Habitat Management of Grassland Birds at Westover Air Reserve Base

A Major Qualifying Project submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree in Bachelor of Science in Biology and Biotechnology.

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Grasslands of North America

The grassland biome, a term characterized by terrain predominately made up of grasses and forbs with little to no trees, are seen throughout various parts of the world. Grasslands are commonly referred to as prairies, steppes, savannahs, or pampas, dependent on their global locations and vegetative makeup. Major divisions of grassland biomes include two subcategories: tropical and temperate (Pullen 2004). While tropical grasslands remain at a hot climate year round, hot summers and colder winters categorize temperate grasslands. North America hosts a range of temperate grassland habitats, predominantly abundant in central to western regions (Pullen 2004). Grassland biomes not only provide ecological importance including vital niches to a large variety of grassland species but also a range of recreational and economic functions including water catchments, biodiversity reserves, and potential carbon sinks to alleviate the effects of greenhouse gases (Boval and Dixon 2012). In addition to the ethical reasons managing grassland habitats within North America, the various functions such habitats serve further emphasize their importance in the region.

Grassland habitats have an extensive and dynamic history within North America. Glacial deposits are thought to have caused the introduction of grasslands. Retreating ice from the last glacial period about 10,000 years ago left desolate landscape colonized by wind-dispersed grasses and forbs. However, grasslands before

European settlement in the Northeast region of the United States were likely sparse, mostly maintained by prescribed Native American fires (Litvaitis and Weidman 2011, Askins et. al. 2007). As time progressed and European colonization expanded in the Northeast region, agriculture became prominent. Such human-induced change in landscape promoted more grassland patches as a result of native forest clearings (Natural Heritage and Fisheries Program 2013). In more recent history, grasslands have been created and maintained by natural disturbances such as fires, disease among trees, flooding, and insect damage (Askins et. al. 2007). Currently, human intervention on lands for agricultural use and management practices are primarily responsible for much of the grasslands present. Habitat management techniques such as livestock grazing, mowing, and prescribed burns are responsible for about 355,000 ha (or just under 50%) of the hay fields and pastures providing grassland habitat in New England (Askins et. al. 2007). However, with growing urban expansion, aggressive agricultural approaches, and the decline of natural landscape disturbances, suitable grassland habitats are on the decline (Natural Heritage and Fisheries Program 2013). For similar reasons, the Northeast Upland Habitat Technical Committee states that about 55% of grassland habitat has declined throughout the past 100 years in eastern North America (Covell 2006). Such declines will likely continue to be observed unless action is taken. Grassland habitats within the northeast region must be actively managed in order to restore their presence and prevent the transformation back into forested landscapes for a number of ecological reasons.

History of grassland bird obligates in the Northeast

Avian bird obligates are categorized by their literal “obligation” to grassland niches for habitat and reproduction. These animals have been present in North America in considerable populations prior to European colonization with Native American land clearings and natural disturbances (Norment 2002). Following, a large population of grassland obligates increased from the expansion of suitable habitat with European agricultural landscape changes (Litvaitis and Weidman 2011). However, throughout the late 19th and 20th centuries, as agriculture became less prominent and land began to naturally revert back to forested landscape, suitable grassland habitats started to decline (Litvaitis and Weidman 2011). While the return of forested habitat has shown successful for many forest-dwelling species, it has greatly contributed to the long-term decline of many grassland and shrub land avian obligates (Natural Heritage and Fisheries Program 2013). In addition, growing urban expansion and more aggressive agricultural approaches (such as monocultures less suitable to grassland birds) contributed to habitat losses (Askins et. al. 2007, Litvaitis and Weidman 2011). In fact, since the 1930’s, suitable grassland habitats within New York and New England have declined by about 60% (Norment 2002). The declines of grassland habitats are now of particular concern to a number of avian obligates in the northeast (Clyde 2008). Significant declines are cited in many grassland species over the past 30 years (Normant 2002). Breeding Bird Survey data from 1966 and 2002 showed that 17 grassland bird species showed significant population declines (Askins et. al. 2007). Additionally, data from the USGS Patuxent Wildlife Research Center showed that 67%

of grassland birds in New England and the Mid-Atlantic Coast region showed significant drops in population trends from 1966-2013 (Sauer et. al. 2017). By the early 1990's, no types of birds in the Northeast showed more frequent listings as endangered, threatened, or of special concern than grassland birds (Norment 2002). Such substantial evidence for population declines of grassland birds must be addressed in maintaining avian biodiversity within North America. Not only is a call for management important to the conservation of biodiversity and ecological health within the Northeast, but an ethical stance as well.

Management Techniques of Grasslands For Avian Biodiversity

Restoration and management of grassland habitats is done so in a variety of ways in conjunction with historic practices as well as soil and climatic conditions to support a variety of grassland types. Grassland sites are naturally maintained through frequent disturbances such as flooding, drought, fires, and grazing (Vickery et. al. 1995). Currently, such natural disturbances are particularly rare in the Northeast. Active management strategies are now incorporated in a variety of ways to maintain grassland habitat and the threatened avian biodiversity within them. Most common practices include mowing, grazing, mowing, prescribed fires, and the use of herbicides.

Grazing, for example, is utilized in areas known to support avian species of conservation concern, considerable measures are taken. The Massachusetts Audubon Society suggests light, rotational grazing by livestock in fields supporting threatened grassland birds, keeping approximately 40% of vegetation cover at around 8-12 inches.

At times of the most critical nesting period (June 1st - July 15) or arrival of grassland birds, livestock should be kept off of fields.

Mowing is also a common practice by which grassland management can be achieved in conjunction with grassland obligate species. Mowing is an important management strategy, but must be employed intelligently with timing. Because mowing during grassland bird nesting periods could be detrimental to the young, mowing during this critical period is usually avoided. If mowing during the nesting period must occur, research the New Jersey Audubon Society at Westover Air Reserve Base suggested that mowing at a higher grass height of 7-14 inches led to many nest remaining unharmed (Natural Heritage and Fisheries Program 2013). Outside of the nesting period, however, mowing can be very beneficial to maintaining suitable grassland habitat to these birds and deter forest restoration. Mowing regimes are suggested no earlier than August 1st in order to avoid all possible nesting periods of grassland obligates (Natural Heritage and Fisheries Program 2013). Additionally, the implementation and encouragement for the growth of native warm season grasses can allow for later mowing regimes because of the fact that they tend to mature later than cool season grasses (Natural Heritage and Fisheries Program 2013).

Prescribed burns serves as another useful tool to maintain the presence of grassland habitat in the northeast. Burning will rapidly prevent the buildup of wooded areas as well as remove any dead vegetation and rejuvenating plant growth by the addition of more nutrients to the soil. On large grasslands, burning can be particularly beneficial to birds when rotated to keep the majority of habitat intact while burning a portion. Most grassland birds are known to reoccupy grassland portions within a year or two of the burn (Sandercock et. al. 2015). With consideration for threatened birds in managing grassland habitat, the Massachusetts Audubon society recommends burning in early spring, after snowmelt and before greening and bird nesting periods. Additionally, burning is recommended to occur every 2-6 years with not more than 20-40% burned annually, ideally.

The Upland Sandpiper

One grassland species of particular concern within the northeast region is the *Bartramia longicauda*, also known as the Upland Sandpiper. This species will be one of the primary focuses of project efforts and objectives. The Upland Sandpiper is a grassland shorebird that has a completely terrestrial niche. Tall dense vegetation is preferred for nesting while open areas with shorter grasses are utilized primarily for foraging (Natural Heritage and Fisheries Program 2013). This sandpiper displays many distinctive grassland adaptations such as: ground nesting, flight song, relatively short incubation and nesting periods, and cryptic coloration (Houston et. al 2011). *B. longicauda* are medium-sized (280-320 mm), exhibiting sexual dimorphism in that females are generally larger than males (Houston et. al 2011) However, both genders are quite similar in appearance. Its small dove-like head, thin neck, yellow bill, and long lanky legs distinguish this sandpiper (*Figure 1*).

Figure 1. Upland Sandpiper (*Bartramia longicauda*)

Breeding sites within the United States are largely prevalent in the upper to central Midwest region of the United States and southern Canada, however sporadic and spatially distributed sites are seen among the northeast region of America and up through eastern Canada (Houston et. al. 2011). Breeding ranges also may include parts of Alaska, Utah, Oklahoma, northern Texas, Tennessee, Virginia, and Maryland (State of Connecticut 1997). Breeding occurs largely in the months of mid-April to mid-May in the northeastern region as the birds arrive from their migratory sites predominantly in parts of South America (Houston et. al. 2011). It mainly forages insects such as grasshoppers, crickets, weevils, beetles, ants, spiders, snails, and ground earthworms (NHESP, Upland Sandpiper 2015).

Since the 1800's and early 1900's, considerable conservation threats have been associated with the Upland Sandpiper due to overexploitation in hunting markets and major habitat loss in both North and South America (Natural Heritage and Fisheries Program 2013). This species has been listed as a conservation concern in 24 different states or provinces (Sandercock et. al. 2015). Throughout the United States Upland Sandpipers have faced average populations declines of 0.29% yearly from 1966-2013

(Sauer et. al. 2017). In the eastern regions of the United States and Canada, yearly declines were even greater among the same time period at 3.78%, with a 2.46% yearly decline from 2003-2013 (Sauer et al. 2017). While the species thrives in some of its habitat, such as upper and central North America, they are of conservation concern within the northeast (Houston et. al. 2011). Within the state of Massachusetts, the Upland Sandpiper is currently listed as endangered. Habitat within the state is restricted to open expanses of grassy fields, hay fields, and mown grassy strips within airfields and military bases (NHESP, Upland Sandpiper 2015). Figure 2, adopted from the Natural Heritage and Endangered Species Program (Upland Sandpiper, 2015), shows current habitat of the Upland Sandpiper within the state of Massachusetts. The species continues to serve as a conservation concern within the state, requiring immediate action to preserve its natural presence and habitat within the state of Massachusetts.

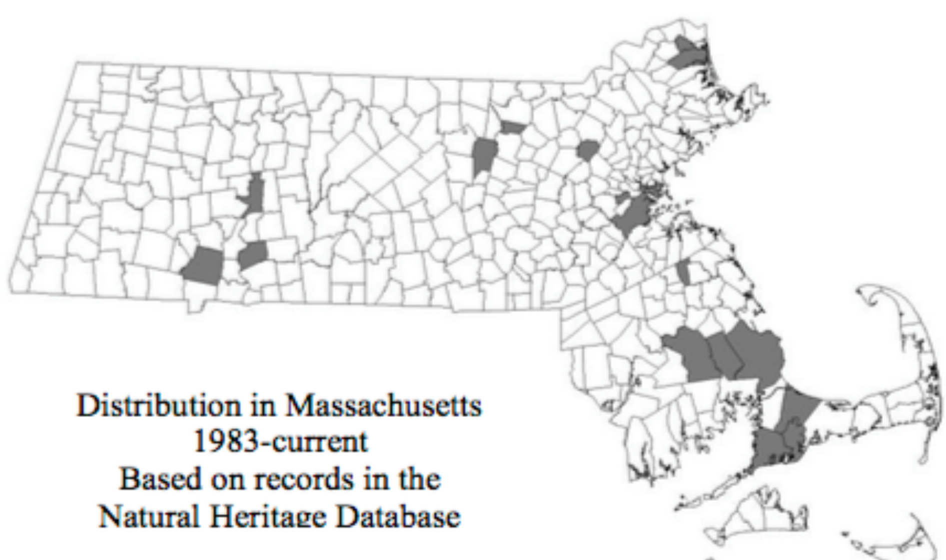

Figure 2. Map of Massachusetts showing the distribution of major *Bartramia longicauda* breeding grounds.

The Grasshopper Sparrow

Another species of conservation concern and focus within project objectives is the Grasshopper Sparrow (*Ammodramus savannarum*). The Grasshopper Sparrow is named for its distinct, cricket-sounding song, consisting of two chips followed by a "tsk tsick tsurrr" (NHESP, Grasshopper Sparrow 2015). The species is small in size (10.8-11.5 cm) with a characteristic unstreaked, cream-buffed breast and yellow-orange lores (Figure 1).

Figure 3. Grasshopper Sparrow (*Ammodramus savannarum*)

Though the Grasshopper Sparrow does exhibit distinct characteristics from other *Ammodramus* sparrows, it is sometimes difficult to distinguish. Within the northeast region of the United States, these sparrows are observed primarily within lush, tall-grass prairies with greater amounts of bare ground than similar species such as the Savannah Sparrow (Vickery et. al. 1996). Breeding sites include all of the midwest and eastern regions of the continental United States, extending west to Idaho (some spotty sites further west), south to southern Texas, and North to the southernmost parts of Canada in Saskatchewan, Ontario, and Quebec. Within the northeast, breeding sites extend east covering all of New York state but only as far north as southern Vermont, New Hampshire, and Maine (Vickery et. al. 1996). Breeding periods occur between the months of April to August where the species later migrates south starting in October to Mexico and southern parts of the US (eBird 2013). Its diet is predominantly insects, such as grasshoppers, in the summer while in the winter Grasshopper Sparrows mainly forage for seeds, mostly panic grass and sedges (Vickery 1996).

Grasshopper Sparrows have faced considerable population declines within the northeastern region of the United States and several other states. Within each state of New England, the Grasshopper Sparrow is listed as either endangered or threatened (Ruth 2015). In the Eastern region of the United States and Canada, Grasshopper Sparrows have faced average yearly declines of 5.38% and 4.02%, from 1993-2003 and 2003-2013, respectively (Sauer et al. 2017). With such massive grassland declines, Grasshopper Sparrow populations are struggling to remain in healthy numbers in the northeast. Additionally, this particular species has been shown to be very area-sensitive, showing a positive correlation in population density with increased patch size (Ruth 2015). The habitat fragmentation and loss of suitable grassland habitats make this species particularly vulnerable in the northeast region. Within the state of Massachusetts, Grasshopper Sparrows have a state status of threatened. Suitable habitat within the state is sparse, but many reside in sandplain grasslands, pastures, hayfields, and airfields characterized by bunch-grasses with a fair amount of bare ground (NHESP, Grasshopper Sparrow 2015). Due to substantial changes in the landscape of Massachusetts such as land development, changes in agricultural practices, and natural succession, Grasshopper Sparrows are currently known to nest at fewer than 20 sites in the state, making them a target species for conservation (NHESP, Grasshopper Sparrow 2015). Figure 4, adopted from the Natural Heritage and Endangered Species Program (Grasshopper Sparrow, 2015), shows current habitat of the Grasshopper Sparrows within the state of Massachusetts.

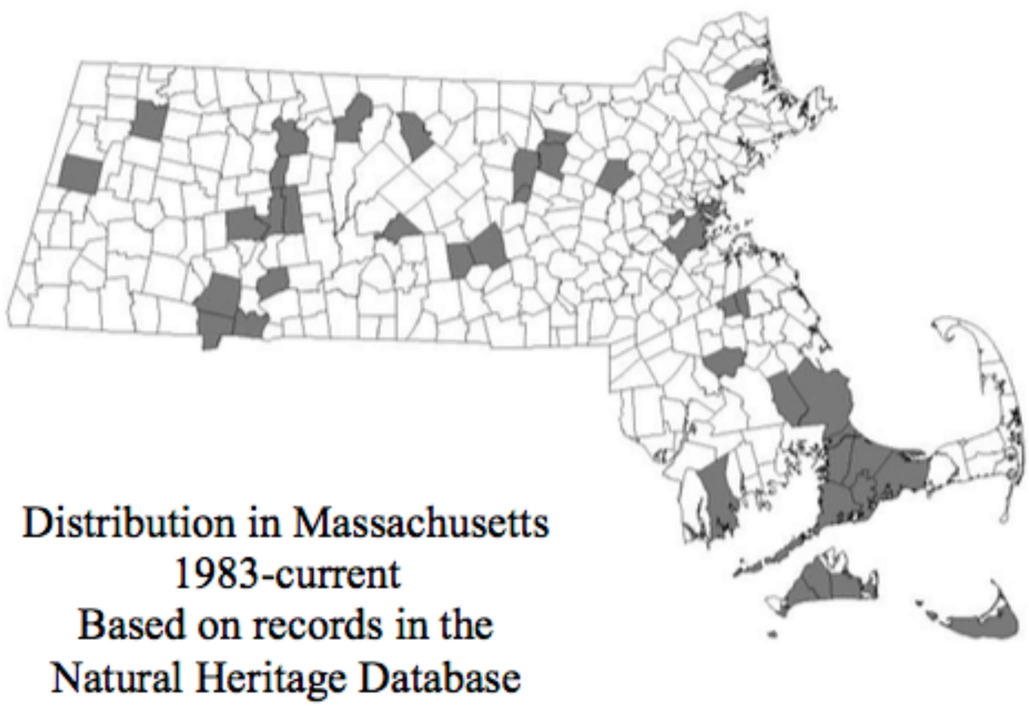

Figure 4. Map of Massachusetts showing the distribution of major *Ammodramus savannarum* breeding grounds.

Other Grassland Species of Focus

Several other grassland obligate bird species will be surveyed within this project including the Bobolink (*Dolichonyx oryzivorus*), Eastern Meadowlark (*Sturnella magna*), and Savannah Sparrow (*Passerculus sandwichensis*). Each of these species faces varying degrees of population declines within the northeast region but all are of conservation concern due to loss of suitable grassland habitat in the region within recent history.

Bobolinks do not have a state or federal listed conservation status, however, they have faced notable declines within the past 30 years in northeastern United States. In New England specifically, data from the USGS Patuxent Wildlife Research Center showed average yearly population declines among the species at 2.48% from 1993-2003, and 2.02% from 2003-2013 (Sauer et al. 2017). On breeding grounds, population declines are mostly attributed to habitat loss and mowing regimes in hayfield nesting sites (NHESP, Bobolink 2015). Additionally, the Massachusetts Audubon Society states that Bobolinks population declines in the region can be attributed to reduction in field diversity, as they prefer a mixture of grasses and wildflowers, rather than pure legume/alfalfa fields for nesting.

Figure 5. Bobolink (*Dolichonyx oryzivorus*)

Eastern Meadowlarks are experiencing similar population declines due to loss of suitable habitat within the region. Breeding bird survey data shows steep declines for

Eastern Meadowlarks within northeastern states, with Massachusetts showing declines of 10.4% from 1966-2002 (NHESP, Eastern Meadowlark 2015). Reasons for such declines are similarly attributed to a reduction in large, unfragmented grassland habitats, as well as hayfield mowing regimes within nesting periods (NHESP, Eastern Meadowlark 2015). Additionally, the Massachusetts Audubon Society claims that loss of field diversity in medium to large sized hayfields may also contribute to loss of nesting grounds because these birds prefer larger fields (at least 15 acres) with mixed vegetation.

Figure 6. Eastern Meadowlark (*Sturnella magna*)

Savannah Sparrows are another species on the decline in the northeast region due to habitat loss. In the New England/Mid-Atlantic Coast region specifically, population declines for Savannah Sparrows averaged about 2.9% yearly from 1966-2013 (Sauer et al. 2017). Numbers are high enough, however, to keep this species off the list of being endangered, threatened, or a species of concern. The Savannah Sparrow is more dynamic many other grassland bird species in that it may tolerate fields of all ages, and areas scattered with saplings, shrubs, and forbs. However, the species is still subject to considerable declines in recent history due to its preference for large, unfragmented fields (20-40 acres) for breeding and early mowing regimes.

Figure 7. Savannah Sparrow (*Passerculus sandwichensis*)

Westover Air Reserve Base

As the suitable grassland habitat within the northeast is on the decline, military and civilian airfields with large grassland expanses will become increasingly important to avian grassland obligates of conservation focus (Tsipoura et. al. 2014). One site of particular importance in relation to grassland obligates within the northeast region and state of Massachusetts is Westover Air Reserve Base. This site hosts a number of avian grassland obligates of conservation concern and remains as one of the best sites for such due to its wide expanses of suitable grassland habitat. In fact, Westover ARB hosts one of the largest contiguous grasslands in New England, supporting the largest breeding populations of Upland Sandpiper and Grasshopper Sparrow in the region (Tsipoura et. al. 2014, Milroy 2007). The base lies in an area of the Connecticut Valley Watershed, with terrain characterized by gently sloping terrain of medium fertile, sandy loams, containing a large grassland area of about 1,200 acres (Tsipoura et. al. 2014, Milroy 2007). Over 100 species of plants are known to make up the grasslands of Westover with large areas dominated mostly by non-native vegetation (Tsipoura et. al. 2014). Each of the species previously listed annually utilize Westover ARB for breeding and nesting grounds throughout the summer.

Bird strike hazards with military aircraft continue to be a threat and must be avoided at all costs on a military base. While personnel and aircraft safety are top priorities, management of grasslands on military airfields in conjunction with threatened avian grassland species continue to be debated issues in terms of management practices. Although not specifically required by the Federal Endangered Species Act, the U.S. Air Force does work closely with the Natural Heritage and Endangered Species Program as well as the Massachusetts Division of Fisheries and Wildlife concerning the management of rare species the base provides habitat to (Milroy 2007). Insofar as management activities do not interfere with base and military operations, conservation measures are taken to continue supporting suitable habitat for such species, while providing safety to aircraft. United States Air Force Installations are required to draft a Bird/Wildlife Aircraft Strike Hazard (BASH) plan in order to ensure preventative measures are enacted to mitigate the risks of collision with aircraft. As such, Westover ARB must maintain a height of 7-14 inches for vegetation in order to discourage granivorous insects and flocking species, as well as predators such as predatory birds, Eastern Coyotes, Red Foxes, and insectivorous bird species (Milroy 2007). All of these species pose threats as high-risk BASH species and are discouraged from habitat close to runways.

Chapter 2:

Habitat Management of Grassland Birds at Westover Air Reserve Base

Abstract

Due to substantial losses of suitable grassland habitat in the Northeast region of North America over the last century, avian grassland obligates have faced considerable declines in population (Natural Heritage and Fisheries Program 2013, Vickery et. al. 1995, Normant 2002). With such declines, military and civilian airfields with large grassland expanses provide very important habitat to avian grassland obligates of conservation focus (Tsipoura et. al. 2014). Westover Air Reserve Base, in Chicopee, Massachusetts, hosts one of the largest expanses of continuous grasslands in New England, making it a site of major conservation focus for grassland birds (Milroy 2007). This project surveyed all grassland fields of the base in the summer of 2016 and compared archived survey data in order to determine the effects of grassland management practices on the distribution and abundance of five grassland birds. Survey results showed a statistically significant positive correlation among four of the species totals from the years of 2007-2016 and general increase in most species following a prescribed burn management treatment. Additionally, each species showed positive trends in abundance and Shannon diversity in relation to unit size. Results from survey data allowed for suggestions in management practices the base can implement to

effectively maintain grassland bird populations while safely continuing airfield operations.

Introduction

Grassland habitats have historically been present in the Northeast region of the United States, upheld by frequent natural disturbances such as fires, tree disease, flooding, and insect damage (Askins et. al. 2007). In recent history, urban expansion, aggressive agricultural approaches, regrowth of forested areas, and declines in natural disturbances has diminished much of the grassland habitat previously in the region (Natural Heritage and Fisheries Program 2013). Since the 1930's, suitable grassland habitats within New York and New England have declined by about 60% (Norment 2002). As a result, species that require grassland habitat are on the decline in the region. Grassland obligate birds are particularly vulnerable to such dramatic landscape changes. In fact grassland avian species have experienced the steepest and more widespread declines in population than all other groups of birds in North America over the past 25 years (Vickery et. al. 1995). As suitable grassland habitat diminishes, military and civilian airfields with large expanses of grassland will become increasingly important habitat for grassland obligate birds of conservation concern in the northeast (Tsipoura et. al. 2014). This study focused on one site in particular, Westover Air Reserve Base (ARB), in Chicopee, Massachusetts. Westover ARB holds one of the largest continuous grasslands in New England and supports several grassland birds of conservation concern in the state of Massachusetts (Tsipoura et. al. 2014). Research focused primarily on two rare grassland species known to annually occupy Westover ARB, the Upland Sandpiper (*Bartramia longicauda*) and Grasshopper Sparrow (*Ammodramus savannarum*). The Upland Sandpiper is a state-listed endangered bird while the Grasshopper Sparrow is state-listed as threatened. These two species in particular, as well as several other species including the Bobolink (*Dolichonyx oryzivorus*), Savannah Sparrow (*Passerculus sandwichensis*), and Eastern Meadowlark (*Sturnella magna*) were involved in research efforts.

Though Westover ARB provides suitable habitat for rare grassland birds in the state of Massachusetts, the primary goal of the base is to safely ensure military training and operations will not be disrupted (Westover ARB 2016). Westover Air Reserve Base must actively manage grasslands adjacent to runways in order to comply with Air Force regulations for grass height standard 7-14 inches (17.78-35.56 cm) to minimize Bird/Wildlife Aircraft Strike Hazards (BASH) to ensure safety of aircraft and personnel (Westover ARB 2016). Management such as mowing and prescribed burns is used regularly in such attempts to deter high BASH-risk species from occupying the base and maintain grassland height in accordance with Air Force policy. However, management practices can prove detrimental to state-listed grassland birds. The United States Air Force policy works to conserve state-listed rare species when practical (Milroy 2007). Additionally, under the Massachusetts Endangered Species Act, it is illegal to kill, harm, harass, or disrupt the feeding, breeding, or migration behavior of state-listed rare animals (Milroy 2007). The seemingly contradicting agendas can make it a challenge for the base to safely continue aircraft operations while simultaneously protecting the rare state-listed birds by which such habitat is so important to in the state.

The best ways to manage grasslands adjacent to runways is currently a debated topic (Milroy 2007). Analysis of our most recent, as well as documented historical surveys, of state-listed rare grassland birds at Westover ARB will be compared to management strategies practiced at the base over time. In doing so, this study aims to generate suggestions to ensure base activities are safe from BASH hazards while simultaneously protecting the state-listed grassland birds the base provides important habitat to. Through analysis of most recent and historical survey data, in conjunction with base grassland management procedure, a practical and optimal solution will be suggested for the continuous compliance of Air Force regulations to meet the needs of these threatened and endangered grassland avian obligates. With survey data obtained from 5 years from 2007-2016, I hypothesize that larger areas (units, *see methods*) of grassland with less fragmented landscapes and units management by prescribed burns will ultimately produce increased counts of rare grassland birds over time. Such activity could allow for the increase of total numbers of rare grassland birds at Westover Air Reserve Base, providing critical habitat for endangered grassland birds in the State of Massachusetts. Management activity analyzed in this study includes use of prescribed fires and unit size.

Methods

Study Area and Data Collection

We surveyed all grassland fields of Westover Air Reserve Base over the course of three days on the mornings of 9, 10, and 16 June, 2016, from 6 am-10 am each day.

Weather data on the 9th of June ranged from 56-72°F, 3-13 mph winds, and clear to partly cloudy skies. Weather data on the 10th of June ranged from 62-71°F, 8-10.5 mph winds, and clear to mostly cloudy skies. On the 16th of June weather ranged from 52-74°F, 0-4.6 mph winds, and fog to overcast skies.

The entireties of the grassland fields within the base were separated into 26 units designated by Westover staff. Units were categorized by the year prescribed burns occurred or will occur. Each unit of grassland separated by runways and roads were surveyed individually by groups of 3-4 people walking in parallel transects. Individuals were spaced ranging from 25-75 meters apart depending on the width of the unit. The majority of units were rectangular in shape. Units smaller in width were walked through once from a start point of the unit and ended at the far end. Units larger in width were walked through on one half and we would rotate at the end of the unit to cover the other half and end the survey back at the starting point of the survey. Unit sizes ranged from 9.44 – 117.77 acres in a variety of shapes. Each surveyor carried binoculars to aid in visual identification. State ornithologist, Dr. Andrew Vitz, of the Massachusetts Division of Fisheries and Wildlife was positioned in the middle of surveyors with 1-2 helpers on either side of him when conducting species counts in parallel transects. Dr. Vitz controlled the recording of birds on one large map of the grasslands of the base. These unit designations are referred to throughout the results and discussion sections of this report for analysis of species data. Due to privacy concerns by Westover staff, the aerial view of the base showing grassland unit designations could not be included in this report.

In addition to surveying in the summer of 2016, past data on surveys conducted by staff members of the Massachusetts Division of Fisheries and Wildlife was collected. Archived maps documented counts of all grassland species from the breeding seasons of 2007, 2009, 2012, and 2015 for a total of five years of data including the data we surveyed in 2016. Counts for each species in respective grassland units were obtained by manual counting from maps of each year and compiled. Archived map data was collected in essentially the same way as our data collection, indicating symbolically on a location on the map where an individual was located and observed.

Analyses

Total Species Abundances

Species total abundances among the entire base and by specific units were plotted over time for analyses of trends. In order to examine the relationship between species trends over time a correlation test was conducted in Microsoft Excel 2016 for the totals plot, comparing each of the five species to one another with an R-value. The R-value for this research was determined to be statistically significant if >0.70.

Burn Year

Additionally, species abundances both pre and post burn year were averaged among all units and survey years for each species by grouping units with the same burn years. To visualize data, a plot was created showing the trends of each species total counts before and after the year of burn. I tested for differences in average abundances before and after a prescribed burn using a t-test for equal variances. P-values were obtained from the t-test in order to test the null hypothesis that species abundance would show no significant change following a burn year for each species. I used the P-value quantity ($P<0.05$) to determine if the null hypothesis could be rejected.

Shannon Diversity

Mean Shannon diversity was analyzed for each unit by averaging all survey year counts for each species in order to generate the relative diversities among each unit. Shannon diversity values were calculated from the averaged counts of all survey years with the formula:

$$H = -\sum_{i=1}^{S} p_i \ln{(p_i)}$$

$$where; H = Shannons\ diversity\ index$$

$$S = total\ number\ of\ species\ in\ the\ community,$$

$$p_i = proportion\ of\ S\ made\ up\ of\ i^{th}\ species$$

p_i was calculated first for each unit by dividing the count for each species for a given year by the total sum of all year counts for that species. Next, $p_i \ln(p_i)$ was calculated based on the obtained p_i values. $p_i \ln(p_i)$ values were then averaged among all species in a given survey year and all survey years were averaged for data Shannon diversity indices per unit. Standard deviation bars were acquired based on Shannon diversity indices for all years in a given unit.

Unit Size

The final data analyses conducted included the evaluation of unit size to both species abundances and Shannon diversity indices per unit. Unit size data were plotted in the form of acres and based on a map the staff of Westover ARB supplied. I plotted both species abundance per unit and Shannon diversity per unit against unit size with trend lines in order to assess the relationship between unit size and these two dependent variables. F and P-values were obtained for each data set through linear regression analysis in Microsoft Excel 2016. Again, significant P-values were set at the standard ($P<0.05$) for rejection of the null hypothesis, that species abundances and Shannon diversity had no association with unit size.

Results

We surveyed the entirety of grassland fields of Westover Air Reserve base within the breeding season on three separate mornings from June 9-16, 2016 in order to obtain counts of individual avian grassland obligates including Upland Sandpiper, Grasshopper Sparrow, Bobolink, Eastern Meadowlark, and Savannah Sparrow. Archived maps from the Massachusetts Division of Fisheries and Wildlife were also analyzed for respective species counts from surveys conducted in the breeding seasons of 2007, 2009, 2012, and 2015. Total counts for each species among the five years of data collected can be seen in *Table 1* and graphed in *Figure 8*.

	2007	2009	2012	2015	2016	Average	Standard Deviation
US	98	57	53	106	86	80	23.9
GS	186	131	216	177	156	173.2	32.0
EM	104	89	67	95	83	87.6	13.9
BB	78	51	80	135	104	89.6	31.6
SS	84	72	62	116	118	90.4	25.5

Table 1. Total number of individuals counted of all units from surveyed years for five target species (US: Upland Sandpiper; GS: Grasshopper Sparrow; EM: Eastern Meadowlark; BB: Bobolink; SS: Savannah Sparrow).

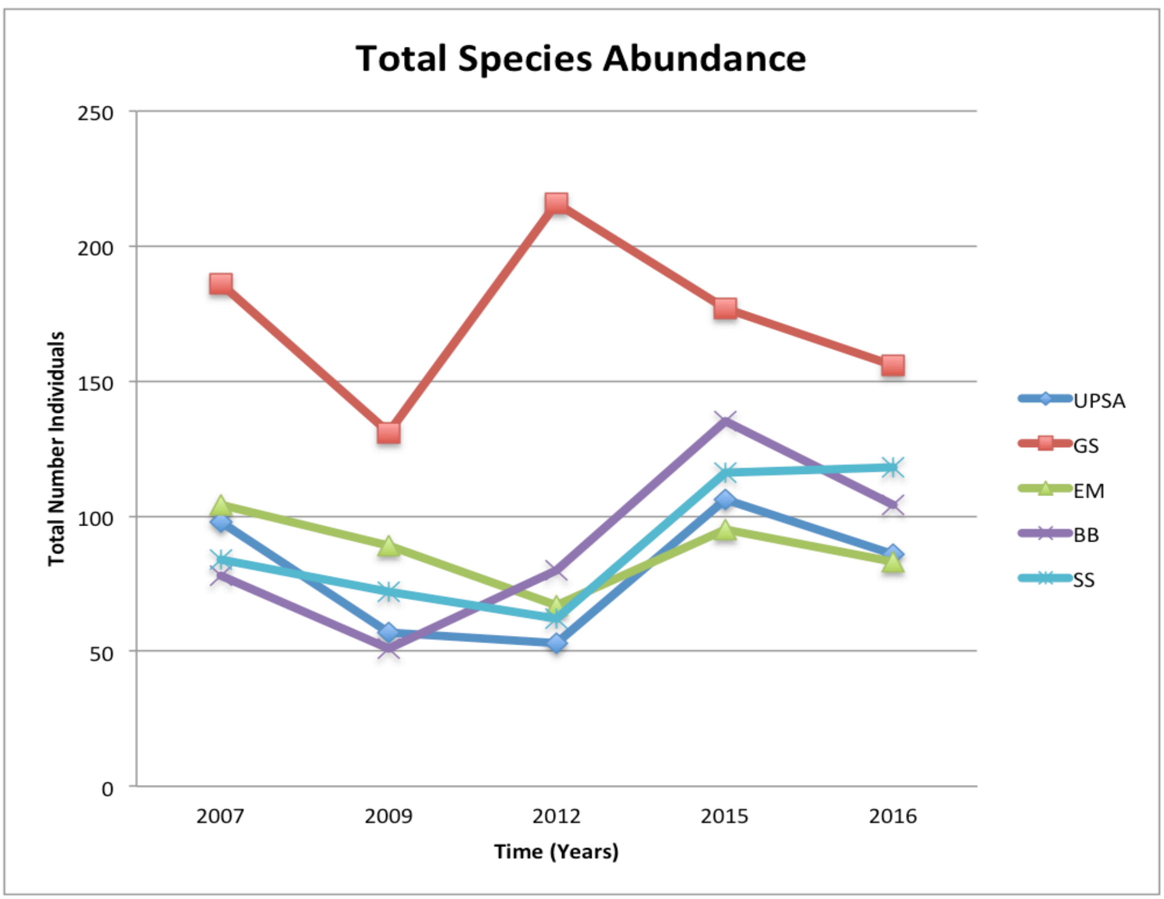

Figure 8. Total number of individuals counted of all units from surveyed years for five target species.

Total counts of Grasshopper Sparrows were much higher than all other species throughout all years with an average of 173.2 (31.96 SD, standard deviation). Averages for the other four species surveyed including Upland Sandpiper, Eastern Meadowlark, Bobolink, and Savannah Sparrow were very similar at 80 (23.95, SD), 87.6 (13.89, SD), 89.6 (31.56, SD), 90.4 (25.51, SD), respectively. General trends showed similar inclines and declines among all species at relative time points. Abundance of Upland Sandpiper showed positive correlation with Eastern Meadowlark ($r = 0.74$), Bobolink ($r = 0.73$), and Savannah Sparrow ($r = 0.78$). Bobolink abundance was also positively correlated with Savannah Sparrow ($r = 0.81$). See Appendix A, *Table A.1*.

When examining individual units by the date of prescribed burns, many of the unit distribution trends were quite random. However, a few units showed interesting patterns in correlation with prescribed burns for individual species. *Figures 9-11* show select units with interesting trends in bird populations pertaining to burn years. Units 16 and 21 showed similar trends in that all species increased following a burn with a drop in Upland Sandpiper 3 years post burn. Unit 2 showed an increase in all species with no declines. Data for population trends in all other units can be seen in *Table B.1* Appendix B.

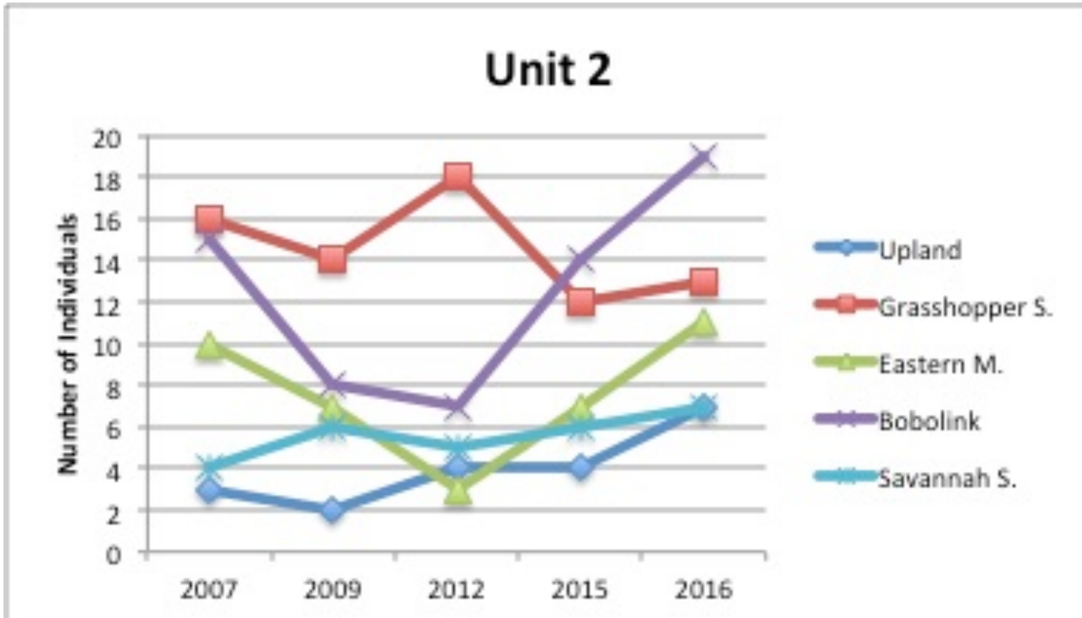

Figure 9. Total number of individuals counted by species for Unit 2. (Burn Year: 2014)

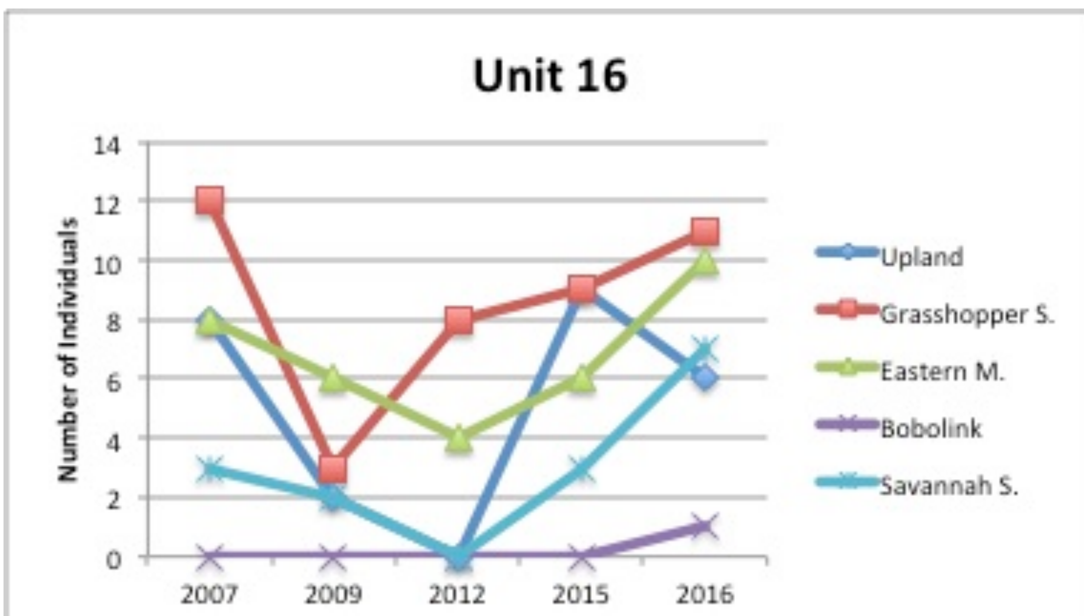

Figure 10. Total number of individuals counted by species for Unit 16. (Burn Year: 2013)

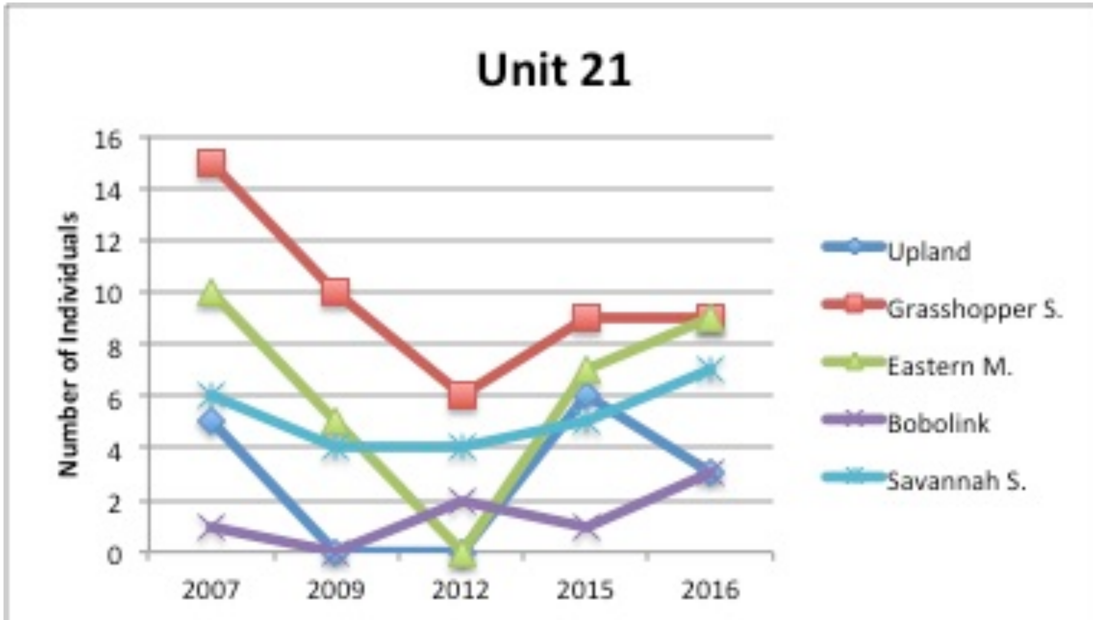

Figure 11. Total number of individuals counted by species for Unit 21.
(Burn Year: 2013)

Statistically significant increases in abundances (see *Figure* 12) were observed among Upland Sandpiper (P = 0.031), Bobolink (P = 0.030), and Savannah Sparrow (P < 0.001). Insignificant trends were observed for Eastern Meadowlark (P = 0.430) and Grasshopper Sparrow (P = 0.148). Burn years for each unit can be seen in *Table C.1* of Appendix C, as well as a plot of species trends pre and post burn per year in *Figure C.1*.

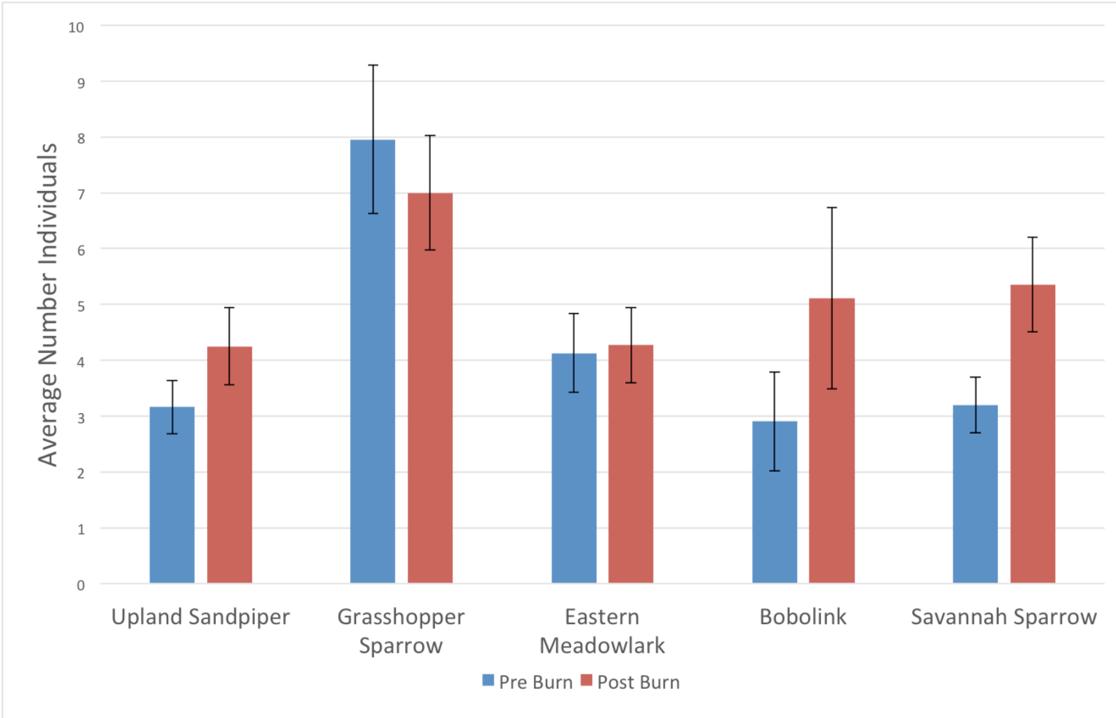

Figure 12. Pre and post burn counts averaged across all units and years for each species with standard error bars

Mean Shannon diversity values (*Figure 13*) was highest in units 1 (Shannon Diversity (H) = 1.44, Standard Deviation (SD) = 0.11), 2 (H = 1.47, SD = 0.06), 3 (H = 1.43, SD = 0.09), 8 (H = 1.35, SD = 0.15), 10 (H = 1.49, SD = 0.11), 12 (H = 1.49, SD = 0.18), 24 (H = 1.41, SD = 0.08), and 25 (1.31, SD = 0.08). Year of burn from these units ranged from 2013-2016 including some units with no burn. No year of burn significantly outnumbered others. Lowest diversity was observed in units 5 (H = 0.22, SE = 0.49), 17 (H = 0.26, SE = 0.37), 20 (H = 0.39, SE = 0.36), and 23 (H = 0.57, SE = 0.55) where burn year showed no pattern.

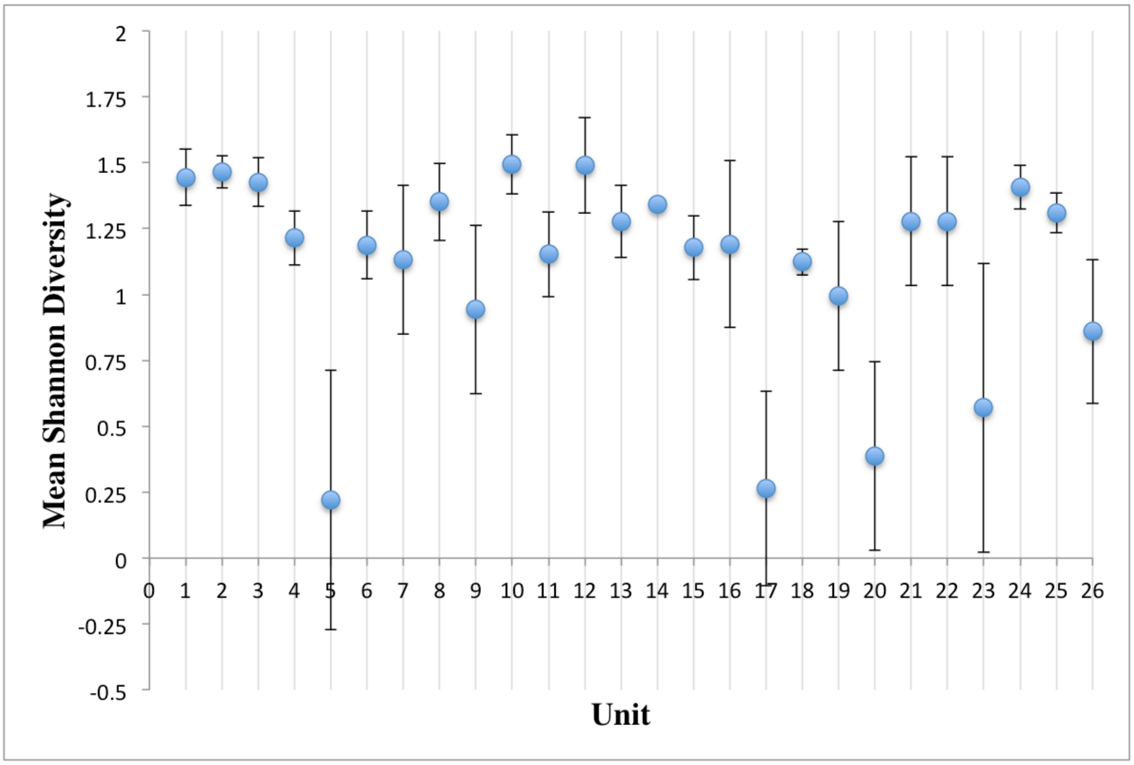

Figure 13. Mean Shannon Diversity Index (H) averaged among all years by unit with standard deviation bars

All species showed statistically positive correlations with unit size through linear regression analysis: US (F = 6.78, P = 0.016), GS (F = 42.32, P < 0.001), EM (F = 14.57, P < 0.001), BB (F = 12.37, P = 0.002), SS (F = 19.90, P = 0.002). Table D.1 of Appendix D shows raw data of species abundances per unit averaged among all years as well as mean Shannon Diversity data from (*Figure 15*).

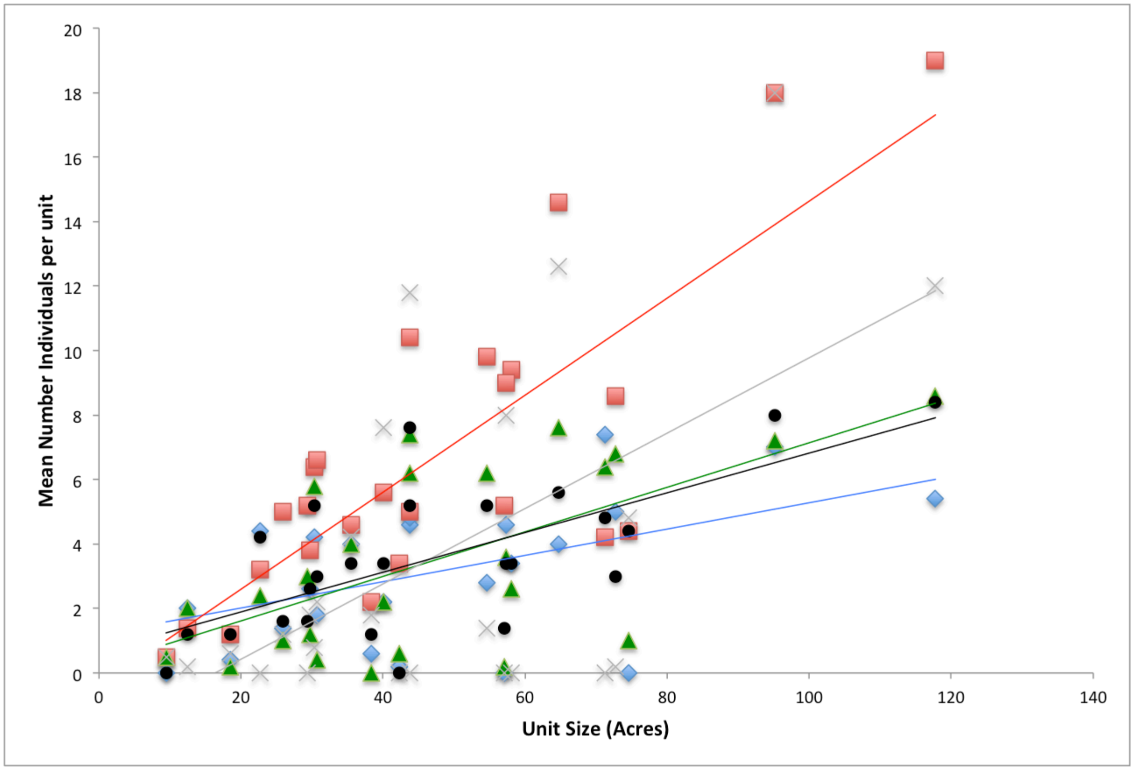

Figure 14. Abundances for each species per unit averaged among all years with linear trend lines (US = blue diamond, GS = red square, EM = green triangle, BB =

Results of Shannon diversity against unit size (as seen in *Figure 15*) showed a near-statistically significant positive relationship among the five species surveyed across all survey years (F = 3.79, P = 0.064), with a trend line slope of y = 0.0054x + 0.8688 ($R^2 = 0.141$).

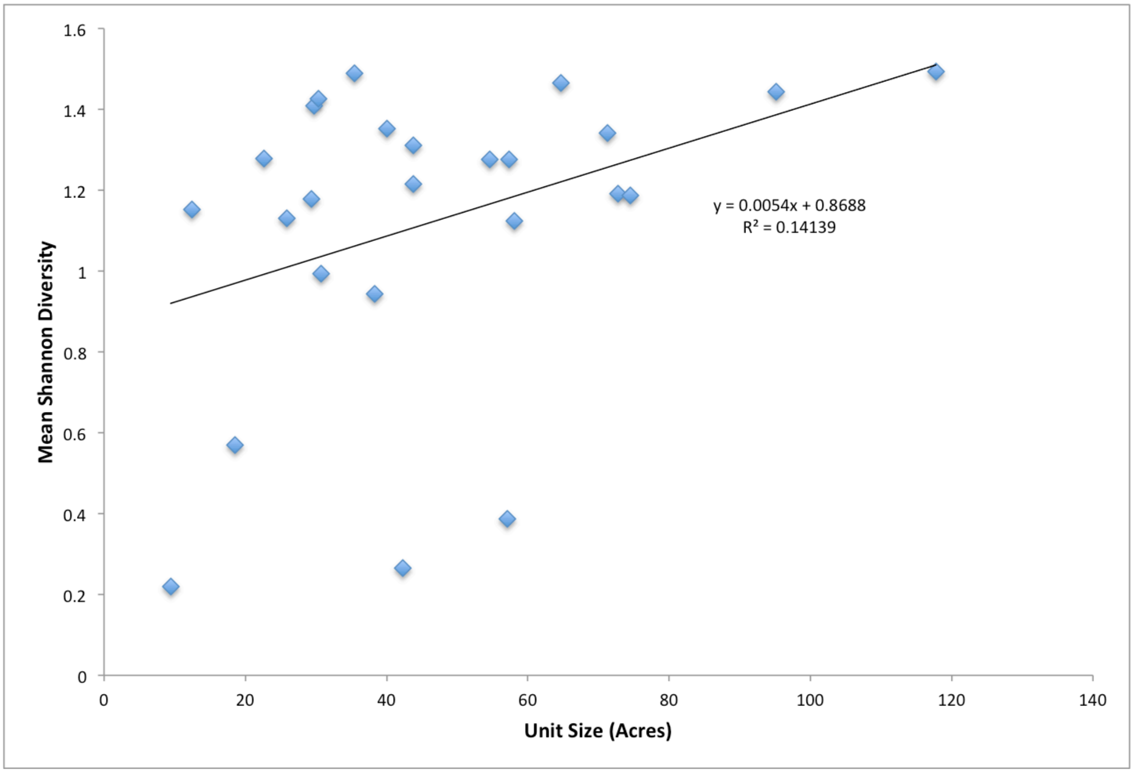

Figure 15. Shannon Diversity per unit averaged among all years

Discussion

Our research surveyed the entirety of grassland fields of Westover Air Reserve Base in early June of 2016 and compiled archived data from the years of 2007, 2009, 2012 for five grassland birds of conservation concern, including the Upland Sandpiper, Grasshopper Sparrow, Eastern Meadowlark, Bobolink, and Savannah Sparrow. Grassland management techniques utilized by the base staff was compared with species diversity indices and numbers of individual species abundances in an effort to come up with recommendations for management practices. The goal of the research was to optimize the coherence of base operations in conjunction with the remaining populations of rare grassland birds the habitat of the base provides. It was hypothesized that units with grassland management activity would ultimately produce increased counts of rare grassland birds over time. Such activity could allow for the increase of total numbers of rare grassland birds at Westover Air Reserve Base, providing critical habitat for endangered avian obligates in the State of Massachusetts. Management activity of the base includes yearly prescribed fires of particular units, mowing of all grassland units to maintain a height of 7-14 inches year-round, and unit size allocations.

Total species abundances throughout the entire base (*Figure* 8) showed interesting correlations among grassland species as well as a general increase in total abundance for all species since 2012. Since Upland Sandpiper showed the most statistically significant positive correlations with Eastern Meadowlark, Savannah Sparrow, and Bobolink, results suggest Upland Sandpiper may be a key indicator species for all species surveyed, besides Grasshopper Sparrow. Because Grasshopper Sparrow population totals were so much more abundant than the rest of the birds, this species would likely require individual attention to its needs when considering management while the four other species should continue to show similar trends to one another. Though Grasshopper Sparrow was not directly correlated with the other four species in abundance trends, this does not imply that it is not a good indicator species pertaining to the health of the grassland habitat at Westover. Because Grasshopper Sparrows are known to be quite sensitive to disturbances such as grazing, haying, and fragmentation, its much higher total abundances than all of the other species can suggest that the grassland habitat currently at the base is suitable for other sensitive grassland species (Elliot 2016). Additionally, Grasshopper Sparrow is known to occupy similar litter and vegetative characteristics as Savannah Sparrow and Eastern Meadowlark, showing a possible specific indicator to these two species (Wiens 1969).

Three individual units were also plotted and analyzed due to the interesting trends in when the year of the units prescribed burn was taken into consideration. For unit 2 (burn year 2014), all species showed an increase in numbers after the prescribed burn occurred, except for Upland Sandpiper showing a drop. However, in units 16 and 21 (burn year 2013), all species showed a slight rise in counts post burn, in the next survey year. The data from these example units showed some consistency with pre and post burn trends observed from summing all units of each survey year (*Figure 12*). All species showed an in increase in base population counts post burn, excluding Grasshopper Sparrow. Grasshopper Sparrow was in fact the only species to show a decrease in numbers on average following a prescribed burn. This result for Grasshopper Sparrows specifically is surprising due to the fact that only short periods of time is needed for this species to reoccupy a burned site and in one study Grasshopper Sparrows were six times more likely to be found in transects burned within the last year (Debinski et. al. 2011, Butler et. al. 2009). Upland Sandpiper however, are known to reoccupy recently burned sites as they tend to select sites with recent disturbances and burns for a number of reasons including easier foraging and greater abundances of herbivorous insects (Sandercock 2015). These data suggest that prescribed burns as a management technique employed by the base may serve as a useful tool when applied periodically to drive up numbers of most of the species of interest. With that being said, it is suggested that one should approach the data with slight caution, as standard deviation values for data were excessively high in some cases. Although, the great diversity in unit sizes may have a major factor in the reason why standard deviations were calculated to be so high based off of the average value, for the reason that unit abundances tend to be associated with their sizes for many species. Additionally, burns were conducted prior to 2013, to which I did not have knowledge of when compiling and analyzing data. These prior burns could have had some influence on my designations of pre and post burn categories and skewed interpretations of the influence from prescribed burns. This statement holds true for all data and analyses related to prescribed burns from the results obtained.

Shannon Diversity was calculated by unit and summed for all years in order to quantify the relative species diversity differences between units (*Figure 13*). Data indicated that the year of prescribed burn did not have a significant effect on diversity of species among units due to the fact that no burn year significantly outnumbered others in relation to increased or decreased Shannon diversity indices. From the five years surveyed, prescribed burns ranged from 2013-2016, with no burns beforehand. Based on the results obtained, units with 3 years of recovery post burn did not show any statistically greater or lesser diversity indices than units that only had one year of post burn recovery. Therefore, it is recommended that if species diversity or the five grassland species on the base is desired then time between burn intervals need not to be considered. Essentially, selection of unit burn years and intervals should be based solely on specific species management and base funding.

Because diversity was seemingly unchanged based on burn year, unit size was considered as a potential factor to differences observed in diversity. Results strongly suggest that unit size is an important factor to diversity indices and that with larger unit acreage also comes increased species diversity among the five grassland species surveyed. Similar to Shannon diversity's correlation with unit size, abundance for each species individually showed strongly convincing results for every species. Grasshopper Sparrow showed the greatest trend line slope followed by Bobolink, Eastern Meadowlark, Savannah Sparrow, and Upland Sandpiper, respectively. Though these results may seem obvious, it does importantly confirm that increasing unit size will likely drive up population numbers for every species. However, obtained results were expected as each of these species has shown positive associations with patch area in both occurrence and density (Bakker 2009). These results provide important considerations in future management strategies for the base. For example the base may consider creating landscape that is less fragmented in order to drive up population numbers. Due to the BASH concern, it may be best for less fragmented units to be positioned towards the outer grasslands, with more fragmented grasslands more towards runways in order to lessen numbers of species closer to runways. For Grasshopper Sparrow especially, which was seemingly uncorrelated with the other four species, increasing patch size may especially be the best option for increasing their numbers. This is because patch size may have an important factor in nest success of Grasshopper Sparrows, as smaller patches tend to have larger failure rates due to edge-associated predation (Debinski et. al. 2011).

Although Westover Air Reserve Base continues to operate its airfields seeking to mitigate BASH risks from grassland and forest birds, there is an important and ongoing need to conserve the populations of threatened and endangered species both by federal law moral considerations. The research conducted in this project provides essential management recommendations that should be considered by the base in order to help maintain and increase populations of the grassland species of conservation concern surveyed. Though this study has taken several management variables into consideration there was some potential for ambiguity in results. For instance, as previously mentioned, I was unaware of several prescribed burns that occurred in some units before the year of 2013, which was not included in results and analyses. Additionally, it came to my knowledge late in the project that herbicides were used in different regions of the grasslands of Westover, which could serve as a potential variable for species abundances and site selections. Finally, the airfield operations, which occur adjacent to grassland fields, cause obvious disturbances to nearby wildlife. Teach of these factors was not considered in analysis of the results obtained.

I am hopeful that surveys of this important grassland site in the State of Massachusetts continue to be conducted in years to come. For future research, I suggest consideration of the many variables mentioned above, to serve as analyses tools in species abundance and distribution exploration. Additionally, vegetation surveying of each unit might be useful in explaining some of the randomness I observed for species trends in many of the units.

It is my hope that practical efforts will be made by base staff in order to safely conduct airfield operations while simultaneously making conscious management decisions to promote the longevity of the populations of rare grassland birds in the Northeast region.

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Appendix

Appendix A

	UPSA	GS	EM	BB	SS
UPSA	1				
GS	0.013390459	1			
EM	0.739800944	-0.351261785	1		
BB	0.729267444	0.246402076	0.127316772	1	
SS	0.779960164	-0.275438271	0.364741539	0.812440758	1

Table A.1. Correlation table showing R-value among five tested species

Appendix B

Unit	Species	2007	2009	2012	2015	2016
	Upland	9	4	5	12	5
	Grasshopper	29	8	20	21	12
	Eastern M.	13	8	5	6	4
	Bobolink	15	9	18	29	19
1	**Savannah S.**	0	9	5	13	13
	Upland	3	2	4	4	7
	Grasshopper	16	14	18	12	13
	Eastern M.	10	7	3	7	11
	Bobolink	15	8	7	14	19
2	**Savannah S.**	4	6	5	6	7
	Upland	9	2	1	5	4
	Grasshopper	8	6	4	7	7
	Eastern M.	8	6	4	7	4
	Bobolink	1	1	0	1	1
3	**Savannah S.**	5	5	2	8	6
	Upland	5	2	5	2	9
	Grasshopper	16	8	14	5	9
	Eastern M.	10	4	5	5	7
	Bobolink	14	9	10	18	8
4	**Savannah S.**	8	7	5	3	3
	Upland	0	0	0	*5 not surveye	0
	Grasshopper	0	0	2	*5 not surveye	0
	Eastern M.	0	0	2	*5 not surveye	0
	Bobolink	0	0	2	*5 not surveye	0
5	**Savannah S.**	0	0	0	*5 not surveye	0
	Upland	0	0	0	0	0
	Grasshopper	2	2	4	9	5
	Eastern M.	0	1	2	0	2
	Bobolink	1	2	2	8	11
6	**Savannah S.**	1	1	1	14	5
	Upland	4	1	0	0	2
	Grasshopper	5	2	6	6	6
	Eastern M.	1	1	1	0	2
	Bobolink	0	1	2	3	0
7	**Savannah S.**	0	2	0	3	3
	Upland	2	1	1	7	0
	Grasshopper	5	9	6	3	5
	Eastern M.	0	4	4	2	1
	Bobolink	3	5	11	8	11
8	**Savannah S.**	3	3	4	4	3
	Upland	0	1	0	0	2
	Grasshopper	4	3	2	1	1
	Eastern M.	0	0	0	0	0
	Bobolink	3	0	3	1	2
9	**Savannah S.**	0	0	2	2	2

10	**Upland**	7	5	5	5	5
	Grasshopper	21	9	36	17	12
	Eastern M.	9	9	9	9	7
	Bobolink	9	6	13	23	9
	Savannah S.	9	6	5	12	10
11	**Upland**	5	2	1	2	0
	Grasshopper	1	0	3	2	1
	Eastern M.	1	3	3	2	1
	Bobolink	1	0	0	0	0
	Savannah S.	0	1	1	2	2
12	**Upland**	7	3	1	5	4
	Grasshopper	3	4	5	8	3
	Eastern M.	7	3	0	8	2
	Bobolink	6	3	3	6	3
	Savannah S.	5	1	1	6	4
13	**Upland**	7	4	3	5	3
	Grasshopper	3	5	3	4	1
	Eastern M.	1	3	3	4	1
	Bobolink	0	0	0	0	0
	Savannah S.	3	4	4	3	7
14	**Upland**	5	8	7	13	4
	Grasshopper	4	4	4	7	2
	Eastern M.	8	7	5	9	3
	Bobolink	0	0	0	0	0
	Savannah S.	8	3	5	6	2
15	**Upland**	2	3	4	4	13
	Grasshopper	6	5	1	4	10
	Eastern M.	1	3	2	6	3
	Bobolink	0	0	0	0	0
	Savannah S.	1	0	1	4	2
16	**Upland**	8	2	0	9	6
	Grasshopper	12	3	8	9	11
	Eastern M.	8	6	4	6	10
	Bobolink	0	0	0	0	1
	Savannah S.	3	2	0	3	7
17	**Upland**	0	0	1	0	0
	Grasshopper	1	2	8	3	3
	Eastern M.	0	0	2	0	1
	Bobolink	0	0	0	0	0
	Savannah S.	0	0	0	0	0
18	**Upland**	1	4	6	4	2
	Grasshopper	4	8	14	8	13
	Eastern M.	1	5	2	3	2
	Bobolink	0	0	0	0	0
	Savannah S.	6	0	4	1	6

19	Upland	1	1	1	6	0
	Grasshopper	7	2	11	8	5
	Eastern M.	0	0	0	1	1
	Bobolink	0	0	2	9	0
	Savannah S.	5	2	0	3	5
20	Upland	0	0	0	0	0
	Grasshopper	6	0	7	9	4
	Eastern M.	0	0	1	0	0
	Bobolink	0	0	0	0	0
	Savannah S.	2	0	1	0	4
21	Upland	5	0	0	6	3
	Grasshopper	15	10	6	9	9
	Eastern M.	10	5	0	7	9
	Bobolink	1	0	2	1	3
	Savannah S.	6	4	4	5	7
22	Upland	10	2	2	6	3
	Grasshopper	7	9	16	7	6
	Eastern M.	4	4	3	4	3
	Bobolink	6	4	4	12	14
	Savannah S.	3	2	4	4	4
23	Upland	0	0	0	2	0
	Grasshopper	0	3	1	0	2
	Eastern M.	1	0	0	0	0
	Bobolink	1	0	0	0	2
	Savannah S.	1	2	0	0	3
24	Upland	1	3	3	2	4
	Grasshopper	4	1	4	7	3
	Eastern M.	1	1	1	1	2
	Bobolink	2	3	1	2	1
	Savannah S.	4	4	3	2	0
25	Upland	6	5	1	6	6
	Grasshopper	1	7	5	5	7
	Eastern M.	10	9	5	7	6
	Bobolink	0	0	0	0	0
	Savannah S.	6	8	5	8	11
26	Upland	1	2	2	1	4
	Grasshopper	6	7	8	5	6
	Eastern M.	0	0	1	1	1
	Bobolink	0	0	0	0	0
	Savannah S.	1	0	0	1	2

Table B.1. Raw survey data for each species by unit and year

Appendix C

Year Burned	2013			2014					
Unit	10	16	21	2	5	6	9	15	23
US pre avg.	5.7	3.3	1.7	3	0	0	0.3	3	0
US post avg.	5	7.5	4.5	5.5	0	0	1	8.5	1
GS pre avg.	22	7.7	10.3	16	0.7	2.7	3	4	1.3
GS post avg.	14.5	10	9	12.5	0	7	1	7	1
EM pre avg.	9	6	5	6.7	0.7	1	0	2	0.3
EM post avg.	8	8	8	9	0	1	0	4.5	0
BB pre avg.	9.3	0	1	10	0.7	1.7	2	0	0.3
BB post avg.	16	0.5	2	16.5	0	9.5	1.5	0	1
SS pre avg.	6.7	1.7	4.7	5	0	1	0.7	0.7	1
SS post avg.	11	5	6	6.5	0	9.5	2	3	1.5

Year Burned	2015				2016						
Unit	1	13	14	22	3	7	11	17	19	24	25
US pre avg.	6	4.7	6.7	4.7	4.3	1.3	2.5	0.3	2.3	2.3	4.5
US post avg.	8.5	4	8.5	4.5	4	2	0	0	0	4	6
GS pre avg.	19	3.7	4	10.7	6.3	4.8	1.5	3.5	7	4	4.5
GS post avg.	16.5	2.5	4.5	6.5	7	6	1	3	5	3	7
EM pre avg.	8.7	2.3	6.7	3.7	6.3	0.8	2.3	0.5	0.3	1	7.8
EM post avg.	5	2.5	6	3.5	4	2	1	1	1	2	6
BB pre avg.	14	0	0	4.7	0.8	1.5	0.3	0	2.8	2	0
BB post avg.	24	0	0	13	1	0	0	0	0	1	0
SS pre avg.	4.7	3.7	5.3	3	5	1.3	1	0	2.5	3.3	6.8
SS post avg.	13	5	4	4	6	3	2	0	5	0	11

Table C.1. Pre and Post Burn Data for all surveyed years

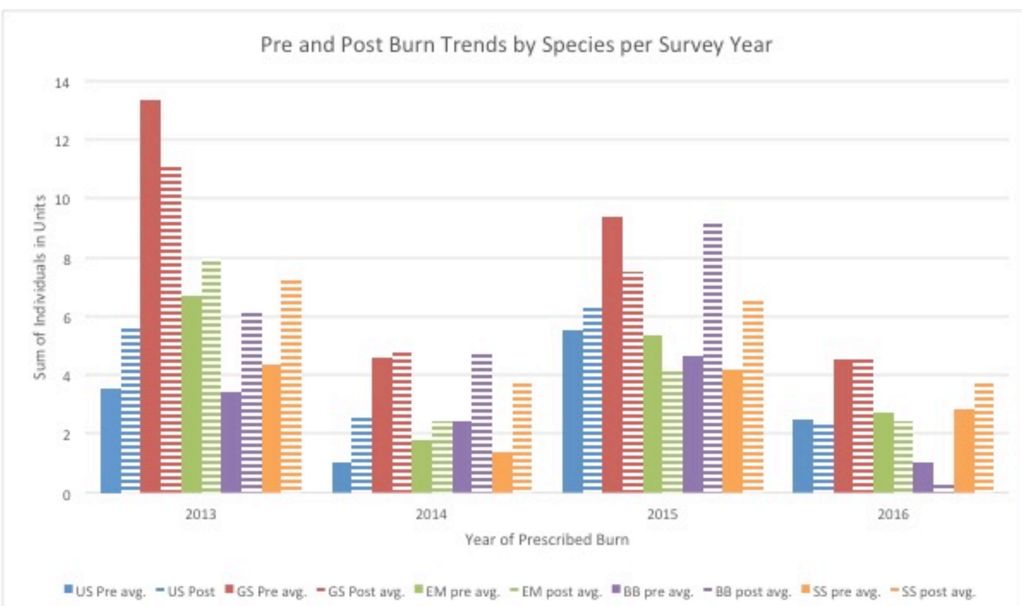

Figure C.1. Species trends pre and post burn per year

Appendix D

Unit	Acres	Mean Shanno	US	GS	EM	BB	SS
1	95.19	1.44426867	7	18	7.2	18	8
2	64.69	1.46645688	4	14.6	7.6	12.6	5.6
3	30.39	1.42654748	4.2	6.4	5.8	0.8	5.2
4	43.75	1.21501187	4.6	10.4	6.2	11.8	5.2
5	9.44	0.21972246	0	0.5	0.5	0.5	0
6	74.56	1.18773536	0	4.4	1	4.8	4.4
7	25.94	1.13055245	1.4	5	1	1.2	1.6
8	40.09	1.35225894	2.2	5.6	2.2	7.6	3.4
9	38.31	0.94314804	0.6	2.2	0	1.8	1.2
10	117.77	1.49330114	5.4	19	8.6	12	8.4
11	12.44	1.15328891	2	1.4	2	0.2	1.2
12	35.5	1.48978134	4	4.6	4	4.2	3.4
13	22.68	1.27784641	4.4	3.2	2.4	0	4.2
14	71.26	1.34141159	7.4	4.2	6.4	0	4.8
15	29.36	1.17793676	5.2	5.2	3	0	1.6
16	72.72	1.19169826	5	8.6	6.8	0.2	3
17	42.26	0.26437651	0.2	3.4	0.6	0	0
18	58.06	1.12342	3.4	9.4	2.6	0	3.4
19	30.73	0.99417277	1.8	6.6	0.4	2.2	3
20	57.04	0.38784425	0	5.2	0.2	0	1.4
21	54.58	1.27710693	2.8	9.8	6.2	1.4	5.2
22	57.32	1.27710693	4.6	9	3.6	8	3.4
23	18.5	0.57012323	0.4	1.2	0.2	0.6	1.2
24	29.74	1.40821681	2.6	3.8	1.2	1.8	2.6
25	43.79	1.31008931	4.8	5	7.4	0	7.6

Table D.1. Raw data of species abundances per unit averaged among all years as well as mean Shannon Diversity data