 2009 and 2010.

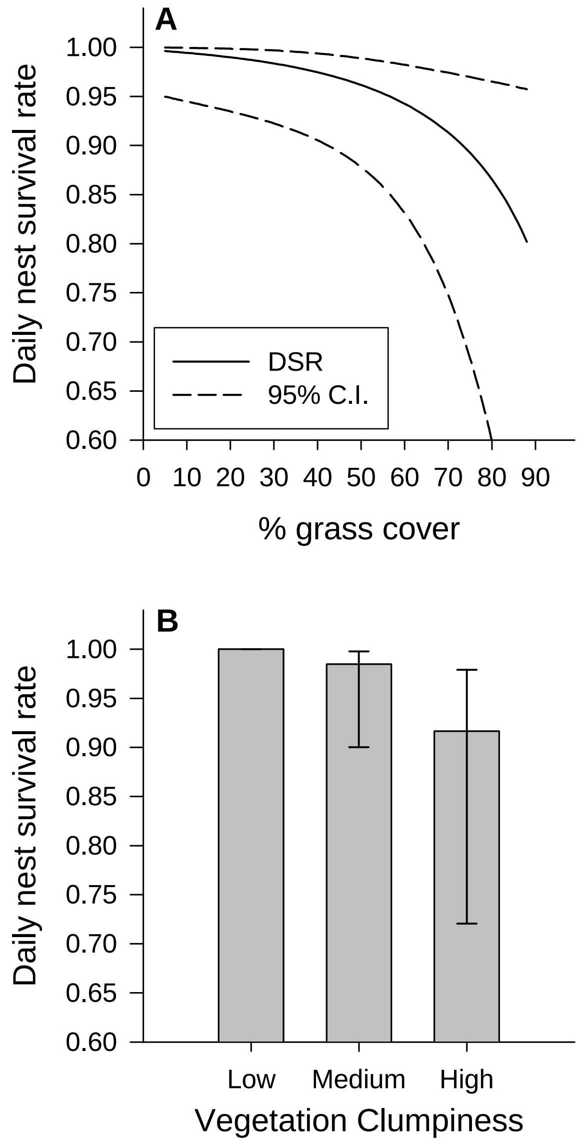


Figure 12. The best-performing models of daily survival rate for eastern meadowlark nests at Joint Base McGuire-Dix-Lakehurst, Lakehurst, NJ. Models are based on data from seven nests monitored in 2009 and 2010. Error bars show 95% confidence intervals.

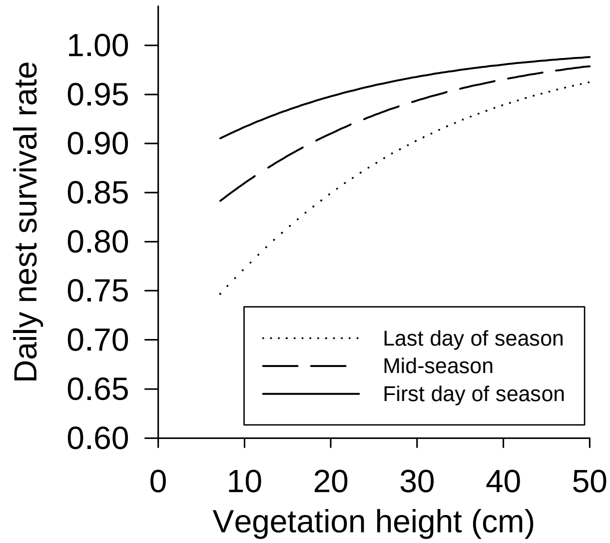


Figure 13. The best-performing model of daily survival rate for eastern meadowlark nests at Patuxent River Naval Air Station, Patuxent River, MD. Model is based on data from 52 nests monitored in 2009 and 2010.

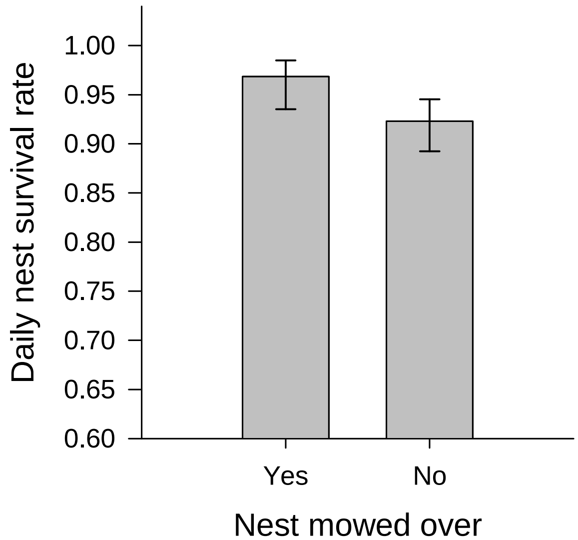


Figure 14. The best-performing models of daily survival rate for nests of "other passerine" species (savannah sparrow, bobolink, and horned lark) at Westover Air Reserve Base, Chicopee, MA. Models are based on data from 62 nests monitored in 2009 and 2010. Error bars show 95% confidence intervals.

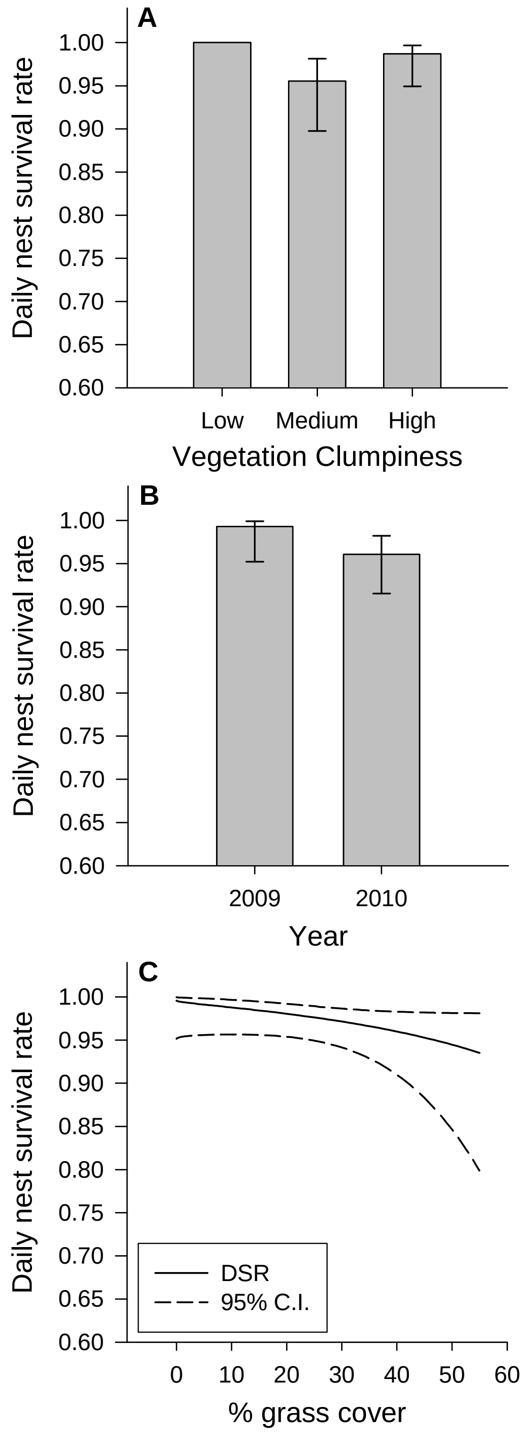


Figure 15. The best-performing models of daily survival rate for nests of "other passerine" species (field sparrow and horned lark) at Joint Base McGuire-Dix-Lakehurst, Lakehurst, NJ. Models are based on data from 24 nests monitored in 2009 and 2010. Error bars show 95% confidence intervals.

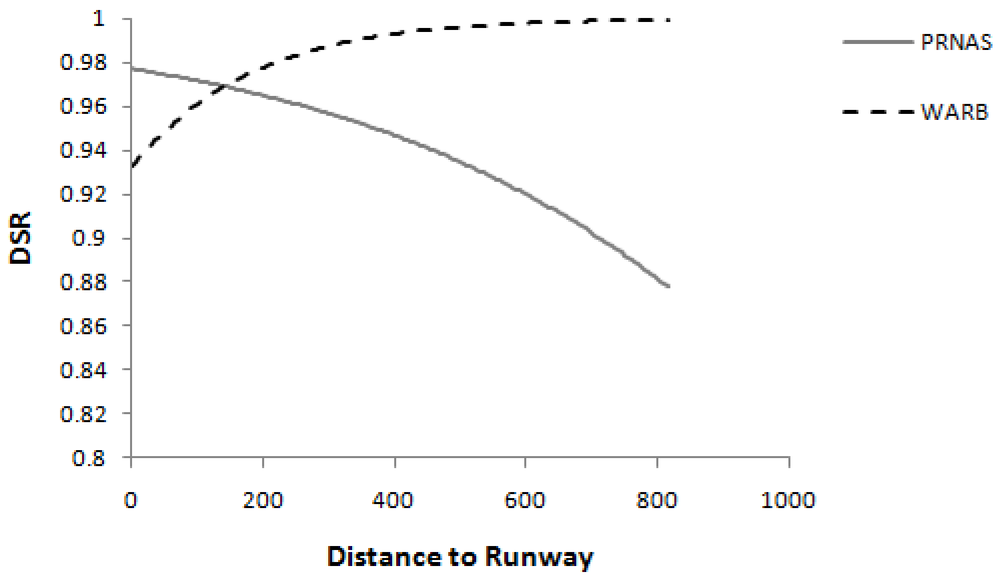


Figure 16. Interaction between Site and Distance to Runway for predicting grasshopper sparrow DSR. Day of season was held constant at 1 (i.e., first day of season). Nests further from active runways were more successful at WARB, whereas those closer to the runways were more successful at PRNAS.

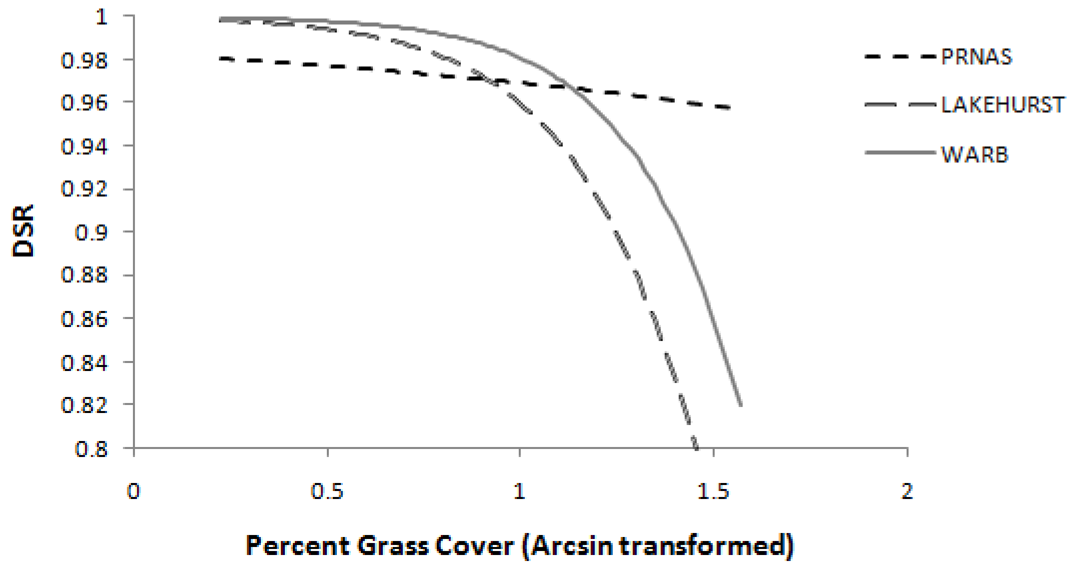
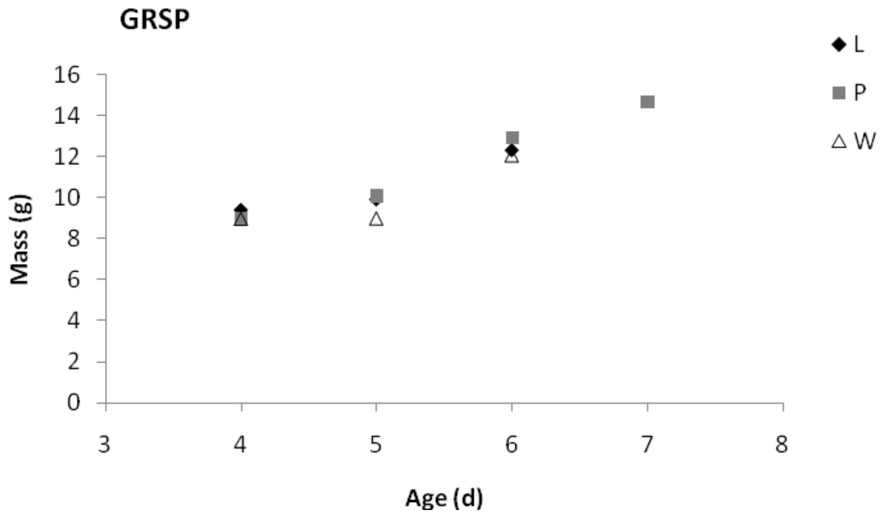


Figure 17. Interaction between Site and horizontal grass cover for predicting eastern meadowlark DSR. Day of season was held constant at 1 (i.e., first day of season). Nests surrounded by less grass were more successful, particularly at Lakehurst and WARB.

a)



b)

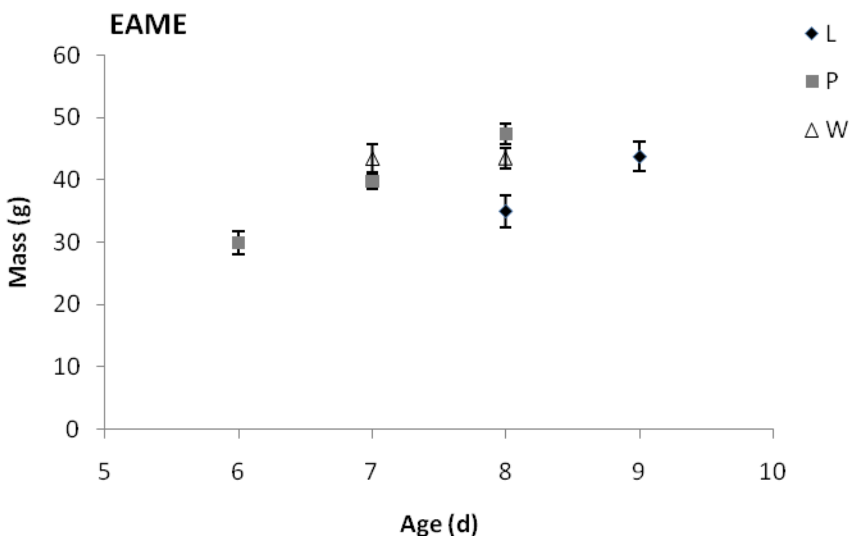


Figure 18. Grasshopper sparrow (GRSP) and eastern meadowlark (EAME) mean daily chick mass (SE) by age (days) at Lakehurst (L), PRNAS (P), and WARB (W), 2009-2010. To increase visual clarity, grasshopper sparrow standard error bars not displayed, but indicated considerable overlap among sites.

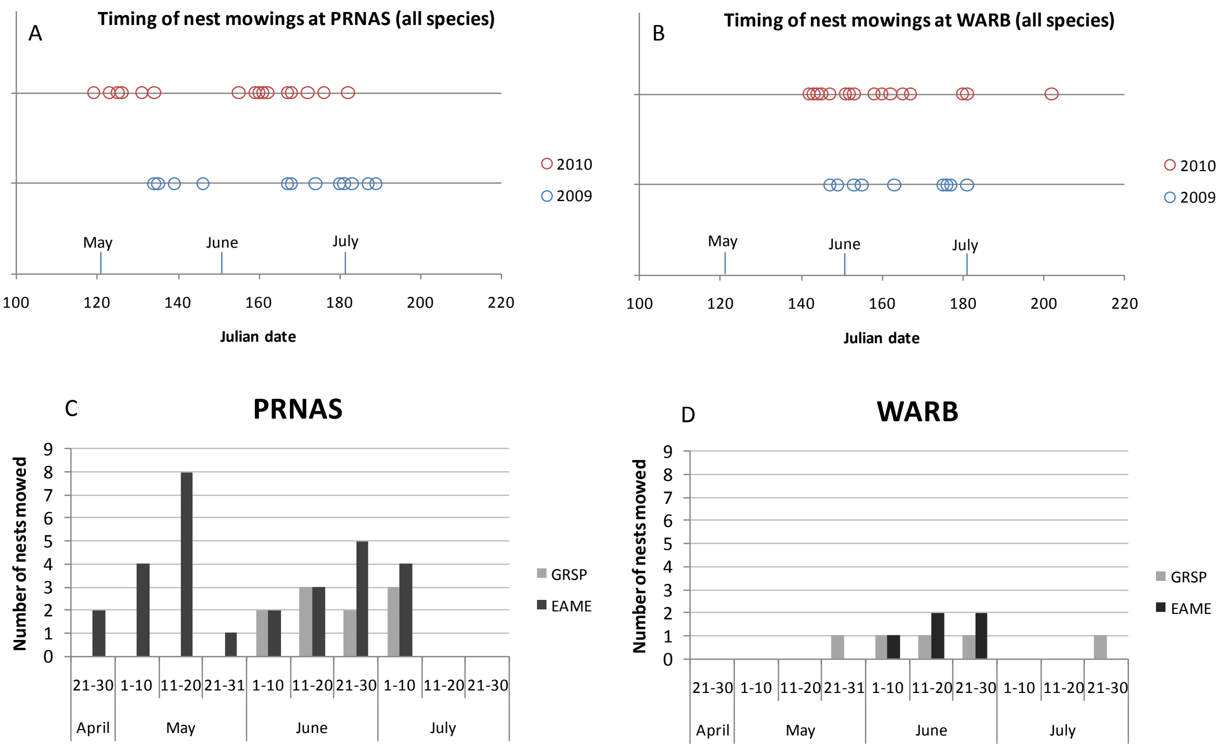


Figure 19. Timing of nest mowing events at Patuxent River Naval Air Station (PRNAS, A and C) and Westover Air Reserve Base (WARB, B and D) in 2009 and 2010.

Figure 20. Eastern meadowlark nest placed beneath a small shrub (*Juniperus* sp.) at Patuxent River Naval Air Station, Patuxent River, Maryland.

Table 1. Summary of nest daily survival (DSR) logistic models examined; (a) individually by site, and (b) using combined data from multiple sites. See text for justification of candidate model sets.

	PAX	LAKEHURST	WARB
Individual-Site Models			
Null (intercept only	X	X	X
Day of Season (Julian Day)	X	X	X
Year	X	X	X
Distance to Runway	X		X
Location[a]		X	
Vegetation Height	X	X	X
Grass Cover	X	X	X
Shrub Cover	X	X	X
Forb Cover	X	X	X
Bare Ground Cover	X	X	X
Clumpiness	X	X	X
Mowed Area[b]			X
Mowed Over[c]	X		X
Combined-Site Models			
Site	X	X	X
Day of Season, Site	X	X	X
Day of Season, Site, Grass, Site x Grass	X	X	X
Day of Season, Site, Veg Height, Site x Veg Height	X	X	X
Day of Season, Site, Distance[d], Site x Distance	X		X
Day of Season, Site, Mowed Over, Site x Mowed	X		X

[a] Test Runway, Jump Circle, Westfield Runway.
[b] Within mowing plan (1) or outside mowing plan (0).
[c] Mowed over while active (1) or not mowed over (0).
[d] Distance to nearest active runway.

Table 2. Summary statistics for vegetation characteristics at grasshopper sparrow and eastern meadowlark nests at Westover Air Reserve Base, Chicopee, MA (2009-2010).

Measurement	Mean	Std. Dev.	C.V.	Min	Med	Max	n
Grasshopper Sparrow							
Initial Height (cm)	**22.3**	**9.1**	**0.41**	**10.0**	**21.0**	**51.6**	**26**
2009	25.4	12.2	0.48	16.4	23.2	51.6	7
2010	21.2	7.8	0.37	10.0	20.0	44.4	19
Final Height (cm)	**32.2**	**15.2**	**0.47**	**12.6**	**29.0**	**68.0**	**26**
2009	29.1	8.0	0.28	21.2	25.2	43.0	7
2010	33.3	17.1	0.51	12.6	30.4	68.0	19
% Bare	**23.3**	**14.1**	**0.61**	**0.0**	**20.0**	**45.0**	**26**
2009	16.4	16.3	0.99	0.0	15.0	40.0	7
2010	25.8	12.8	0.50	0.0	20.0	45.0	19
% Grass	**52.5**	**27.9**	**0.53**	**10.0**	**50.0**	**100.0**	**26**
2009	55.7	31.0	0.56	20.0	50.0	100.0	7
2010	51.3	27.5	0.54	10.0	50.0	100.0	19
% Forb	**21.3**	**21.5**	**1.01**	**0.0**	**12.5**	**75.0**	**26**
2009	30.0	24.3	0.81	5.0	25.0	70.0	7
2010	18.1	20.2	1.12	0.0	10.0	75.0	19
% Shrub	**4.5**	**14.8**	**3.27**	**0.0**	**0.0**	**70.0**	**26**
2009	2.1	5.7	2.65	0.0	0.0	15.0	7
2010	5.4	17.1	3.15	0.0	0.0	70.0	19
Clumpiness	**2.2**	**0.8**	**0.37**	**1.0**	**2.0**	**3.0**	**26**
2009	2.1	0.9	0.42	1.0	2.0	3.0	7
2010	2.2	0.8	0.36	1.0	2.0	3.0	19
Litter Depth (cm)	**0.8**	**0.6**	**0.79**	**0.0**	**0.8**	**2.2**	**19**
2009	-	-	-	-	-	-	-
2010	0.8	0.6	0.79	0.0	0.8	2.2	19
Eastern Meadowlark							
Initial Height (cm)	**24.7**	**9.4**	**0.38**	**10.8**	**23.2**	**44.4**	**27**
2009	22.9	10.1	0.44	10.8	20.5	44.4	14
2010	26.8	8.5	0.32	13.6	26.4	44.4	13
Final Height (cm)	**28.9**	**11.2**	**0.39**	**13.4**	**26.8**	**62.0**	**27**
2009	26.3	7.5	0.29	13.4	26.6	39.6	14
2010	31.7	13.9	0.44	18.2	26.8	62.0	13
% Bare	**8.6**	**12.4**	**1.44**	**0.0**	**5.0**	**50.0**	**27**
2009	2.5	4.3	1.71	0.0	0.0	10.0	14
2010	15.2	15.0	0.98	0.0	8.0	50.0	13
% Grass	**73.5**	**19.1**	**0.26**	**15.0**	**80.0**	**100.0**	**27**
2009	78.2	16.1	0.21	45.0	82.5	100.0	14
2010	68.5	21.3	0.31	15.0	70.0	95.0	13
% Forb	**18.5**	**16.4**	**0.89**	**0.0**	**10.0**	**50.0**	**27**
2009	23.4	15.7	0.67	2.0	20.0	50.0	14
2010	13.2	16.0	1.21	0.0	8.0	50.0	13
% Shrub	**2.8**	**7.4**	**2.66**	**0.0**	**0.0**	**30.0**	**27**
2009	0.7	2.7	3.74	0.0	0.0	10.0	14
2010	5.0	10.0	2.00	0.0	0.0	30.0	13
Clumpiness	**2.0**	**0.7**	**0.34**	**1.0**	**2.0**	**3.0**	**27**
2009	2.0	0.6	0.28	1.0	2.0	3.0	14
2010	2.0	0.8	0.41	1.0	2.0	3.0	13
Litter Depth (cm)	**1.2**	**0.9**	**0.81**	**0.0**	**1.4**	**2.6**	**13**
2009	-	-	-	-	-	-	-
2010	1.2	0.9	0.81	0.0	1.4	2.6	13

Table 3. Summary statistics for vegetation characteristics at grasshopper sparrow and eastern meadowlark nests at Joint Base McGuire-Dix-Lakehurst, Lakehurst, NJ (2009-2010).

Measurement	Mean	Std. Dev.	C.V.	Min	Med	Max	n
Grasshopper Sparrow							
Initial Height (cm)	**19.0**	**5.9**	**0.31**	**10.0**	**18.5**	**31.0**	**32**
2009	18.1	5.7	0.32	10.0	18.2	30.4	15
2010	19.8	6.1	0.31	10.8	19.0	31.0	17
Final Height (cm)	**19.5**	**6.5**	**0.33**	**5.0**	**19.4**	**34.6**	**32**
2009	20.2	7.1	0.35	9.4	21.0	34.6	15
2010	18.9	6.0	0.32	5.0	18.6	28.6	17
% Bare	**28.2**	**20.2**	**0.72**	**0.0**	**30.0**	**80.0**	**32**
2009	24.8	20.7	0.83	0.0	30.0	70.0	15
2010	31.2	19.8	0.64	0.0	35.0	80.0	17
% Grass	**52.7**	**19.1**	**0.36**	**15.0**	**50.0**	**90.0**	**32**
2009	60.0	19.6	0.33	25.0	65.0	90.0	15
2010	46.2	16.6	0.36	15.0	50.0	70.0	17
% Forb	**4.2**	**10.5**	**2.49**	**0.0**	**0.0**	**50.0**	**32**
2009	1.3	3.3	2.47	0.0	0.0	12.0	15
2010	6.8	13.8	2.04	0.0	0.0	50.0	17
% Shrub	**17.5**	**16.0**	**0.91**	**0.0**	**15.0**	**70.0**	**32**
2009	17.0	13.1	0.77	0.0	15.0	50.0	15
2010	17.9	18.5	1.03	0.0	15.0	70.0	17
Clumpiness	**2.3**	**0.7**	**0.30**	**1.0**	**2.0**	**3.0**	**32**
2009	2.3	0.7	0.31	1.0	2.0	3.0	15
2010	2.2	0.7	0.30	1.0	2.0	3.0	17
Litter Depth (cm)	**1.3**	**0.9**	**0.75**	**0.0**	**1.2**	**3.6**	**17**
2009	-	-	-	-	-	-	-
2010	1.3	0.9	0.75	0.0	1.2	3.6	17
Eastern Meadowlark							
Initial Height (cm)	**21.6**	**11.4**	**0.53**	**5.8**	**18.5**	**42.4**	**8**
2009	17.1	8.0	0.47	5.8	16.6	30.2	6
2010	34.8	10.7	0.31	27.2	34.8	42.4	2
Final Height (cm)	**23.1**	**15.3**	**0.66**	**9.6**	**17.9**	**58.4**	**8**
2009	18.4	6.5	0.35	9.6	17.9	27.2	6
2010	37.2	30.0	0.81	16.0	37.2	58.4	2
% Bare	**13.8**	**14.6**	**1.06**	**5.0**	**5.0**	**45.0**	**8**
2009	16.7	16.0	0.96	5.0	10.0	45.0	6
2010	5.0	0.0	0.00	5.0	5.0	5.0	2
% Grass	**44.1**	**32.4**	**0.73**	**5.0**	**37.5**	**90.0**	**8**
2009	38.0	31.4	0.83	5.0	30.0	88.0	6
2010	62.5	38.9	0.62	35.0	62.5	90.0	2
% Forb	**20.6**	**27.8**	**1.35**	**0.0**	**12.5**	**80.0**	**8**
2009	26.7	30.1	1.13	0.0	20.0	80.0	6
2010	2.5	3.5	1.41	0.0	2.5	5.0	2
% Shrub	**21.3**	**24.9**	**1.17**	**0.0**	**12.5**	**60.0**	**8**
2009	22.5	27.2	1.21	0.0	12.5	60.0	6
2010	17.5	24.7	1.41	0.0	17.5	35.0	2
Clumpiness	**2.3**	**0.7**	**0.31**	**1.0**	**2.0**	**3.0**	**8**
2009	2.3	0.8	0.35	1.0	2.5	3.0	6
2010	2.0	0.0	0.00	2.0	2.0	2.0	2
Litter Depth (cm)	**2.4**	**3.1**	**1.30**	**0.2**	**2.4**	**4.6**	**2**
2009	-	-	-	-	-	-	-
2010	2.4	3.1	1.30	0.2	2.4	4.6	2

Table 4. Summary statistics for vegetation characteristics at grasshopper sparrow and eastern meadowlark nests at Patuxent River Naval Air Station, Patuxent River, MD (2009-2010).

Measurement	Mean	Std. Dev.	C.V.	Min	Med	Max	n
Grasshopper Sparrow							
Initial Height (cm)	**24.7**	**7.7**	**0.31**	**9.4**	**23.8**	**51.8**	**59**
2009	25.8	8.1	0.31	13.6	25.2	51.8	20
2010	24.1	7.6	0.31	9.4	22.2	45.8	39
Final Height (cm)	**24.6**	**8.2**	**0.33**	**10.4**	**22.0**	**49.4**	**59**
2009	24.7	6.2	0.25	13.8	25.2	34.8	20
2010	24.6	9.1	0.37	10.4	21.4	49.4	39
% Bare	**9.3**	**13.8**	**1.49**	**0.0**	**5.0**	**80.0**	**59**
2009	0.1	0.4	4.47	0.0	0.0	2.0	20
2010	14.0	15.0	1.07	0.0	10.0	80.0	39
% Grass	**65.3**	**26.7**	**0.41**	**20.0**	**70.0**	**100.0**	**59**
2009	85.8	21.4	0.25	40.0	100.0	100.0	20
2010	54.9	23.0	0.42	20.0	50.0	95.0	39
% Forb	**23.4**	**20.7**	**0.88**	**0.0**	**20.0**	**90.0**	**59**
2009	24.4	24.8	1.02	5.0	15.0	90.0	20
2010	22.9	18.6	0.81	0.0	20.0	60.0	39
% Shrub	**7.7**	**13.1**	**1.70**	**0.0**	**0.0**	**60.0**	**59**
2009	9.0	16.7	1.85	0.0	2.5	60.0	20
2010	7.1	11.0	1.57	0.0	0.0	50.0	39
Clumpiness	**1.7**	**0.6**	**0.38**	**1.0**	**2.0**	**3.0**	**59**
2009	2.1	0.5	0.25	1.0	2.0	3.0	20
2010	1.5	0.6	0.42	1.0	1.0	3.0	39
Litter Depth (cm)	**2.2**	**1.1**	**0.51**	**0.6**	**2.2**	**5.4**	**39**
2009	-	-	-	-	-	-	-
2010	2.2	1.1	0.51	0.6	2.2	5.4	39
Eastern Meadowlark							
Initial Height (cm)	**28.1**	**9.2**	**0.33**	**13.0**	**26.9**	**62.6**	**52**
2009	28.7	7.6	0.26	16.4	27.8	45.8	27
2010	27.4	10.8	0.39	13.0	25.2	62.6	25
Final Height (cm)	**26.4**	**9.2**	**0.35**	**7.2**	**25.1**	**50.0**	**52**
2009	25.2	9.1	0.36	7.2	23.8	48.6	27
2010	27.6	9.3	0.33	16.4	25.6	50.0	25
% Bare	**2.6**	**8.1**	**3.13**	**0.0**	**0.0**	**50.0**	**52**
2009	0.0	0.0	-	0.0	0.0	0.0	27
2010	5.4	11.2	2.07	0.0	0.0	50.0	25
% Grass	**74.4**	**24.9**	**0.33**	**15.0**	**77.5**	**100.0**	**52**
2009	87.4	19.2	0.22	35.0	100.0	100.0	27
2010	60.4	22.9	0.38	15.0	60.0	100.0	25
% Forb	**16.8**	**18.5**	**1.10**	**0.0**	**10.0**	**70.0**	**52**
2009	13.6	16.4	1.21	0.0	10.0	70.0	27
2010	20.2	20.2	1.00	0.0	15.0	60.0	25
% Shrub	**17.4**	**21.8**	**1.25**	**0.0**	**10.0**	**90.0**	**52**
2009	20.2	25.4	1.26	0.0	10.0	90.0	27
2010	14.4	17.1	1.19	0.0	10.0	60.0	25
Clumpiness	**1.8**	**0.6**	**0.34**	**1.0**	**2.0**	**3.0**	**52**
2009	1.9	0.6	0.32	1.0	2.0	3.0	27
2010	1.6	0.5	0.32	1.0	2.0	2.0	25
Litter Depth (cm)	**3.7**	**0.9**	**0.25**	**2.2**	**3.8**	**5.8**	**25**
2009	-	-	-	-	-	-	-
2010	3.7	0.9	0.25	2.2	3.8	5.8	25

Table 5. Summary statistics for vegetation characteristics measured in June 2010 at random locations throughout nest searching plots on Westover Air Reserve Base (MA), Joint Base McGuire-Dix-Lakehurst (NJ), and Patuxent River Naval Air Station (MD).

Measurement	Mean	Std. Dev.	C.V.	Min	Med	Max	n
Westover							
Veg. Height (cm)	41.2	18.8	0.46	4.6	38.4	150.2	125
Mowed	31.3	10.8	0.34	4.6	29.9	61.0	60
Non-mowed	50.3	20.0	0.40	9.8	52.8	150.2	65
% Bare	30.0	24.3	0.81	0.0	25.0	95.0	125
Mowed	32.7	24.3	0.75	0.0	35.0	95.0	60
Non-mowed	27.6	24.2	0.88	0.0	20.0	95.0	65
% Grass	47.6	27.0	0.57	1.0	50.0	100.0	125
Mowed	48.1	28.3	0.59	1.0	50.0	100.0	60
Non-mowed	47.1	26.0	0.55	3.0	50.0	95.0	65
% Forb	14.5	16.4	1.13	0.0	10.0	90.0	125
Mowed	14.7	16.9	1.15	0.0	8.0	70.0	60
Non-mowed	14.2	16.0	1.12	0.0	10.0	90.0	65
% Shrub	8.6	16.5	1.92	0.0	0.0	80.0	125
Mowed	5.5	9.6	1.76	0.0	0.0	35.0	60
Non-mowed	11.6	20.7	1.79	0.0	0.0	80.0	65
Clumpiness	2.3	0.6	0.27	1.0	2.0	3.0	125
Mowed	2.2	0.7	0.31	1.0	2.0	3.0	60
Non-mowed	2.4	0.5	0.22	1.0	2.0	3.0	65
Lakehurst							
Veg. Height (cm)	21.5	12.3	0.57	0.0	21.2	50.2	80
% Bare	31.8	25.6	0.81	0.0	22.5	100.0	80
% Grass	40.4	27.2	0.67	0.0	40.0	100.0	80
% Forb	3.1	8.6	2.78	0.0	0.0	65.0	80
% Shrub	29.1	26.6	0.92	0.0	22.5	95.0	80
Clumpiness	2.1	0.8	0.38	1.0	2.0	3.0	80
Patuxent River							
Veg. Height (cm)	24.9	9.3	0.37	8.6	22.4	56.8	60
% Bare	6.7	10.8	1.63	0.0	5.0	70.0	60
% Grass	57.3	27.0	0.47	5.0	60.0	100.0	60
% Forb	13.0	14.1	1.09	0.0	10.0	70.0	60
% Shrub	23.1	29.4	1.27	0.0	10.0	90.0	60
Clumpiness	1.6	0.6	0.41	1.0	1.5	3.0	60

Table 6. Logistic models of daily survival rates for grasshopper sparrow nests monitored during the 2009 and 2010 seasons. Models are ranked by ΔAIC_c.

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	k*	Deviance	Pseudo R^2
Westover (n = 26 nests)							
D. to Runway	66.22	0.00	0.39	1.00	2	62.18	0.08
Mowed Area	68.59	2.37	0.12	0.31	2	64.54	0.04
Year	69.23	3.01	0.09	0.22	2	65.19	0.03
Null	69.30	3.08	0.08	0.21	1	67.29	-
Veg. Clumpiness	70.01	3.79	0.06	0.15	3	63.92	0.05
% Shrub	70.31	4.09	0.05	0.13	2	66.26	0.02
% Grass	70.34	4.11	0.05	0.13	2	66.29	0.01
% Forb	71.08	4.85	0.03	0.09	2	67.03	0.00
Day of Season	71.16	4.94	0.03	0.08	2	67.11	0.00
% Bare	71.23	5.00	0.03	0.08	2	67.18	0.00
Veg. Height	71.32	5.09	0.03	0.08	2	67.27	0.00
Nest Mowed	71.32	5.10	0.03	0.08	2	67.27	0.00
Lakehurst (n = 31 nests)							
Location	88.30	0.00	0.23	1.00	3	82.22	0.05
Null	88.88	0.59	0.17	0.75	1	86.87	-
% Shrub	89.62	1.33	0.12	0.52	2	85.59	0.01
Day of Season	90.18	1.88	0.09	0.39	2	86.14	0.01
% Grass	90.32	2.02	0.08	0.36	2	86.28	0.01
% Forb	90.54	2.24	0.07	0.33	2	86.50	0.00
Veg. Height	90.54	2.24	0.07	0.33	2	86.50	0.00
% Bare	90.57	2.28	0.07	0.32	2	86.54	0.00
Year	90.88	2.58	0.06	0.27	2	86.84	0.00
Veg. Clumpiness	91.76	3.47	0.04	0.18	3	85.69	0.01
Patuxent River (n = 58 nests)							
Nest Mowed	139.19	0.00	0.43	1.00	2	135.17	0.04
D. to Runway	141.13	1.93	0.16	0.38	2	137.10	0.03
% Grass	142.10	2.90	0.10	0.23	2	138.07	0.02
Null	142.65	3.46	0.08	0.18	1	140.64	-
% Bare	143.60	4.40	0.05	0.11	2	139.57	0.01
Veg. Height	143.72	4.53	0.04	0.10	2	139.70	0.01
Year	144.53	5.33	0.03	0.07	2	140.50	0.00
% Forb	144.58	5.39	0.03	0.07	2	140.56	0.00
% Shrub	144.59	5.40	0.03	0.07	2	140.57	0.00
Day of Season	144.63	5.44	0.03	0.07	2	140.61	0.00
Veg. Clumpiness	145.11	5.92	0.02	0.05	3	139.07	0.01

* number of estimable parameters

Table 7. Parameter estimates from the best performing logistic models (≤ 2 ΔAIC_c) of grasshopper sparrow daily nest survival rates in 2009-2010.

Model	Independent variables	β *	SE	95% lower CI	95% upper CI
Westover					
D. to Runway	D. to Runway	0.00588	0.00336	-0.00071	0.01246
	Intercept	2.49513	0.47906	1.55616	3.43410
Lakehurst					
Location (vs. Westfield)	Test Site	0.95673	0.77861	-0.56934	2.48279
	Jump Circle	-0.41130	0.72902	-1.84017	1.01757
	Intercept	2.96009	0.59262	1.79855	4.12163
Null	Intercept	3.25133	0.28278	2.69708	3.80559
% Shrub	% Shrub	1.38339	1.23292	-1.03314	3.79992
	Intercept	2.74475	0.49776	1.76914	3.72037
Day of Season	Day of Season	-0.01777	0.02011	-0.05719	0.02165
	Intercept	4.08751	1.01644	2.09528	6.07974
Patuxent River					
Nest Mowed	Nest Mowed	1.82815	1.03094	-0.19249	3.84878
	Intercept	3.04705	0.23494	2.58656	3.50753
D. to Runway	D. to Runway	-0.00213	0.00106	-0.00421	-0.00004
	Intercept	3.62574	0.31356	3.01116	4.24032

* Beta; parameter estimate

Table 8. Daily survival rate (DSR) estimates for grasshopper sparrow nests monitored during the 2009 and 2010 seasons.

	Total No. Nests	No. Failures	DSR	SE	95 CI - Lower	95 CI - Upper
Westover						
Mowed areas	14	7	0.94942	0.01864	0.89767	0.97570
Non-mowed areas	12	2	0.98467	0.01076	0.94081	0.99616
Mowed nests	5	2	0.96429	0.02480	0.86812	0.99105
Non-mowed nests	21	7	0.96712	0.01222	0.93264	0.98425
All nests	26	9	0.96653	0.01097	0.93693	0.98250
Lakehurst						
All nests	31	13	0.96272	0.01015	0.93685	0.97824
Patuxent River						
Mowed nests	9	1	0.99242	0.00755	0.94823	0.99893
Non-mowed nests	49	19	0.95465	0.01017	0.92999	0.97090
All nests	58	20	0.96371	0.00797	0.94441	0.97647

Table 9. Logistic models of daily survival rates for eastern meadowlark nests monitored during the 2009 and 2010 seasons. Models are ranked by ΔAIC_c.

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	k*	Deviance	Pseudo R^2
Westover (n = 27 nests)							
% Grass	81.29	0.00	0.65	1.00	2	77.25	0.10
D. to Runway	84.39	3.09	0.14	0.21	2	80.34	0.06
% Forb	86.23	4.94	0.05	0.08	2	82.19	0.04
Mowed Area	86.80	5.51	0.04	0.06	2	82.76	0.03
Null	87.61	6.32	0.03	0.04	1	85.59	0.00
Year	88.88	7.58	0.01	0.02	2	84.83	0.01
Veg. Clumpiness	89.05	7.75	0.01	0.02	3	82.95	0.03
% Bare	89.09	7.79	0.01	0.02	2	85.04	0.01
Day of Season	89.22	7.93	0.01	0.02	2	85.17	0.00
Nest Mowed	89.24	7.94	0.01	0.02	2	85.19	0.00
Veg. Height	89.32	8.02	0.01	0.02	2	85.27	0.00
% Shrub	89.52	8.23	0.01	0.02	2	85.48	0.00
Lakehurst (n = 7 nests)							
% Grass	23.85	0.00	0.41	1.00	2	19.75	0.22
Veg. Clumpiness	25.46	1.61	0.18	0.45	2	21.36	0.15
% Forb	26.27	2.42	0.12	0.30	2	22.17	0.12
Null	27.22	3.37	0.08	0.19	1	25.18	0.00
Day of Season	28.10	4.25	0.05	0.12	2	23.99	0.05
Year	28.50	4.65	0.04	0.10	2	24.40	0.03
Location	28.73	4.88	0.04	0.09	2	24.63	0.02
% Bare	28.93	5.08	0.03	0.08	2	24.83	0.01
Veg. Height	29.27	5.42	0.03	0.07	2	25.17	0.00
% Shrub	29.29	5.44	0.03	0.07	2	25.18	0.00
Patuxent River (n = 52 nests)							
Day of Season - Veg. Height	208.84	0.00	0.45	1.00	3	202.80	0.04
Day of Season - Nest Mowed	211.72	2.88	0.11	0.24	3	205.68	0.03
Day of Season - % Bare	212.09	3.25	0.09	0.20	3	206.05	0.03
Day of Season	212.17	3.33	0.08	0.19	2	208.15	0.02
Day of Season - % Grass	212.64	3.80	0.07	0.15	3	206.59	0.03
Day of Season - Year	213.15	4.31	0.05	0.12	3	207.10	0.02
Day of Season - D. to Runway	213.64	4.80	0.04	0.09	3	207.60	0.02
Day of Season - % Forb	214.06	5.21	0.03	0.07	3	208.01	0.02
Day of Season - % Shrub	214.06	5.21	0.03	0.07	3	208.01	0.02
Null	214.19	5.35	0.03	0.07	1	212.18	0.00
Day of Season - Veg. Clumpiness	214.85	6.00	0.02	0.05	4	206.77	0.03

* number of estimable parameters

Table 10. Parameter estimates from the best performing logistic models (≤ 2 ΔAIC_c) of eastern meadowlark daily nest survival rates in 2009-2010.

Model	Independent variables	β *	SE	95% lower CI	95% upper CI
Westover					
% Grass	% Grass	-3.66437	1.29940	-6.21118	-1.11755
	Intercept	6.98863	1.54573	3.95899	10.01826
Lakehurst					
% Grass	% Grass	-4.22738	1.84123	-7.83619	-0.61857
	Intercept	6.54366	1.73212	3.14870	9.93863
Clumpiness	Clumpiness (1 vs. 3)	19.01660	8225.95	-16103.84	16141.87
	Clumpiness (2 vs. 3)	1.77850	1.24980	-0.67110	4.22810
	Intercept	2.39591	0.73931	0.94686	3.84496
Patuxent River					
Day of Season - Vegetation Height	Day of Season	-0.01307	0.00844	-0.02961	0.00347
	Vegetation Height	0.05047	0.02277	0.00583	0.09511
	Intercept	1.90740	0.74672	0.44383	3.37097

* Beta; parameter estimate

Table 11. Daily survival rate (DSR) estimates for eastern meadowlark nests monitored during the 2009 and 2010 seasons.

	No. Nests	No. Failures	DSR	SE	95 CI - Lower	95 CI - Upper
Westover						
Mowed areas	15	9	0.92874	0.02291	0.86864	0.96253
Non-mowed areas	12	4	0.97231	0.01366	0.92853	0.98957
Mowed nests	5	3	0.93256	0.03761	0.81071	0.97809
Non-mowed nests	22	10	0.95581	0.01367	0.91981	0.97607
All nests	27	13	0.95199	0.01300	0.91906	0.97193
Lakehurst						
All nests	7	3	0.97457	0.01449	0.92413	0.99178
Patuxent River						
Mowed nests	26	18	0.92294	0.01747	0.88096	0.95093
Non-mowed nests	26	18	0.94485	0.01265	0.91415	0.96500
All nests	52	36	0.93571	0.01038	0.91212	0.95329

Table 12. Logistic models of daily nest survival rates for "other passerines" monitored during the 2009 and 2010 seasons. Species included field sparrow and horned lark at Lakehurst, and savannah sparrow, horned lark, and bobolink at Westover. Models are ranked by ΔAIC_c.

Model	AICc	Delta AICc	AICc Weig	Model Like	k*	Deviance	Pseudo R^2
Westover (n = 62 nests)							
Nest Mowed	216.73	0.00	0.44	1.00	2	212.71	0.03
Day of Season	218.96	2.22	0.15	0.33	2	214.94	0.02
% Forb	219.54	2.81	0.11	0.25	2	215.52	0.01
Null	220.43	3.70	0.07	0.16	1	218.43	-
D. to Runway	221.41	4.67	0.04	0.10	2	217.39	0.00
% Shrub	221.58	4.84	0.04	0.09	2	217.56	0.00
% Bare	221.67	4.93	0.04	0.08	2	217.65	0.00
Veg. Height	221.80	5.06	0.04	0.08	2	217.78	0.00
Year	222.18	5.44	0.03	0.07	2	218.16	0.00
% Grass	222.43	5.70	0.03	0.06	2	218.41	0.00
Mowed Area	222.45	5.71	0.03	0.06	2	218.43	0.00
Lakehurst (n = 24 nests)							
Veg. Clumpiness	54.15	0.00	0.25	1.00	2	50.10	0.07
Year	54.46	0.31	0.22	0.85	2	50.42	0.07
% Grass	55.38	1.23	0.14	0.54	2	51.33	0.05
Null	56.18	2.03	0.09	0.36	1	54.16	-
% Shrub	56.20	2.05	0.09	0.36	2	52.16	0.04
% Forb	57.11	2.96	0.06	0.23	2	53.07	0.02
Day of Season	57.65	3.50	0.04	0.17	2	53.61	0.01
% Bare	57.79	3.65	0.04	0.16	2	53.75	0.01
Veg. Height	58.14	4.00	0.03	0.14	2	54.10	0.00
Location	58.20	4.05	0.03	0.13	3	52.12	0.04

* number of estimable parameters

Table 13. Parameter estimates from the best performing logistic models (≤ 2 ΔAIC_c) of daily nest survival rates for "other passerines" in 2009-2010. Species included field sparrow and horned lark at Lakehurst, and savannah sparrow, horned lark, and bobolink at Westover.

Model	Independent variables	*B*	SE	95% lower CI	95% upper CI
Westover					
Nest Mowed	Nest Mowed	0.94117	0.42739	0.10349	1.77886
	Intercept	2.48318	0.18735	2.11598	2.85038
Lakehurst					
Clumpiness	Clumpiness (1 vs. 3)	17.95589	0.00000	17.95589	17.95589
	Clumpiness (2 vs. 3)	-1.26018	0.84624	-2.91882	0.39846
	Intercept	4.32735	0.71178	2.93225	5.72245
Year	Year (2010 vs. 2009)	-1.76477	1.08656	-3.89443	0.36488
	Intercept	4.96281	1.00351	2.99594	6.92969
% Grass	% Grass	-3.36429	2.09811	-7.47660	0.74801
	Intercept	5.48028	1.27757	2.97624	7.98433

Table 14. Logistic models of grasshopper sparrow daily nest survival rate (DSR) for all sites combined (PAX, LAKEHURST, WARB). Parameter estimates are from the best performing model (≤ 2 ΔAICc).

Model	Delta AICc	AICc Weights	Model Likelihood	k*	Deviance	Pseudo R^2
{season}	0.00	0.63	1.00	2	294.75	0.00
{site}	2.06	0.23	0.36	3	294.80	0.00
{season + site}	3.90	0.09	0.14	4	294.63	0.00
{season + site + grass + site*grass}	5.37	0.04	0.07	7	290.03	0.02
{season + site + veght + site*veght}	8.67	0.01	0.01	7	293.33	0.01

Parameter	β	Standard Error	LCI	UCI
1:intercept	3.453	0.507	2.459	4.446
2:season	-0.003	0.009	-0.020	0.014

* number of estimable parameters

Table 15. Logistic models of grasshopper sparrow daily nest survival rate (DSR) for PAX and WARB combined. Parameter estimates are from the best performing model ($\leq$ 2 ΔAICc).

Model	Delta AICc	AICc Weights	Model Likelihood	k*	Deviance	Pseudo R^2
{season + site + drun + site*drun}	0.00	0.54	1.00	5	199.25	0.04
{site}	2.62	0.15	0.27	2	207.93	0.00
{season}	2.66	0.14	0.26	2	207.97	0.00
{season + site + nestmow + site*nestmow}	3.17	0.11	0.21	5	202.41	0.03
{season + site}	4.63	0.05	0.10	3	207.92	0.00

Parameter	β	Standard Error	LCI	UCI
1:intercept	2.629	0.868	0.928	4.329
2:season	-0.002	0.011	-0.023	0.019
3:site (PRNAS vs. WARB)	1.122	0.573	-0.002	2.245
4:distance to runway	0.006	0.003	-0.001	0.012
5:distance*site	-0.008	0.004	-0.015	-0.001

* number of estimable parameters

Table 16. Logistic models of eastern meadowlark daily nest survival rate (DSR) for all sites combined (PAX, LAKEHURST, WARB). Parameter estimates are from the best performing model ($\leq$ 2 ΔAICc).

Model	Delta AICc	AICc Weights	Model Likelihood	k*	Deviance	Pseudo R^2
{season + site + grass + site*grass}	0.00	0.99	1.00	7	302.63	0.07
{season}	11.05	0.00	0.00	2	323.80	0.01
{season + site}	11.42	0.00	0.00	4	320.13	0.02
{season + site + height + site*height}	11.43	0.00	0.00	7	314.07	0.04
{site}	12.22	0.00	0.00	3	322.96	0.01

Parameter	β	Standard Error	LCI	UCI
1:intercept	8.16	1.66	4.91	11.41
2:season	-0.02	0.01	-0.03	0.00
3:site (PRNAS vs WARB)	-4.10	1.68	-7.40	-0.80
4:site (LAKE vs WARB)	-1.06	2.35	-5.66	3.54
5:grass	-4.22	1.33	-6.83	-1.61
6:grass*PRNAS	3.62	1.43	0.82	6.42
7:grass*LAKE	0.30	2.30	-4.20	4.81

* number of estimable parameters

Table 17. Logistic models of eastern meadowlark daily nest survival rate (DSR) for PAX and WARB combined. Parameter estimates are from the best performing model (< 2 ∆AICc).

Model	Delta AICc	AICc Weights	Model Likelihood	k*	Deviance	Pseudo R^2
{season}	0.00	0.44	1.00	2	296.31	0.01
{season + site}	1.37	0.22	0.50	3	295.66	0.01
{site}	1.47	0.21	0.48	2	297.77	0.00
{season + site + nestmow + site*nestmow}	3.46	0.08	0.18	5	293.71	0.02
{season + site + drun + site*drun}	4.73	0.04	0.09	5	294.98	0.01

Parameter	β	Standard Error	LCI	UCI
1:intercept	3.232	0.347	2.552	3.913
2:season	-0.011	0.007	-0.026	0.003
1:intercept	3.394	0.408	2.595	4.193
2:season	-0.011	0.007	-0.025	0.004
3:site (PRNAS vs WARB)	-0.264	0.335	-0.920	0.391

* number of estimable parameters

Table 18. Morphological estimates taken from nestlings on days 4-7 (GRSP) or 7-9 (EAME) post-hatch, 2010.

		EAME					GRSP				
		n	Mean	SD	LCI	UCI	n	Mean	SD	LCI	UCI
LAKEHURST **	Mass (g)						25	11.39	1.90	10.65	12.14
	Wing (mm)						25	28.20	4.80	26.32	30.08
	Tail (mm)						25	3.60	1.39	3.05	4.15
	Tarsus (mm)						25	17.43	1.55	16.82	18.04
	Fat Score*						25	2.08	0.64	1.83	2.33
	Keel Score*						25	2.92	0.28	2.81	3.03
PRNAS	Mass (g)	45	40.85	7.33	38.70	42.99	61	11.36	4.54	10.22	12.50
	Wing (mm)	45	52.69	7.73	50.43	54.95	61	30.57	6.99	28.82	32.33
	Tail (mm)	45	5.51	2.56	4.76	6.26	61	3.07	2.01	2.56	3.57
	Tarsus (mm)	45	32.71	4.05	31.52	33.89	61	18.35	2.44	17.74	18.96
	Fat Score*	45	0.29	0.46	0.15	0.42	61	0.84	0.84	0.63	1.05
	Keel Score*	45	1.84	0.37	1.74	1.95	61	1.98	0.34	1.90	2.07
WARB	Mass (g)	31	43.48	7.33	40.90	46.06	25	9.84	1.89	9.09	10.58
	Wing (mm)	31	51.76	5.84	49.70	53.81	25	24.64	4.01	23.07	26.21
	Tail (mm)	31	5.89	2.80	4.90	6.88	25	3.33	1.50	2.74	3.92
	Tarsus (mm)	31	29.37	3.36	28.19	30.55	25	16.22	1.69	15.56	16.89
	Fat Score*	31	1.35	0.61	1.14	1.57	25	1.28	0.54	1.07	1.49
	Keel Score*	31	1.23	0.43	1.08	1.38	25	1.16	0.47	0.97	1.35

* See Appendix B
** No eastern meadowlark nestlings banded in 2010. Results from 2009 banding efforts are presented in Allen et al. 2009.

Appendix A. Nest location maps.

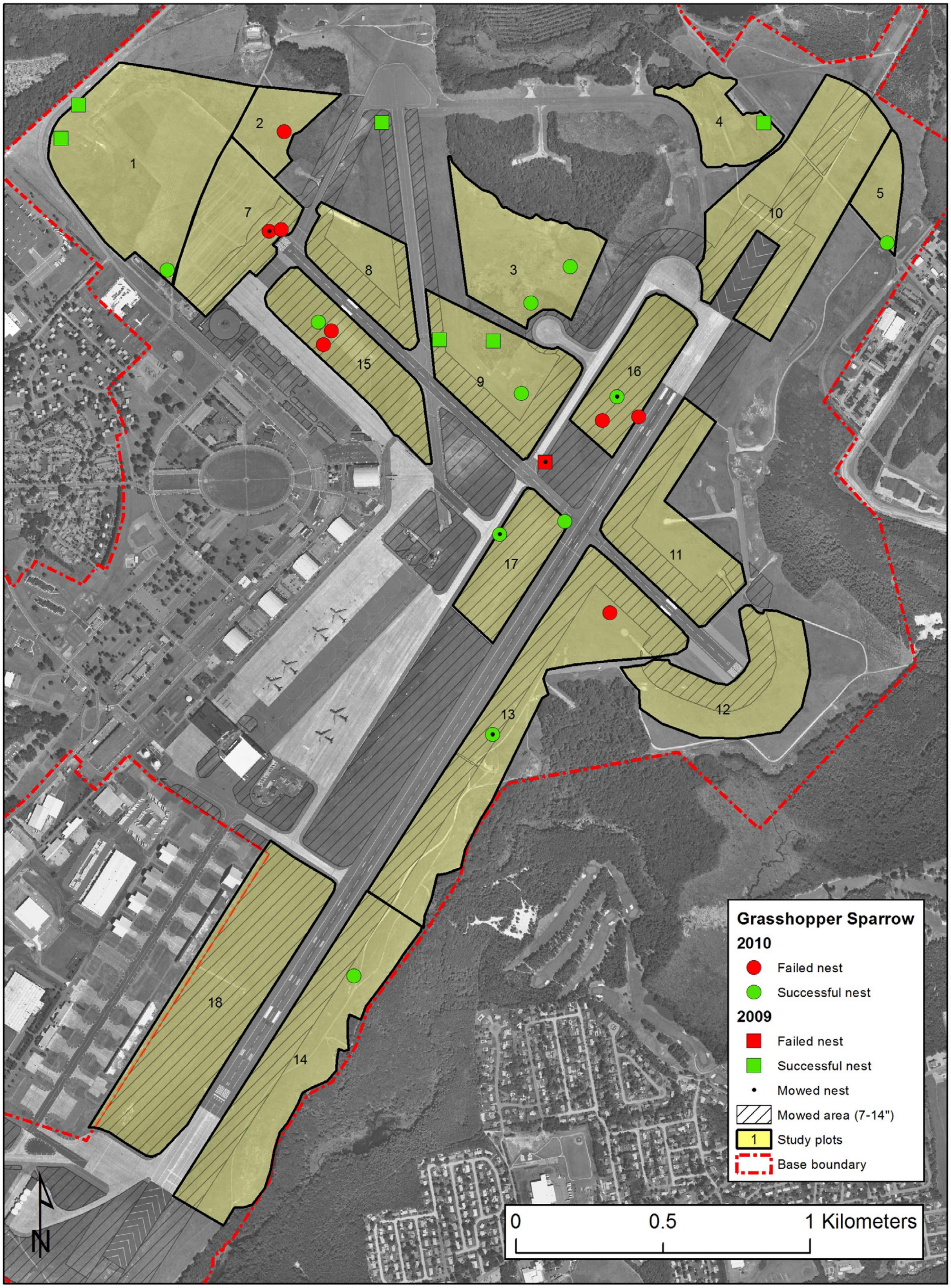


Figure A1. Locations of grasshopper sparrow nests monitored during summer 2009 and 2010 on Westover Air Reserve Base, Chicopee, Massachusetts.

Appendix A. Nest location maps.

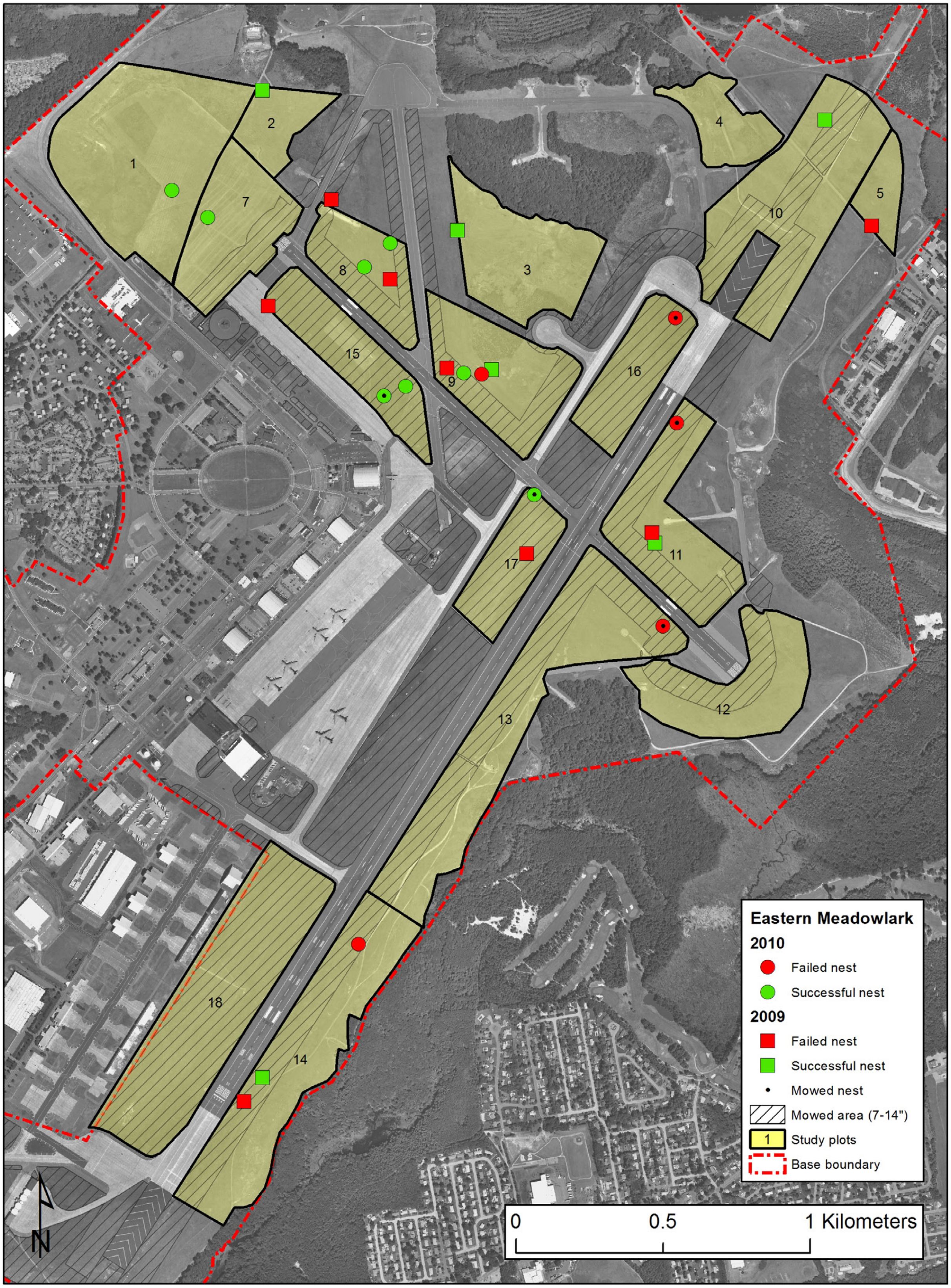


Figure A2. Locations of eastern meadowlark nests monitored during summer 2009 and 2010 on Westover Air Reserve Base, Chicopee, Massachusetts.

Appendix A. Nest location maps.

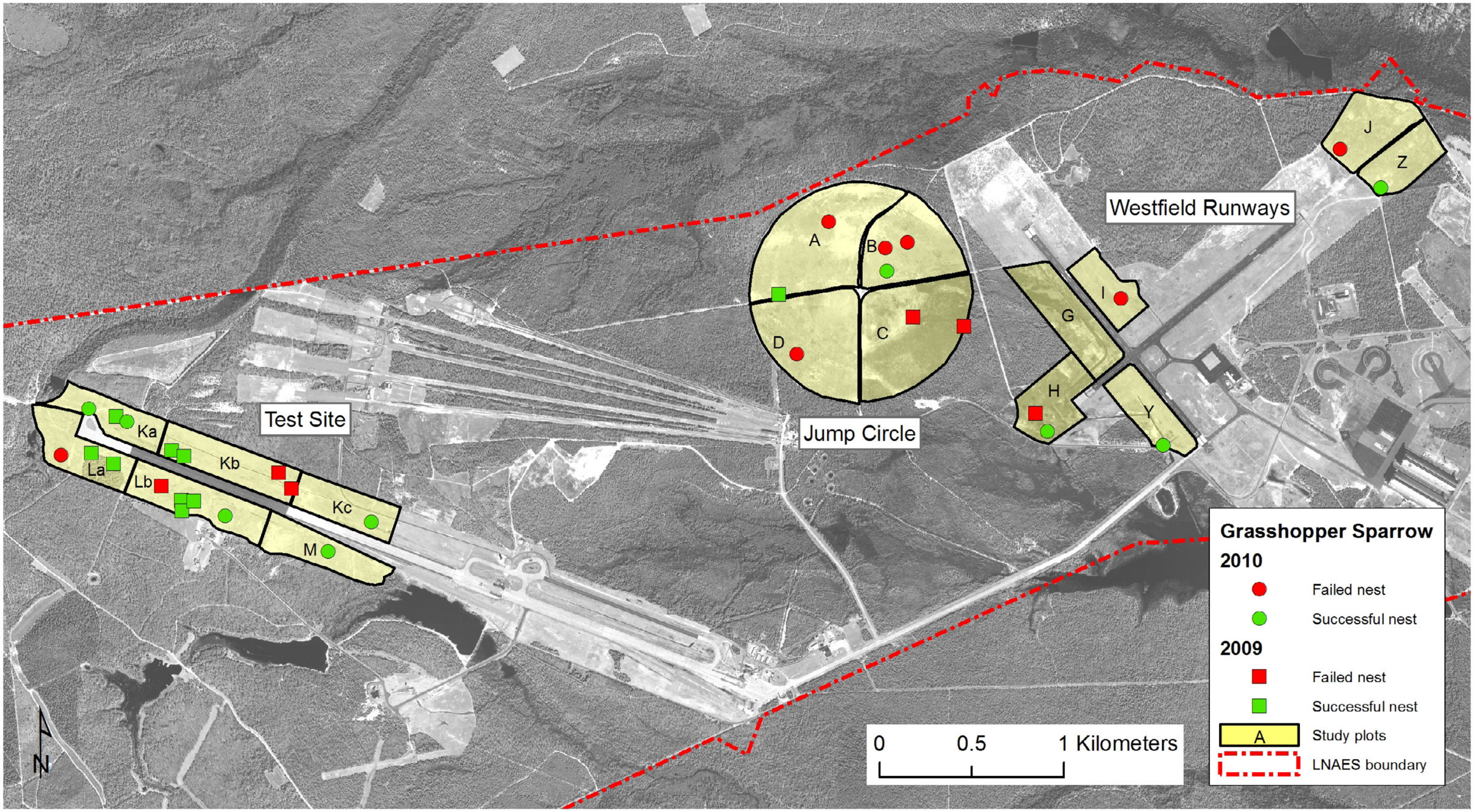


Figure A3. Locations of grasshopper sparrow nests monitored during summer 2009 and 2010 on Joint Base McGuire-Dix-Lakehurst, Lakehurst, NJ.

Appendix A. Nest location maps.

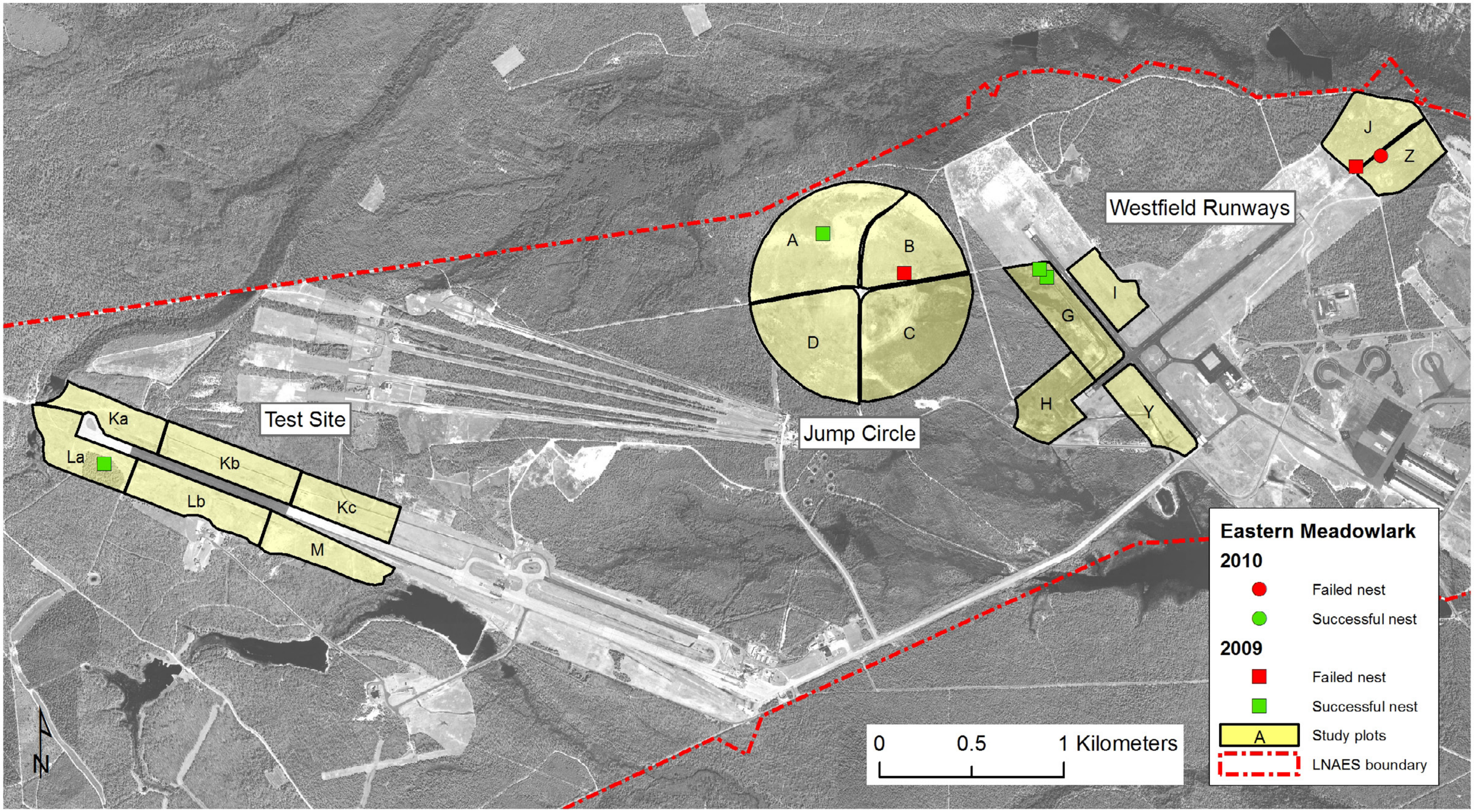


Figure A4. Locations of eastern meadowlark nests monitored during summer 2009 and 2010 on Joint Base McGuire-Dix-Lakehurst, Lakehurst, NJ.

Appendix A. Nest location maps.

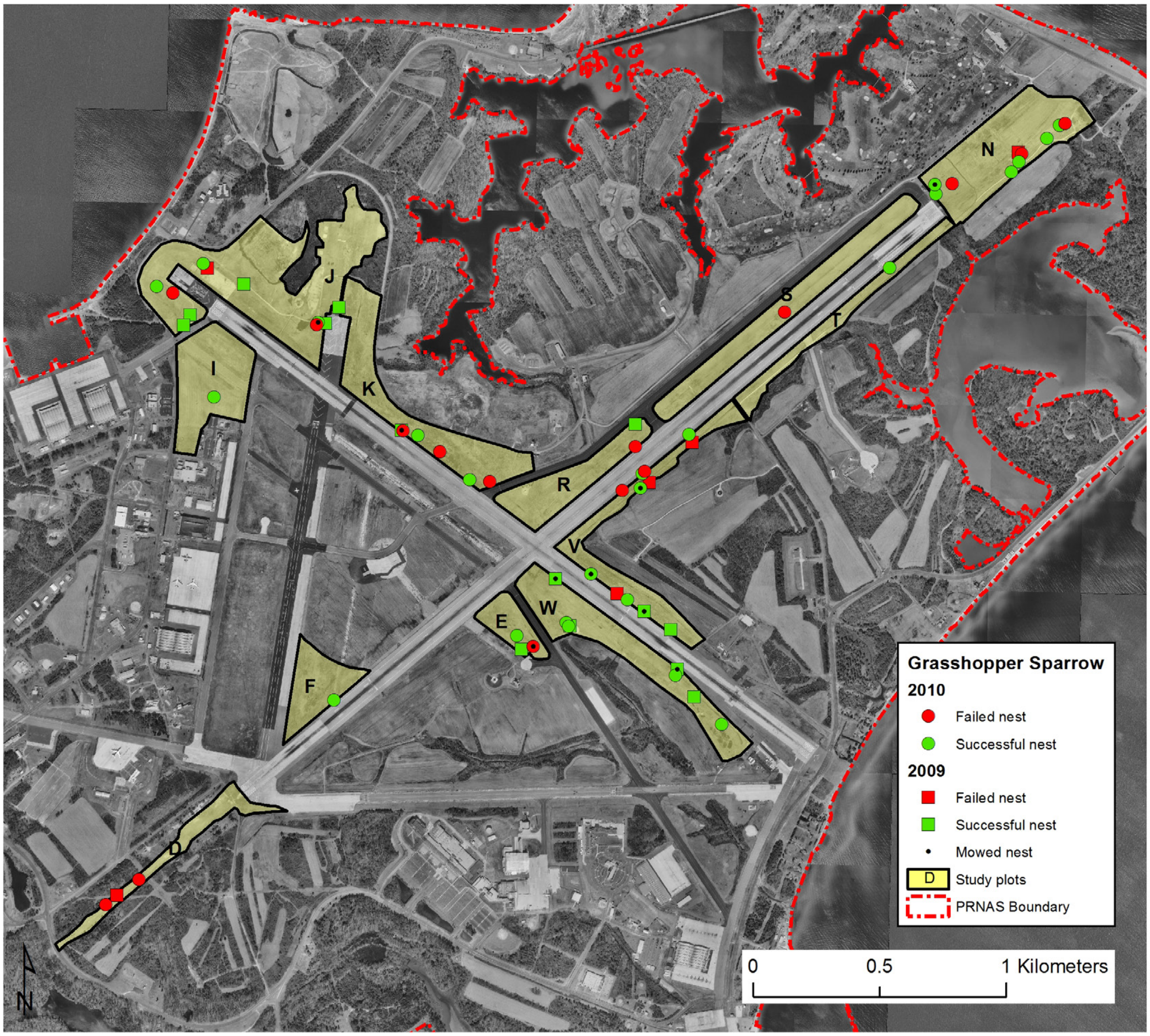


Figure A5. Locations of grasshopper sparrow nests monitored during summer 2009 and 2010 on Patuxent River Naval Air Station, Patuxent River, MD.

Appendix A. Nest location maps.

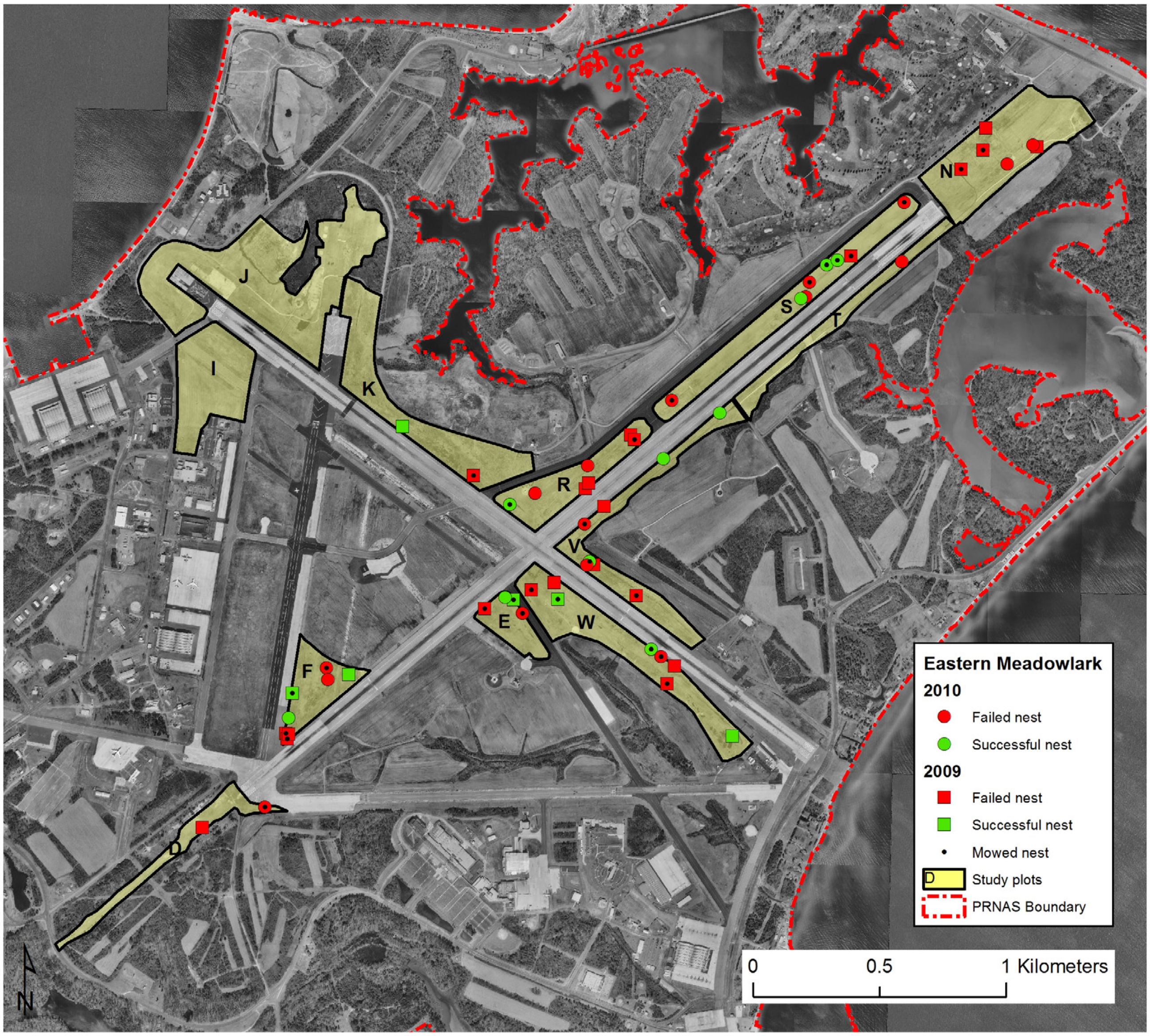


Figure A6. Locations of eastern meadowlark nests monitored during summer 2009 and 2010 on Patuxent River Naval Air Station, Patuxent River, MD.

APPENDIX B. Codes used for morphological measurements.

Fat-
(MAPS categories; examine furcular hollow, wingpits, abdomen)
0 = no fat in furcular hollow or anywhere on the body
1 = furcular hollow less than 5% full; none or just a trace elsewhere
2 = furcular hollow 5% to 33% full; bottom completely covered
3 = furcular hollow 34% to 66% full; fat covering wingpit and/or abdomen
4 = furcular hollow 67% to 100% full; fat thick under wings and on abdomen
5 = fat bulging above furcular hollow; fat well mounded elsewhere
6 = fat bulging greatly above furcular hollow; huge mounds under wings and on abdomen
7 = extremely fat; fat nearly joined in all areas

Keel-
(Bairlein 1995)
0 = sternum sharp; muscles depressed
1 = sternum easy to distinguish, but not sharp; muscles neither depressed or rounded
2 = sternum yet distinguishable; muscles slightly rounded
3 = sternum difficult to distinguish due to rounded muscles