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PROJECT 14-764

Migratory connectivity of At-Risk grassland birds

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JBCC 2015 Research Report

Executive Summary

In 2015 the Vermont Center for Ecostudies initiated an innovative grassland bird research project at Joint Base Cape Cod and five other military installations. Supported by the DoD Legacy Program, Project 14-764, contract no. W81EWF-4119-9496, this research is designed to elucidate the migratory pathways and wintering grounds of three At-Risk grassland bird species: Grasshopper Sparrow (*Ammodramus savannarum)*, Eastern Meadowlark (*Sturnella magna*), and Upland Sandpiper (*Bartramia longicauda*). Understanding the entire annual cycle of migratory birds offers avenues for sharing the burden of protecting declining populations. Data collected from across the breeding range will provide insight into regional population connectivity, applicable to other installations that support grassland birds. In 2015 we exclusively focused our research efforts on Grasshopper Sparrows, but we will expand our efforts to Eastern Meadowlarks and Upland Sandpipers in 2016.

In attempts to further understand the complete annual cycle of a declining migratory grassland bird, the Grasshopper Sparrow, we attached light-level geolocators to individuals throughout Joint Base Cape Cod [JBCC]. Field work commenced on 4 May and lasted to 29 May 2015. In total, we banded 44 Grasshopper Sparrows at JBCC, and we deployed 30 geolocators on male Grasshopper Sparrows. We collected blood and feather samples from nine individual Grasshopper Sparrows. Most birds were captured in the cantonment area of the base, outside of the airfield, and 14 birds were captured in the landfill area. We conducted 28 point counts at 14 stations throughout the base and detected a total of 38 species. We documented all birds detected throughout our daily work effort on eBird and were able to record 54 species on the base.

We found the highest densities of Grasshopper Sparrows in relatively undisturbed and expansive grasslands; the landfill area and zone 8. Currently, JBCC provide critical breeding habitat for many species of grassland birds that are challenging to find throughout Massachusetts and New England (e.g., Upland Sandpiper, Eastern Meadowlark, and Grasshopper Sparrow). We also observed grassland birds moving between JBCC and the nearby Crane Wildlife Management Area, which suggests that the management of grasslands at these two areas should be coordinated.

Project Background

The quantity and quality of grassland bird habitat has declined in North America during the last half century, and concurrently, grassland bird population declines have been among the steepest of all North American landbirds. More than 70% of grassland bird species declined significantly between 1966 and 2012, while only 7% have increased. Upland Sandpiper (*Bartramia longicauda*), Grasshopper Sparrow (*Ammodramus savannarum*), and Eastern Meadowlark (*Sturnella magna*) are three At-Risk migratory grassland bird species that commonly occur on military installations supporting substantial grasslands. Populations of Grasshopper Sparrow, a DoD PIF priority bird species, have dropped by 78% in the last 4 decades. Many states, particularly in the Northeast, have listed Grasshopper Sparrows as Threatened or Endangered. Upland Sandpiper populations have decreased substantially in some regions, including parts of the Midwest (IL, WI, MN, and MI), and in NY and other eastern states. It is Endangered, Threatened, or of Special Concern in five of eight Midwestern states and in most eastern states. The U.S. Fish and Wildlife Service considers Upland Sandpiper to be of national conservation concern due to population declines during the last century, and the U.S. Shorebird Conservation Plan lists Upland Sandpiper as a Species of High Concern. Eastern Meadowlark populations have experienced some of the most dramatic declines of grassland bird species. Their long-term population decline has resulted in a loss of 80% of the population since 1966, and this sharp decline has continued unabated even in recent years.

Until now, the understanding of migration and wintering ecology of most migratory songbirds has been extremely difficult, if not intractable. Managers have necessarily managed breeding populations with sparse, if any, knowledge of the limitations imposed on those populations during the rest of the year. Stable isotopes can provide us with clues for some species, but entail many uncertainties. New, powerful tools have emerged that allow researchers to document the daily movements of birds throughout an entire year. For a bird as small as a Grasshopper Sparrow, light-level geolocators can now provide latitude and longitude estimates for each day of its life through an entire year, and larger birds like Eastern Meadowlark can carry GPS geolocators that provide precise (within 500 m) location fixes for up to 30 programmable dates, downloaded via satellite onto a computer. For a species as large as Upland Sandpiper, we now have the capability of accurately tracking (with 500 m resolution) their every move each day, all year, using battery- and solar-powered GPS technology. With this revolutionary advancement, researchers can accurately track a bird during migration and winter, and they can record fine-scale movements in and around breeding areas. By using the latest state-of-the-art technology available, we will not need to recapture Eastern Meadowlarks or Upland Sandpipers to retrieve data.

These technologies will allow us to record wintering areas and to track the timing and routes of an individual bird's migration. We will be able to determine whether these characteristics differ among breeding populations, with implications for where and how a species may be threatened. The data will provide managers with dramatic new insight into the potential limitations and

threats faced by migratory birds throughout their annual cycle, allowing them to forge new partnerships to address these issues.

Military Mission Benefits

Conservation of natural resources on DoD lands is ultimately necessary to sustain the military training mission by ensuring the long-term availability of training lands (i.e., appropriate habitat conditions). In addition to serving its own mission, conservation fulfills the DoD's obligation, as required by the Migratory Bird Treaty Act, the Readiness Rule, Executive Order 13186, and the Sikes Act, to protect and conserve migratory birds on installations through research, habitat management, partnerships, and education. For all of these reasons, management personnel largely focus on conserving birds and their habitat on installations. Managers can use these resources more efficiently and effectively if there is an understanding of the events that affect migratory birds during their entire life cycle, rather than only during the 3-4 month-long breeding season.

Upland Sandpiper, Grasshopper Sparrow, and Eastern Meadowlark are top DoD priority species in part because they are rare and of high responsibility for DoD. Furthermore, these species are the most likely of grassland bird species to affect or to be in conflict with training activities--further underscoring the need to understand their year-round ecology. We know little about the ecology of these species outside of the breeding season, and therefore the weight of responsibility has fallen entirely on land managers on the breeding grounds, such as DoD, for maintaining populations. Knowledge of the non-breeding ecology of these species will help spread the weight of responsibility to partners, present and future, at migration stopovers and wintering grounds. Addressing threats to these species off the breeding grounds will help the DoD maximize efficacy of breeding season management on installations. Additionally, it will provide opportunities to develop partnerships and enhance cross-cultural outreach with organizations responsible for these same species on migratory and wintering grounds.

By building on grassland bird research previously funded by Legacy, this project provides a rare opportunity to conserve At-Risk species using a "full life cycle" approach. We will complement Legacy-funded work that has assessed the breeding distribution, abundance, productivity, and overall demography of the same grassland bird species on some of the same military airfields (Legacy projects #10-381 and #11-408). Models developed from these breeding season studies have provided an essential means for determining best management practices to benefit birds on installations, but they have not been able to incorporate factors outside of the breeding season that contribute to population viability. Our results will discern where and when, outside of the breeding season, other factors may affect grassland bird populations on installations. Combined with information from Legacy-funded projects on breeding parameters, the data we collect will take the initial, essential steps in ultimately determining the extent to which populations are limited on and outside of military installations. For example, we can begin to address whether

populations that are more productive differ in their migration phenology, routes, or wintering grounds compared to less productive populations.

This project will also benefit from research outside of DOD, further extending the limits of our knowledge, and if DOD desires, maximizing the use of data collected. The Principal Investigator for this Legacy proposal is involved with a project at the University of Wisconsin to develop full life cycle models under different climate change scenarios for other grassland bird species; researchers could use these models as a basis for these three grassland bird species in the future. These novel exercises in full life cycle science and stewardship will serve as templates for other migratory bird species on installations and elsewhere.

The proposed research will directly benefit the six installations included in the study: Joint Base Cape Cod (MA), Patuxent River NAS (MD), Fort Riley (KS), Fort McCoy (WI), Camp Grafton Training Site (ND), and Camp Ripley (MN). In addition, our results will be applicable to other installations across the country. Because our study spans much of the breeding range of the focal species, any installations that support breeding populations of these species may infer the connectivity of migration and wintering grounds with populations breeding on their lands, based on patterns we find. For example, we will discern whether populations breeding in the East migrate and winter in different locations compared to populations in the Midwest. Assuming species behave on this scale, installations in the East can infer where "their" populations are most likely to winter. The list of installations to benefit from our results therefore includes all that support breeding populations of the three focal species. This includes but is not limited to: Hanscom AFB (MA), Fort Devens Army Base (MA), Massachusetts Military Reservation (MA), Warren AFB (WY), Fort Drum (NY), Fort Campbell (KY/TN), McConnell AFB (KS), Grand Forks AFB (ND), Minot AFB (ND), Fort Leavenworth (KS), and Fort Indiantown Gap (PA). These are only the installations that we investigated during our site selection process, a mere subsample of those that will benefit from our study.

Installations that serve as migratory stopovers or wintering areas for these grassland birds will also greatly benefit from knowledge of connectivity between breeding, migratory, and wintering populations. By making connections on a coarse scale between the migration routes and wintering areas of birds with their breeding origin, our study will allow managers to coordinate efforts that will support bird populations during different parts of the life cycle. For example, several Navy installations in Texas host wintering populations of Grasshopper Sparrow and meadowlark spp. Knowledge about where these populations hail from will allow managers to understand where management on the breeding grounds would have the greatest impact on "their" birds. Armed with this insight, installations on the breeding and wintering grounds can work in unison to identify and address the needs unique to the populations they share.

Knowledge of breeding origin and connectivity with wintering grounds will also assist managers at installations supporting migrating bird populations (e.g., Patuxent NAS hosts migrating Upland Sandpipers). By revealing migratory paths, the consistency of migratory stopover use,

the length of time spent at stopovers, and the duration and distance of flights before and after a stopover, we will shed light on how and when different stopover regions are used by migrating birds of different breeding origins. Is a particular installation in the path a commonly used migratory route for all breeding populations or only certain ones? Do the birds stop there prior to or just after a long leg of their migratory flight, suggesting that the food resources may be critical to a successful migration? With the technology we will employ, we will be able to address such questions for the first time.

In this second year (2016) of the project, we will be able to analyze location data from any geolocators that we retrieve from recaptured Grasshopper Sparrows. In 2016 we will also deploy four solar-powered GPS tags on Upland Sandpipers, and almost two dozen battery-powered GPS tags on Upland Sandpipers (22 tags) and Eastern Meadowlarks (20 tags). The battery-powered tags have sufficient battery to store location data for 30 pre-programmed dates, while the solar-powered tags have the ability to last up to 3 years. Based on our observations of grassland birds during the 2015 field season we plan to deploy these tags on Upland Sandpipers and Eastern Meadowlarks at Fort Riley, Fort McCoy, and Joint Base Cape Cod. The other three DoD installations (Camp Grafton, Camp Ripley, and Patuxent River NAS) either lack populations or have very low densities of Upland Sandpipers and Eastern Meadowlarks.

In 2018, we will issue recommendations directly relating to this proposal after we retrieve all data. These recommendations will differ from the typical land use management practices; they will identify where these installation-specific populations may be limited during migration and winter, and thus where land managers may share responsibility. Our recommendations will include a strategy for how and where the DOD, through its alliance with Partners in Flight (PIF), may forge and enhance partnerships on a broad scale in order to maximize positive management impact on grassland bird populations that breed on installations. Installations involved in the project will be advised as to 1) what entities, both military and non-military, they may coordinate with to manage grassland bird populations throughout their life cycle; 2) follow-up research questions or issues that may be helpful for managers; 3) any changes in field protocols that would be advisable or useful for future work using the new technology of geolocators.

Our project will take miniaturized technology to new limits: it will be the first to use light-level geolocators, Argos GPS technology, and PTTs on these grassland bird focal species. We will be able to ask questions that we have never before been able to address, and we will gain insights never before possible. This groundbreaking research will serve as a template for implementing tracking technology for other bird species on military lands throughout the United States. Most importantly, however, the DoD will be involved in a project that will help to transform our way of thinking about how migratory bird species management and partnerships can sustain the military training mission.

Survey & Capture Methods

Male Grasshopper Sparrows are more vocal, visible, and easier to capture, and have lower inter-annual dispersal rates than female Grasshopper Sparrows. Therefore, we exclusively targeted male Grasshopper Sparrows for light-level geolocator deployment. At JBCC we systematically walked transects across the grounds during the first week of May. We predominantly focused on the landfill and cantonment areas (Figure 1) based on Peter Trimble's frequent past encounters with Grasshopper Sparrows in these areas. Working on the airfield would have also posed additional logistical and safety measures. Peter is a local birder who has performed bird surveys at JBCC for many years. Grasshopper Sparrows prefer areas of extensive grass cover >50 m from woodland edges with little woody vegetation and small areas of exposed ground. Our goal was to identify areas with high concentrations of Grasshopper Sparrows, so that we could deploy geolocators on males in a few relatively small areas. Marking males in one small area, as opposed to several scattered areas, will reduce the amount of land that we need to search on 2016 to relocate and recapture males wearing geolocators, because male Grasshopper Sparrows often shift their territories between years. In order to capture enough male Grasshopper Sparrows for our research at JBCC, however, we ended up banding birds in several fields.

Once we located a singing male sparrow we then set up a 6-m 30mm-mesh nylon mist net on 2-m tall poles (Figure 2). We then placed a small speaker, attached to a smartphone, 1-m away from the center of the net and broadcasted a recording of a male Grasshopper Sparrow song. Male Grasshopper Sparrows are territorial and they perceive the recorded song as an intruding male sparrow. Male sparrows generally flew up to the net and landed on the ground near the speaker. About half of the birds that we captured flew into the nets on their own, while the other birds were encouraged into the nets by quickly approaching the mist-nets on foot. Some individuals actually perched on the mist net before being captured (Figure 2).
Occasionally male sparrows would fly into the net without encouragement from us. We limited the use of recordings to <5 min with any given male sparrow, and we generally targeted males between 0600 and 1030. This 4.5 hr period corresponds with the timing of copulation in this species, and males became noticeably less aggressive to our recorded intruder song after 1000. We also attempted to capture males in the evening hours (1730-2030), but males showed little interest in our playback during these hours.

Figure 1. *Grassland areas at JBCC (purple polygons) where we conducted the majority of our grassland bird research in May 2015, including the landfill area (upper left polygon), cantonment (center polygon), and southern end of the airfield (lower right polygons).*

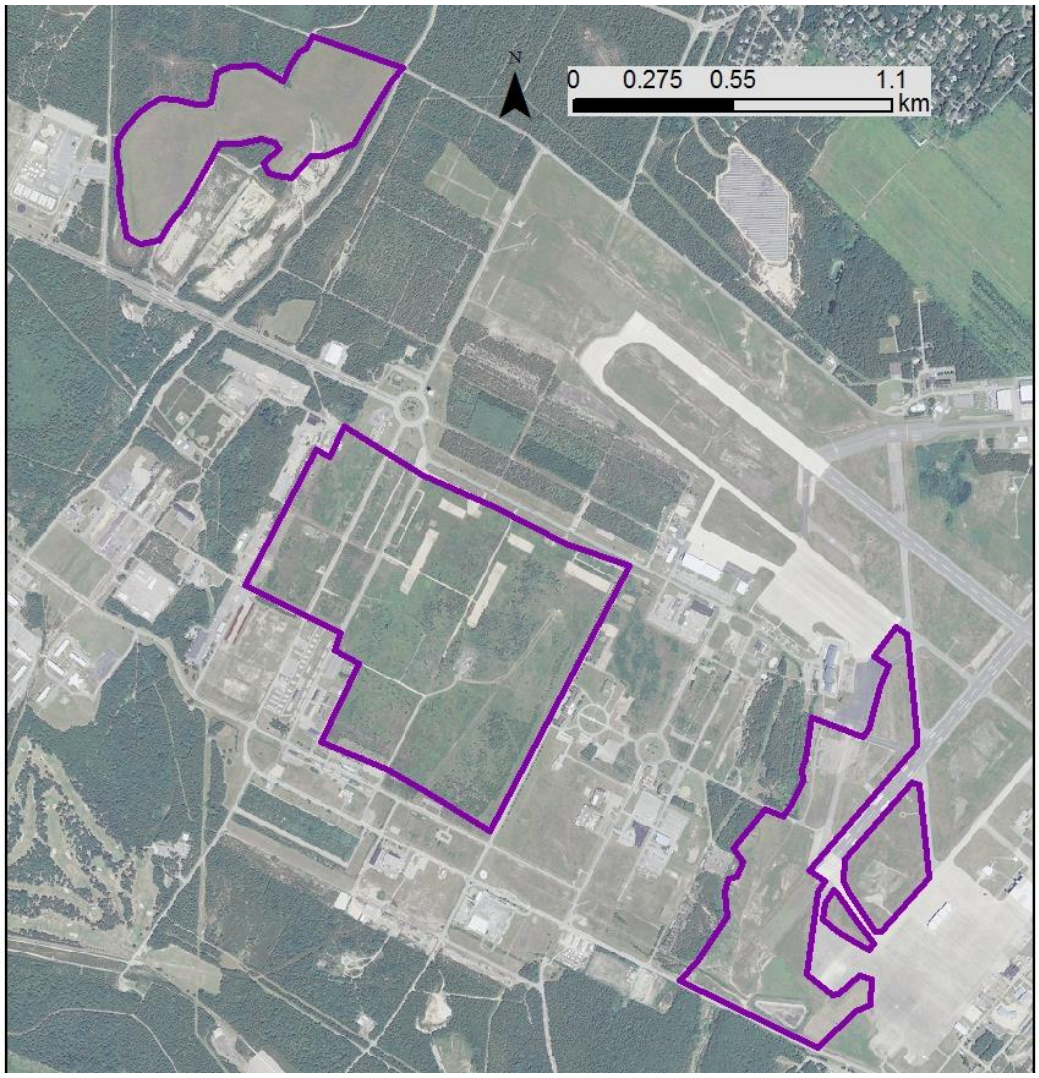


Figure 2. *A male Grasshopper Sparrow perches on a mist net (top panel) looking for the source of the Grasshopper Sparrow song that is coming from our playback equipment. Seconds later we captured him in the mist net after he tried to approach the playback equipment in the Cantonment area at JBCC.*

Banding, Feather, and Blood Sampling

We began banding on 4 May, 2015 and concluded our efforts on 29 May, 2015. For all captured birds we recorded their age, sex, weight, and basic morphological measurements. Handling time was generally less than 10 minutes per bird, and all birds were released unharmed at their capture location. During May, we successfully captured and banded 44 male Grasshopper Sparrows at JBCC (Figure 3; Appendix A). In collaboration with other researchers we also sampled a single primary (i.e., wing) feather and a small amount of blood (<100 µl) from birds that did not receive a geolocator (Figure 4). The feather samples will be used by colleagues in a stable isotope

analysis to determine the diet of wintering Grasshopper Sparrows, and the blood samples will provide our colleagues with insight into internal parasite loads. We obtained feather samples from nine birds, and took blood samples for 12 birds. Four banded birds were unintentionally recaptured, one of which had an intact geolocator.

Figure 3: *Grasshopper Sparrow capture locations (yellow pins) at Joint Base Cape Cod in May, 2015.*

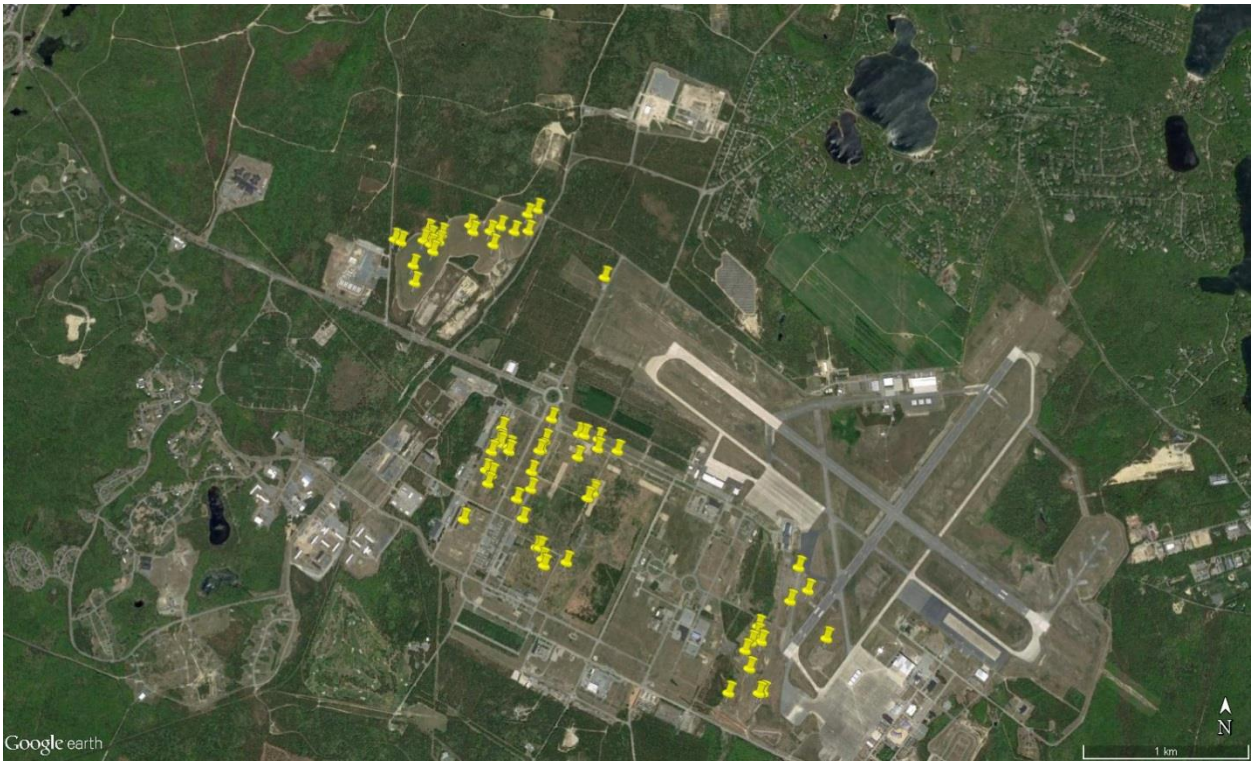


Figure 4. *Collecting a small blood sample for parasite analysis from a male Grasshopper Sparrow at JBCC in May, 2015.*

Geolocator Deployment and Color-banding

Birds wearing geolocators must be recaptured in 2016 to gain access to geolocator data. To facilitate our future recovery efforts we attached a unique combination of color bands to the legs of a Grasshopper Sparrows fitted with a geolocator. The geolocator units are small (~0.5 g, including the harness; Figure 5) and are difficult to see on a moving bird. Color bands, however, are more visible and in 2016 these color band combos will allow us to quickly key in on birds wearing a geolocator. We made a simple loop harness for the geolocators using an 80.5 mm piece of Stretch Magic bead and jewelry cord (0.7 mm). We passed the material through the geolocator loops, and melted the ends of the cord together using a soldering iron. The resulting fused harnesses are strong, but also flexible so as to accommodate sparrows of varying body sizes. We only deployed geolocators on birds that weighed ≥17.0 g, so that the geolocator + harness weight did not exceed 3% of body mass. The geolocator harness slipped on over a bird's legs and fit snugly over their hips (Figure 6). Once the geolocator was on the bird we checked the harness fit by measuring the amount of vertical play between the bird's back and the bottom of the geolocator when slight upwards force was applied to the geolocator. We deemed that the harness fit adequately if the play was 1-2 mm. We used a small thin piece of plastic to smooth the body feathers underneath the harness. Before releasing the bird we made sure that the harness fit securely, and that the wings and legs were free to move unimpeded.

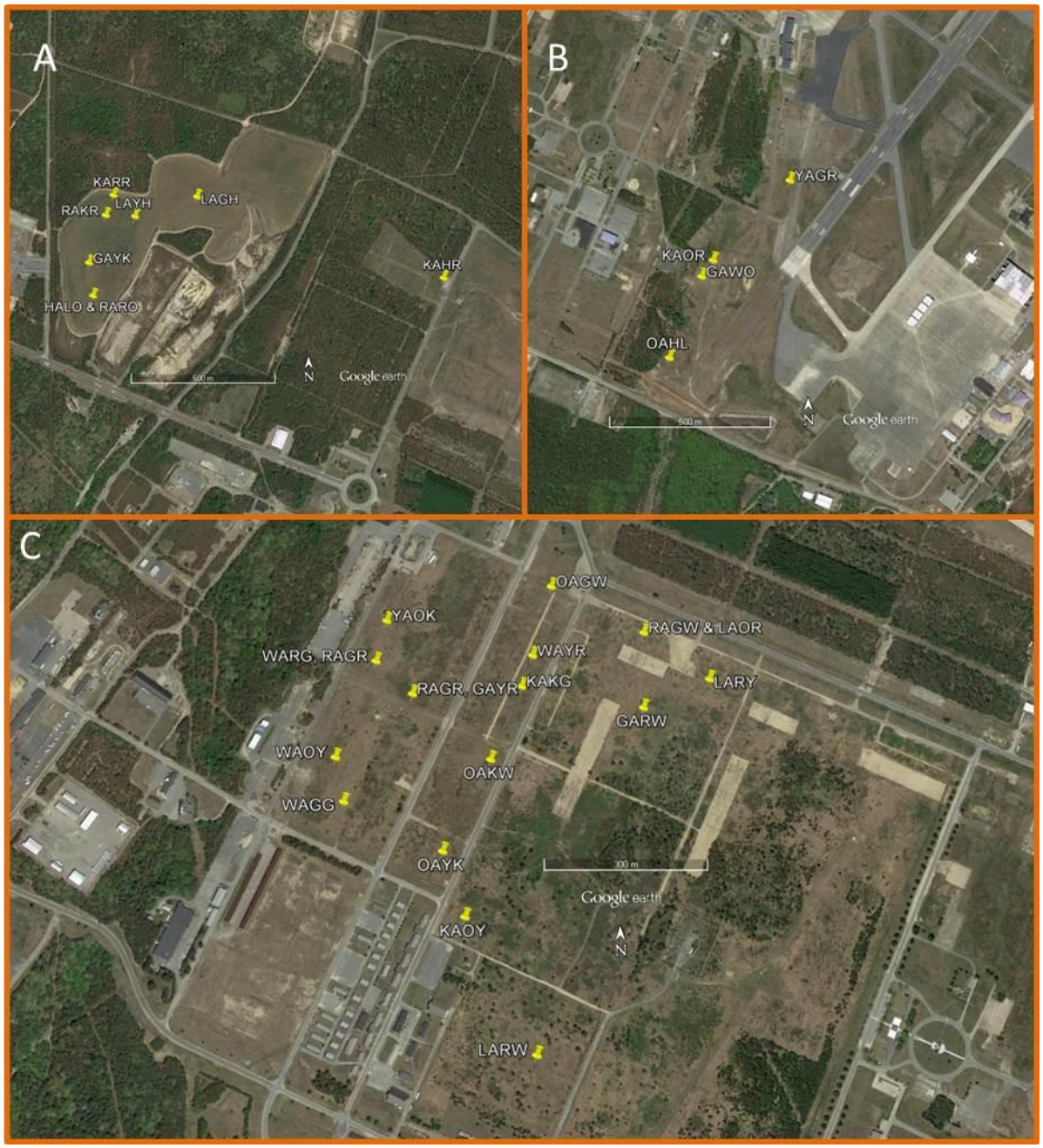
Figure 5. *A geolocator with harness (~0.5 g) prior to deployment on a male Grasshopper Sparrow (visible in background).*

Figure 6. *Grasshopper Sparrow wearing a geolocator at JBCC in May 2015.*

We color-banded 30 adult male Grasshopper Sparrows at JBCC (Figure 7), and we deployed 30 geolocators (Appendix A). The color band combinations consist of an aluminum band (A) with three color bands of the following colors: red (R), white (W), blue (L), orange (O), green (G),

black (K), violet (V), yellow (Y), and hot pink (H). The color band combinations are read in the following order: right leg top, right leg bottom, left le top, left leg bottom.

Figure 7. *Locations and color band combinations of all male Grasshopper Sparrows outfitted with a geolocator on the landfill (panel A), airfield (panel B), and cantonment area (panel C) at JBCC in May, 2015.*



Post-deployment Observations

In general, we tried to avoid areas where we had previously banded male Grasshopper Sparrows to avoid accidentally recapturing birds wearing geolocators. We must recapture male Grasshopper Sparrows wearing geolocators in subsequent years to acquire their data, and males become weary of mist nets if we capture them frequently, which could hinder our recapture efforts in 2016. We incidentally recaptured a male Grasshopper Sparrow wearing a geolocator three days after we put the geolocator on him; the geolocator fitted this male very well. The male had preened his feathers to rest atop of the geolocator base, but this did not cover the light-sensing stalk. In our experience, this behavior is normal and it will not affect our research in any way. Immediately prior to his recapture, this male actively sand and flew aggressively towards the net. We also had several re-sightings of color-banded birds throughout JBCC. Although we could not see the geolocator during these observations, all of the birds behaved naturally. One male in particular deserves special attention in this section; we captured male Grasshopper Sparrow LARW on May 13 2015 in the cantonment area. On May 29, we were assisting Massachusetts State Ornithologist Drew Vitz at the nearby Crane Wildlife Management Area, when we resighted Grasshopper Sparrow LARW singing (Figure 8). This represents a movement of approximately 2.25 km from his initially capture location, and it is an exciting discovery that links JBCC and Crane Wildlife Management Area.

Figure 8. *A male Grasshopper Sparrow (LARW: blue over aluminum on the left leg and red over white on the right leg) was resighted at Crane Wildlife Management Area on May 29, 2015 after being initially banded at JBCC on May 13, 2015. The geolocator is visible as a bump on the bird's lower back.*

Nesting Birds

Nest searching was not one of our main objectives at JBCC, but we did opportunistically discover one Savannah Sparrow (*Passerculus sandwichensis*) nest (Figure 9). We recorded the location of this nest, but we did not monitor it. The nest had a clutch of four eggs, and is located near the weather station (Appendix B).

Figure 9. *Savannah Sparrow nest with four eggs discovered on JBCC near the weather station.*

eBird Summary

All of our daily observations of birds were entered into eBird (www.ebird.org) [Table 1; Appendix C], which is an online database managed by Cornell University that has become an important resource about bird distribution and abundance for scientists, researchers, and amateur birders. eBird is entirely free and available to anyone with an internet connection, and has dramatically changed the way that the professional and amateur birding communities record and assess information about birds throughout the world. Essentially, an observer enters a checklist of the number of individuals seen of each species that they encounter while birding into eBird (Figure 8). The user plots their location on a map, records information about their effort (e.g., number of hours birded, and distance traveled, if any), and can provide comments about their observations or even upload photos. An expert local reviewer examines each observation to

ensure a high level of integrity in the database. In May 2015, for example, users around the world submitted >9.5 million bird observations.

In general, we strived to create a checklist of the bird species that we observed each day on JBCC (Table 1), but we also recorded the breeding statuses and interesting behaviors of individuals that we observed. We detected 54 species at JBCC and contributed an abundance of data to eBird.org (Appendix C). All of our data and bird sighting information is publicly available on eBird.org, and military personnel and the public can view our data at any time.

Table 1. *Summary of eBird avian observation data from JBCC, May 4 through May 29, 2015, which includes the number of checklists submitted and the number of species and individuals detected.*

	May 1-5	May 6-10	May 11-15	May 16-20	May 21-25	May 26-29
No. species	24	19	30	41	38	35
No. individuals	89	55	126	137	237	227
No. of checklists	1	1	4	3	2	3

Point Count Summary

We conducted point count surveys at 14 locations in the general vicinity where we deployed geolocators on male Grasshopper Sparrows (Figure 10). Each point was surveyed twice, by different observers, on different days: 25 May 2015 and 28 May 2015. Point count locations were a minimum of 0.25 km apart. Over the course of five minutes a lone observer counted all individual birds that were detected by either sight or sound within an unlimited distance from the point. In practice, however, most individual birds were detected within 100 m of the observer. No audio records or decoys of any kind were used to increase the detection of individuals. We made every effort to avoid double-counting individual birds (e.g., a soaring hawk) across multiple point count locations. Each count started immediately as the observer arrived at the point count location, and all points were surveyed between 0530 and 900.

In total, 38 bird species were detected during the point counts (Appendix D). The three most frequently detected species were Savannah Sparrow, Eastern Towhee (*Pipilo erythrophthalmus*), and Grasshopper Sparrow (Appendix D). Grasshopper Sparrows were most abundant at point count stations in the landfill and the cantonment areas (Figure 11), while all grassland birds (including Grasshopper Sparrow, Eastern Meadowlark, Eastern Kingbird [*Tyrannus tyrannus*], Killdeer [*Charadrius vociferus*], Savannah Sparrow, Horned Lark [*Eremophila alpestris*], and Upland Sandpiper) were most abundant at point count stations in the landfill and airfield (Figure 12).

Figure 10. *Point count locations at JBCC where observers surveyed for birds on 25 May and 28 May, 2015.*

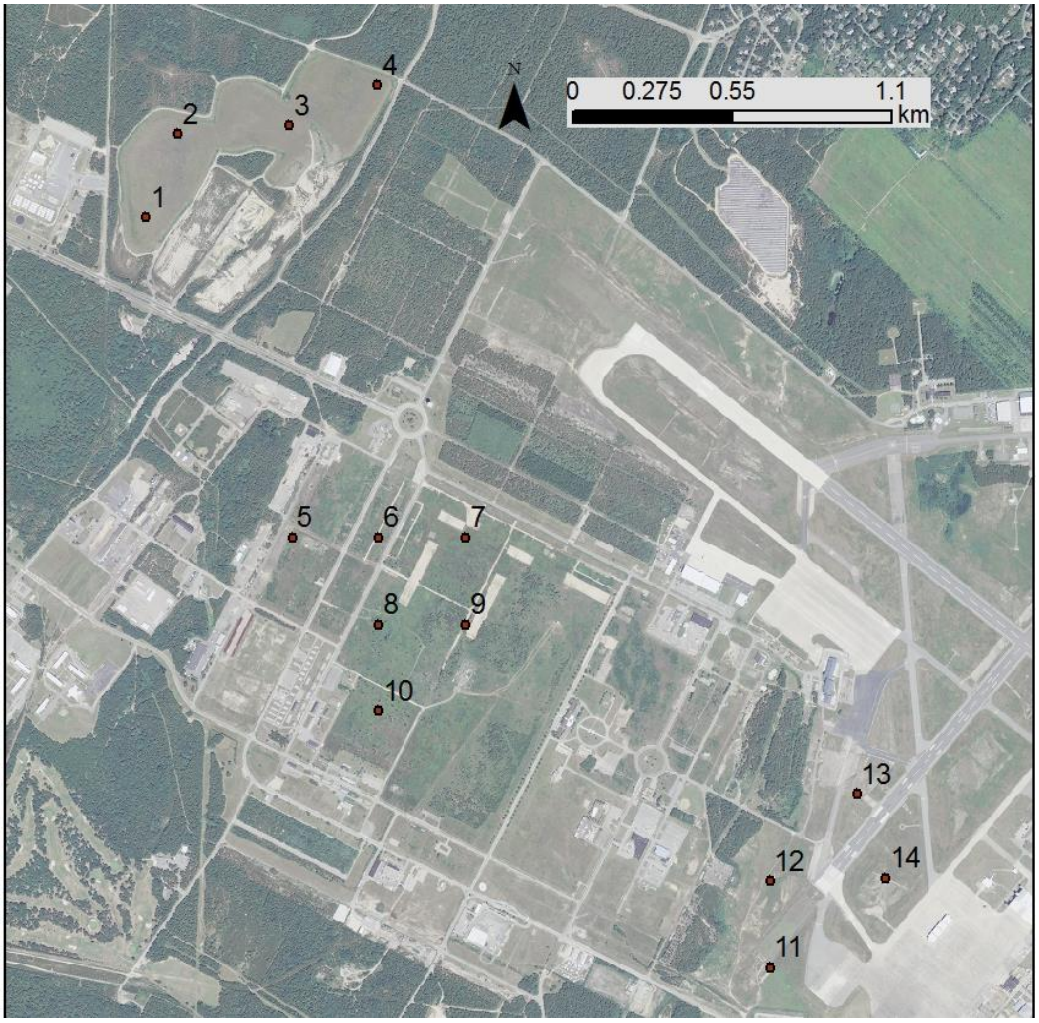


Figure 11. *The mean number of Grasshopper Sparrows detected on a point count in the 100-m area surrounding each point count location at JBCC.*

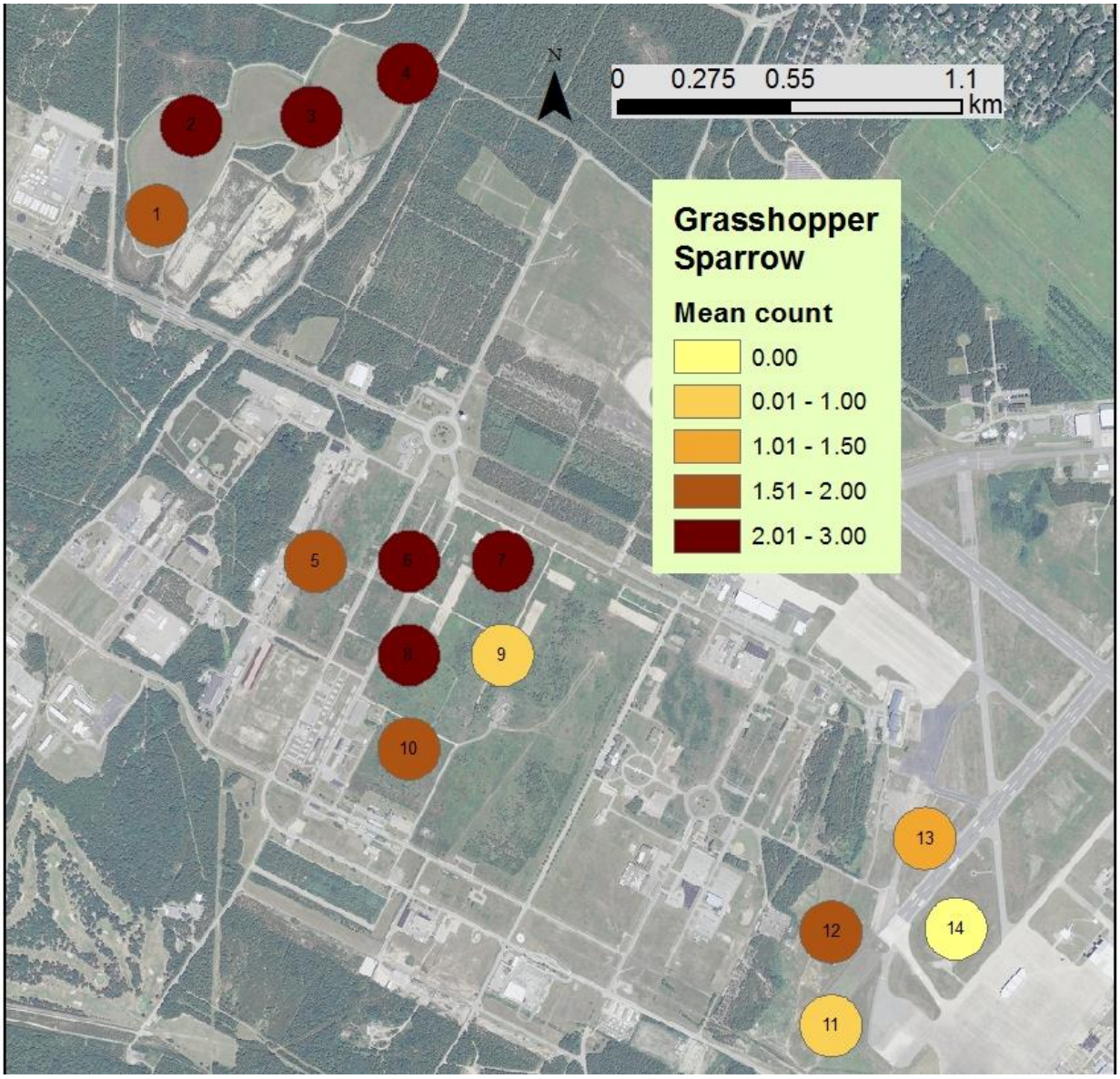
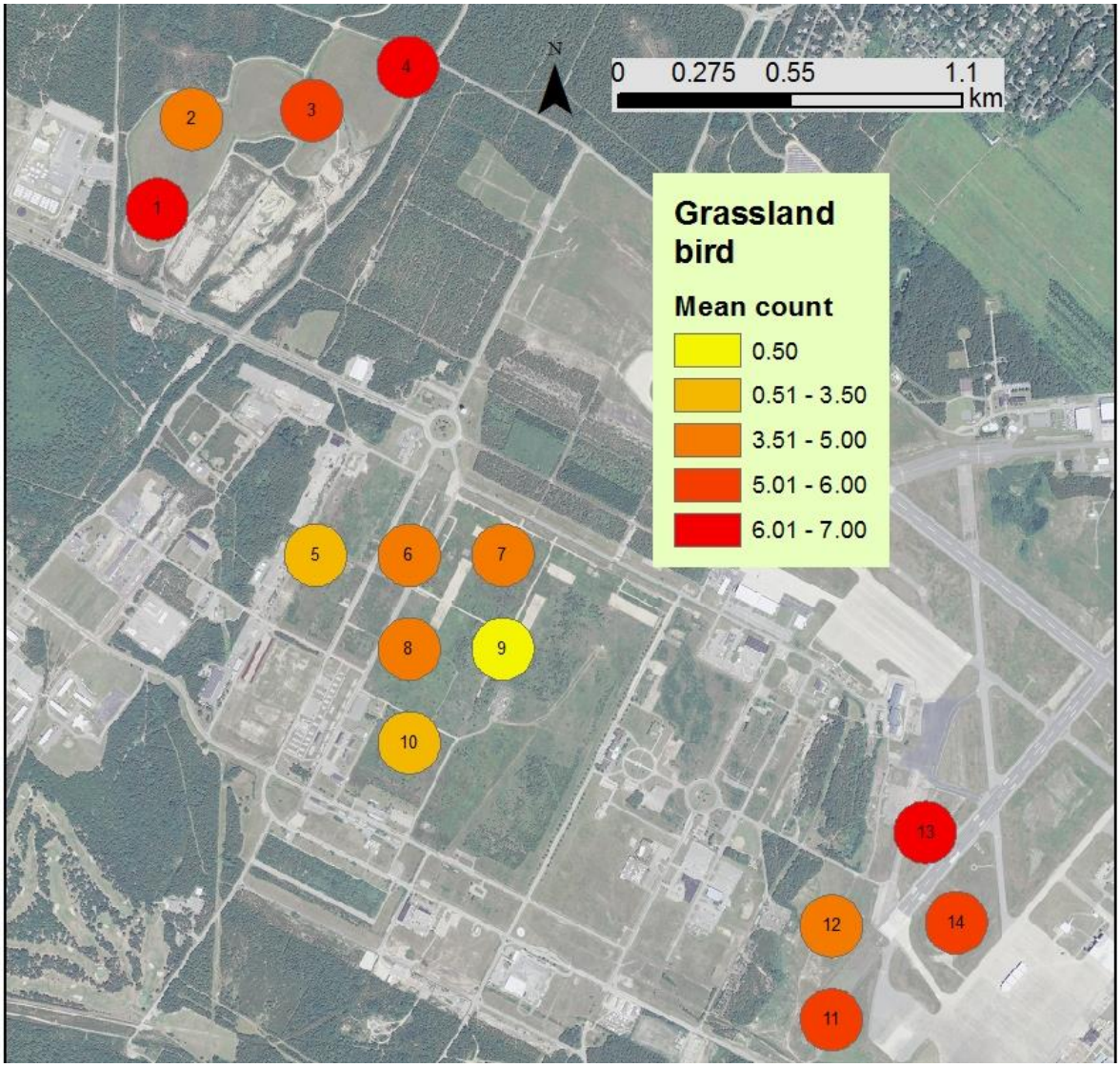


Figure 12. *The color represents the mean number of individual grassland birds (including Grasshopper Sparrow, Eastern Meadowlark, Eastern Kingbird [Tyrannus tyrannus], Killdeer [Charadrius vociferus], Savannah Sparrow, Horned Lark [Eremophila alpestris], and Upland Sandpiper) detected on a point count in the 100-m area surrounding each of the 14 point count locations at JBCC, MA.*



Habitat Management Recommendations

Management of grasslands at JBCC is a complex endeavor due partly to the disjunct agency ownership of grassland parcels. Currently, JBCC provide critical breeding habitat for many species of grassland birds that are challenging to find throughout Massachusetts and New England (e.g., Upland Sandpiper and Grasshopper Sparrow). During our frequent in-person meetings, phone calls, and emails Jake McCumber informed us of the management history for

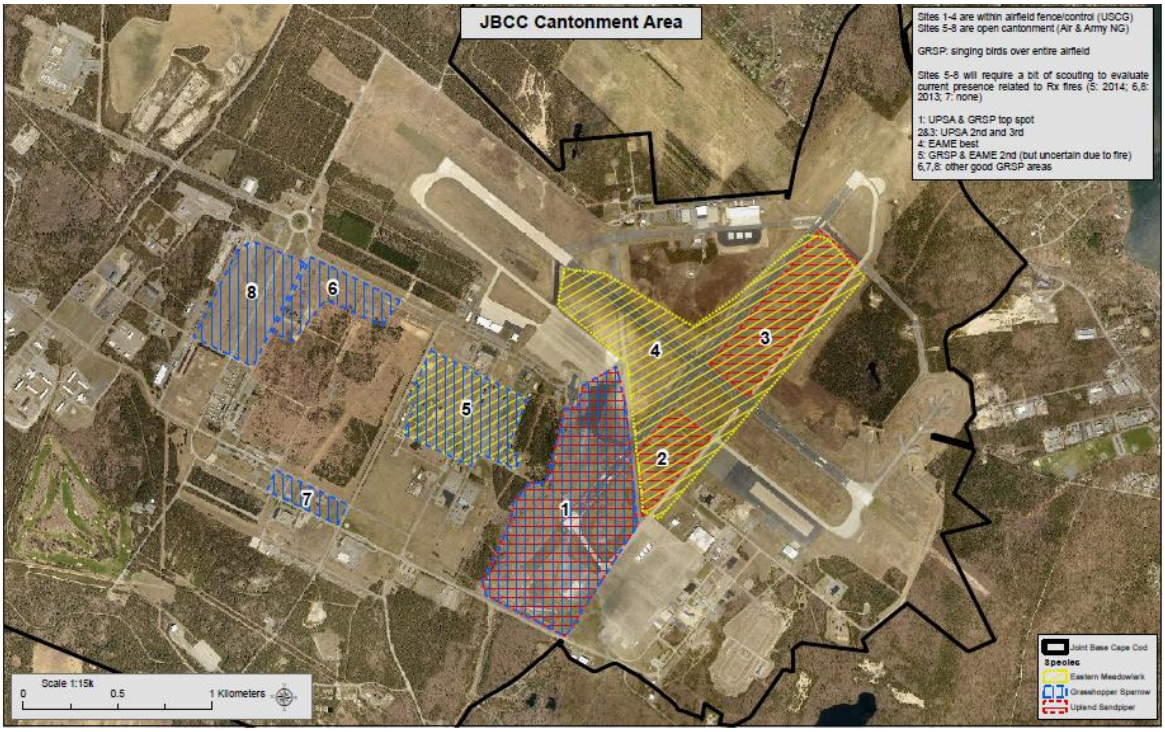
grasslands and grassland bird species at JBCC. We provide here some general recommendations based on our observations, but defer to Mr. McCumber's opinion based on his knowledge of grasslands and his experience with this installation.

The landfill area (~30 ha) contains the highest density of Grasshopper Sparrows and it was the only field where we saw more Grasshopper Sparrows than Savannah Sparrows. The landfill, however, is expected to become a solar field in the immediate future. It is our understanding that the solar field will cover the entire grassland, which could effectively eliminate this important habitat for grassland birds. Grassland bird species prefer continuous, large tracts of habitat. For example, one large 15 ha patch of grassland would be substantially more suitable than three small patches of grassland each 5 ha in size. We recommend that the solar panels and associated infrastructure (especially roads) be clustered together if possible, in order to preserve some of this valuable grassland habitat. Given the sparse grassland habitat in and around JBCC, and the very limited, isolated populations of Grasshopper Sparrows, Upland Sandpipers, and Eastern Meadowlarks in the region, it would be very important to minimize and mitigate the loss of suitable grassland bird habitat whenever possible.

Grassland bird species also tend to avoid roadways and edges (especially forested edges). Clustering maintenance sheds and equipment along the edges of grassland patches would be recommended over placing them in the middle of grasslands. Grassland birds tend to avoid areas with shrubby woody vegetation, such as the south end of zone 6 (Figure 13). The high density and expansion of pitch pine in zone 6 could be halted with chainsaws or woody-specific herbicides (e.g., Garlan 3A and Escort) applied in the late summer. Grasshopper Sparrows, however, can be found in open grassy areas amidst very low density, scattered trees in grasslands, typical of savannah habitats. We observed Grasshopper Sparrows in the most open areas within savannah-like habitat just north of the church. Areas with relatively low tree density could become more attractive to Grasshopper Sparrows if some trees are removed and the grasses are maintained by using prescribed fire. If practical, this could be one means to partially offset loss of grassland habitat from the solar project.

Zone 7 was the only field in the cantonment area where we did not detect any Grasshopper Sparrows, but Grasshopper Sparrows were once common in this area according to Jake McCumber. Ground crews mowed the grass in Zone 7 short in May, which would discourage Grasshopper Sparrows from settling there. Mowing can be an effective tool to retard woody vegetation growth when performed in late summer after the breeding season. Delaying moving activities in zone 7 to the end of the summer would likely result in the return of grassland birds to this area.

Figure 13: *JBCC Cantonment area zones.*



Lessons Learned

Unforeseen events will affect any research project of this size and scope, but for the most part, we were very fortunate and prepared at JBCC in 2015. Compared to some of our other partner installations (e.g., Camp Grafton, ND), we had access to very thorough bird data from eBird and Jake McCumber for JBCC. Access to this information had a large and positive effect on the success of our research at JBCC. Without access to this information, we would have needed a greater amount of time at JBCC to scout for areas with high densities of grassland birds.

We originally planned to conduct our research at Westover Air Force Base (AFB), MA, but we chose to come to JBCC instead due to a tremendous amount of grassland management activities that were planned for the summer of 2015 at Westover AFB. We were concerned that these management activities, and the New England Air Show, would have a detrimental effect on our research in 2015. One needs to have backup sites already identified in the event that one site falls through. In our case, we had already identified JBCC as a possible alternative for Westover AFB, and switching operations to JBCC was largely seamless.

Conducting research at JBCC is challenging due to the disjunct ownership of grasslands on the base, changing land uses, and presence of grassland birds along the runways. We found that it was critical to communicate directly (via phone or in person) with all parties (e.g., Coast Guard and Massachusetts National Guard) before making plans to perform research on a section of

JBCC. Most of the military personnel that we communicated with did not have experience with grassland birds, and they had many questions about what exactly we would be doing out in the grasslands. Conference calls and an over-the-web PowerPoint presentation would have been useful prior to our arrival to educate base personnel about our activities.

Our observation of one of our color-banded Grasshopper Sparrows at Crane Wildlife Management Area (WMA) clearly demonstrates that some grassland birds interchangeably use grasslands at JBCC and Crane WMA. This is an exciting discovery, but it also has implications for recapturing birds, and we will need to seek permission from the State of Massachusetts to recapture Grasshopper Sparrows at Crane WMA. This discovery also highlights the importance of scouting for grassland birds on lands adjacent to the military bases.

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Appendix A Banding summary at JBCC (May, 2015)

Capture date	UTMS Easting zone 19	UTMS Northing zone 19	Capture disposition	Band number	Species	Color band combo	Fitted with a geolocator?	Blood sampled?	Feather collected?	Age	Sex
5/6/2015	370822	4613340	New capture	222152901	Grasshopper Sparrow	None				Adult	Male
5/6/2015	370772	4613135	New capture	222152902	Grasshopper Sparrow	None				Adult	Male
5/6/2015	371052	4612678	New capture	222152903	Grasshopper Sparrow	None				Adult	Male
5/7/2015	372346	4611931	New capture	222152904	Grasshopper Sparrow	None				Adult	Male
5/11/2015	370828	4613322	New capture	222152905	Grasshopper Sparrow	GAYR	Yes			Adult	Male
5/12/2015	370736	4613162	Recapture	222152902	Grasshopper Sparrow	WAOY	Yes			Adult	Male
5/12/2015	370787	4613318	Recapture	222152901	Grasshopper Sparrow	WARG	Yes			Adult	Male
5/12/2015	370930	4612979	New capture	222152906	Grasshopper Sparrow	OAYK	Yes			Adult	Male
5/13/2015	371086	4613282	New capture	222152907	Grasshopper Sparrow	KAKG	Yes			Adult	Male
5/13/2015	371023	4613146	New capture	222152908	Grasshopper Sparrow	OAKW	Yes			Adult	Male
5/13/2015	371312	4613232	New capture	222152909	Grasshopper Sparrow	GARW	Yes			Adult	Male
5/13/2015	371439	4613283	New capture	222152910	Grasshopper Sparrow	LARY	Yes			Adult	Male
5/13/2015	371087	4612608	New capture	222152911	Grasshopper Sparrow	LARW	Yes			Adult	Male
5/14/2015	371321	4613377	New capture	222152912	Grasshopper Sparrow	RAGW	Yes			Adult	Male
5/14/2015	371110	4613342	New capture	222152913	Grasshopper Sparrow	WAYR	Yes			Adult	Male
5/14/2015	370750	4613077	New capture	222152914	Grasshopper Sparrow	WAGG	Yes			Adult	Male
5/15/2015	370881	4613304	New capture	222152915	Grasshopper Sparrow	RAGR	Yes			Adult	Male
5/15/2015	370837	4613420	New capture	222152916	Grasshopper Sparrow	YAOK	Yes			Adult	Male
5/15/2015	370966	4612857	New capture	222152917	Grasshopper Sparrow	KAOY	Yes			Adult	Male
5/15/2015	371097	4612569	Recapture	222152911	Grasshopper Sparrow	LARW	Yes			Adult	Male
5/18/2015	371151	4613475	New capture	222152918	Grasshopper Sparrow	OAGW	Yes			Adult	Male
5/18/2015	371355	4613368	New capture	222152919	Grasshopper Sparrow	LAOR	Yes			Adult	Male
5/19/2015	370597	4612858	New capture	222152920	Grasshopper Sparrow	None				Adult	Male
5/19/2015	372611	4612327	New capture	222152921	Grasshopper Sparrow	YAGR	Yes			Adult	Male
5/19/2015	372361	4612088	New capture	222152922	Grasshopper Sparrow	KAOR	Yes			Adult	Male
5/20/2015	372324	4612038	New capture	222152923	Grasshopper Sparrow	GAWO	Yes			Adult	Male
5/20/2015	372215	4611791	New capture	222152924	Grasshopper Sparrow	OAHL	Yes			Adult	Male
5/21/2015	371498	4614381	New capture	222152925	Grasshopper Sparrow	KAHR	Yes			Adult	Male
5/21/2015	370276	4614368	New capture	222152926	Grasshopper Sparrow	HALO	Yes			Adult	Male
5/21/2015	370276	4614368	New capture	222152927	Grasshopper Sparrow	RARO	Yes			Adult	Male
5/21/2015	370264	4614484	New capture	222152928	Grasshopper Sparrow	GAYK	Yes			Adult	Male
5/21/2015	370329	4614647	New capture	222152929	Grasshopper Sparrow	RAKR	Yes			Adult	Male
5/21/2015	370357	4614715	New capture	222152930	Grasshopper Sparrow	KARR	Yes			Adult	Male
5/21/2015	370445	4614688	New capture	222152931	Grasshopper Sparrow	LAYH	Yes			Adult	Male
5/21/2015	370376	4614617	New capture	222152932	Grasshopper Sparrow	None		Yes	Yes	Adult	Male
5/26/2015	370431	4614638	Recapture	222152931	Grasshopper Sparrow	LAYH	Yes	Yes	Yes	Adult	Male
5/26/2015	370649	4614698	New capture	222152933	Grasshopper Sparrow	LAGH	Yes			Adult	Male
5/26/2015	370781	4614610	New capture	222152934	Grasshopper Sparrow	HAYY	Yes			Adult	Male
5/27/2015	370828	4614730	New capture	222152935	Grasshopper Sparrow	None		Yes	Yes	Adult	Male
5/27/2015	370917	4614694	New capture	222152936	Grasshopper Sparrow	None		Yes	Yes	Adult	Male

Appendix A Banding summary at JBCC (May, 2015)

Capture date	UTMS Easting zone 19	UTMS Northing zone 19	Capture disposition	Band number	Species	Color band combo	Fitted with a geolocator?	Blood sampled?	Feather collected?	Age	Sex
5/27/2015	371007	4614696	New capture	222152937	Grasshopper Sparrow	None		Yes	Yes	Adult	Male
5/27/2015	371004	4614809	New capture	222152938	Grasshopper Sparrow	None		Yes		Adult	Male
5/27/2015	371004	4614809	New capture	222152939	Grasshopper Sparrow	None		Yes		Adult	Male
5/29/2015	369885	4610433	New capture	222152940	Grasshopper Sparrow	None		Yes	Yes	Adult	Male
5/29/2015	369689	4610339	New capture	222152941	Grasshopper Sparrow	None		Yes	Yes	Adult	Male
5/29/2015	369682	4610619	New capture	222152942	Grasshopper Sparrow	None		Yes	Yes	Adult	Male
5/29/2015	369991	4611239	New capture	222152943	Grasshopper Sparrow	None		Yes	Yes	Adult	Male
5/29/2015	369991	4611239	New capture	222152944	Grasshopper Sparrow	None		Yes		Adult	Male

Appendix B: Discovered bird nests at JBCC (May, 2015)

Species	Date discovered	Contents	UTM Easting (Zone 19N)	UTM Northing (Zone 19N)
Savannah Sparrow (*Passerculus sandwichensis*)	18-May-15	4 eggs	371087	4612608

Appendix C: Bird species reported to eBird for JBCC (May, 2015)

Species
Canada Goose (Branta canadensis)
Wild Turkey (Meleagris gallopavo)
Common Loon (Gavia immer)
Great Blue Heron (Ardea herodias)
Turkey Vulture (Cathartes aura)
Osprey (Pandion haliaetus)
Sharp-shinned Hawk (Accipiter striatus)
Cooper's Hawk (Accipiter cooperii)
Red-tailed Hawk (Buteo jamaicensis)
Killdeer (Charadrius vociferus)
Upland Sandpiper (Bartramia longicauda)
Mourning Dove (Zenaida macroura)
Yellow-billed Cuckoo (Coccyzus americanus)
Red-bellied Woodpecker (Melanerpes carolinus)
Northern Flicker (Colaptes auratus)
American Kestrel (Falco sparverius)
Eastern Phoebe (Sayornis phoebe)
Eastern Kingbird (Tyrannus tyrannus)
Red-eyed Vireo (Vireo olivaceus)
Blue Jay (Cyanocitta cristata)
American Crow (Corvus brachyrhynchos)
Fish Crow (Corvus ossifragus)
Horned Lark (Eremophila alpestris)
Tree Swallow (Tachycineta bicolor)
Barn Swallow (Hirundo rustica)
Black-capped Chickadee (Poecile atricapillus)
Red-breasted Nuthatch (Sitta canadensis)
White-breasted Nuthatch (Sitta carolinensis)
Eastern Bluebird (Sialia sialis)
American Robin (Turdus migratorius)
Gray Catbird (Dumetella carolinensis)
Northern Mockingbird (Mimus polyglottos)
European Starling (Sturnus vulgaris)
Ovenbird (Seiurus aurocapilla)
Common Yellowthroat (Geothlypis trichas)
Yellow Warbler (Setophaga petechia)
Pine Warbler (Setophaga pinus)
Prairie Warbler (Setophaga discolor)
Eastern Towhee (Pipilo erythrophthalmus)
Chipping Sparrow (Spizella passerina)
Clay-colored Sparrow (Spizella pallida)
Savannah Sparrow (Passerculus sandwichensis)
Grasshopper Sparrow (Ammodramus savannarum)
Song Sparrow (Melospiza melodia)

Appendix C: Bird species reported to eBird for JBCC (May, 2015)

Species
Scarlet Tanager (Piranga olivacea)
Northern Cardinal (Cardinalis cardinalis)
Indigo Bunting (Passerina cyanea)
Red-winged Blackbird (Agelaius phoeniceus)
Eastern Meadowlark (Sturnella magna)
Brown-headed Cowbird (Molothrus ater)
Baltimore Oriole (Icterus galbula)
House Finch (Haemorhous mexicanus)
American Goldfinch (Spinus tristis)
House Sparrow (Passer domesticus)

Appendix D: Point count summary for JBCC (May, 2015)

Species	Individuals detected	Detection rate (%)
Canada Goose (Branta canadensis)	5	7.1
Wild Turkey (Meleagris gallopavo)	3	7.1
Great Blue Heron (Ardea herodias)	2	7.1
Turkey Vulture (Cathartes aura)	3	3.6
Killdeer (Charadrius vociferus)	8	17.9
Upland Sandpiper (Bartramia longicauda)	9	14.3
Mourning Dove (Zenaida macroura)	4	14.3
Northern Flicker (Colaptes auratus)	10	25.0
American Kestrel (Falco sparverius)	2	7.1
Eastern Phoebe (Sayornis phoebe)	1	3.6
Eastern Kingbird (Tyrannus tyrannus)	5	10.7
Red-eyed Vireo (Vireo olivaceus)	1	3.6
Blue Jay (Cyanocitta cristata)	17	39.3
American Crow (Corvus brachyrhynchos)	42	75.0
Fish Crow (Corvus ossifragus)	1	3.6
Horned Lark (Eremophila alpestris)	3	10.7
Tree Swallow (Tachycineta bicolor)	3	10.7
Black-capped Chickadee (Poecile atricapillus)	17	28.6
White-breasted Nuthatch (Sitta carolinensis)	1	3.6
Eastern Bluebird (Sialia sialis)	6	14.3
American Robin (Turdus migratorius)	14	39.3
Gray Catbird (Dumetella carolinensis)	7	17.9
Northern Mockingbird (Mimus polyglottos)	5	17.9
Ovenbird (Seiurus aurocapilla)	9	25.0
Common Yellowthroat (Geothlypis trichas)	6	21.4
Pine Warbler (Setophaga pinus)	1	3.6
Prairie Warbler (Setophaga discolor)	24	50.0
Eastern Towhee (Pipilo erythrophthalmus)	45	82.1
Chipping Sparrow (Spizella passerina)	21	35.7
Clay-colored Sparrow (Spizella pallida)	7	14.3
Savannah Sparrow (Passerculus sandwichensis)	57	78.6
Grasshopper Sparrow (Ammodramus savannarum)	52	89.3
Song Sparrow (Melospiza melodia)	4	10.7
Northern Cardinal (Cardinalis cardinalis)	6	17.9
Red-winged Blackbird (Agelaius phoeniceus)	13	10.7
Eastern Meadowlark (Sturnella magna)	3	10.7
Baltimore Oriole (Icterus galbula)	3	10.7
American Goldfinch (Spinus tristis)	10	21.4