FINAL REPORT

Improving Safety and Economics Using Switchgrass on Military Airfields – RC-201415

August 19

Version 1

Travis L. DeVault, Ph.D.
U.S. Department of Agriculture
National Wildlife Research Center

and

Raymond B. Iglay, Ph.D.
Department of Wildlife, Fisheries, and Aquaculture
Mississippi State University

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
06/03/2019

2. REPORT TYPE
ESTCP Final Report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Improving Safety and Economics Using Switchgrass on Military Airfields

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Travis DeVault

5d. PROJECT NUMBER
RC-201415

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USDA APHIS WS NWRC
6100 Columbus Avenue
Sandusky, OH 44870

8. PERFORMING ORGANIZATION REPORT NUMBER
RC-201415

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Security Technology Certification Program
4800 Mark Center Drive, Suite 17D03
Alexandria, VA 22350-3605

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
RC-201415

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION A. Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Switchgrass (Panicum virgatum) monocultures were investigated as a land cover alternative to typical airfield grasslands to reduce use by wildlife species hazardous to aircraft and provide cost-effective risk mitigation. Paired sites of switchgrass monocultures and controls (i.e., extant airfield grasslands) were installed across six installations (3 airfields and 3 civil airports): Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), and Wright-Patterson Air Force Base (WPAF).

15. SUBJECT TERMS
Switchgrass, Military Airfields, Bird and Wildlife Aircraft Strike Hazard, GIS, Native Warm Season Grass

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UNCLASS	UNCLASS	UNCLASS	UNCLASS	154	Travis DeVault
					19b. TELEPHONE NUMBER *(Include area code)* 419-625-0242

TABLE OF CONTENTS

Tables

Figures

Acronyms

Name	Acronym
Air Force Base	AFB
Air Operations Area	AOA
Air Reserve Station	ARS
Bird and Wildlife Aircraft Strike Hazard	BASH
Control	C
Columbus Air Force Base	CAFB
Dayton International Airport	DAYT
Deviance Information Criteria	DIC
Department of Defense	DoD
Detroit Metropolitan Airport	DTWA
Environmental Security Technology Certification Program	ESTCP
Federal Aviation Administration	FAA
Geographic Information Systems	GIS
Gerald R. Ford International Airport	GRFI
Infrared	IR
Markov Chain, Monte Carlo generalized linear mixed models	MCMCglmm
Naval Air Station	NAS
Native Warm Season Grass	NWSG
Switchgrass	S
Secure Digital	SD
United States Air Force	USAF
Wright-Patterson Air Force Base	WPAF
NAS Whiting Field	WHIT
USDA Wildlife Services	WS

ACKNOWLEDGEMENTS

We thank the Department of Defense ESTCP program for supporting this effort in addition to the participating airfields and airports including Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), and Wright-Patterson Air Force Base (WPAF). Specifically, we thank all of the personnel from installations and USDA Wildlife Services for their support of project logistics and data collection including but not limited to Bruce Applebach (GRFI), Gary Wright (CAFB), Matt LaFleur (DTWA), Mike Cross (DAYT), Darryn Warner (WPAF); Buck Jolley and Lann Wilf (CAFB); Paul Siegel, Brian Kirby, Samuel Gibson, and Marty Daniel (WHIT); Gary Ludwig and Jeff Pelc (DAYT/WPAF); Aaron Bowden, John Hummel, and Timothy Wilson (DTWA/GRFI). Land managers Terry Lavvy, Lee Woodall, Pennington Family, and JJ McCool provided great recommendations for establishing switchgrass in challenging situations. Your insights to airport management from administrative, land and biologist perspectives have supported the success of this demonstration.

ABSTRACT

Switchgrass (*Panicum virgatum*) monocultures were investigated as a land cover alternative to typical airfield grasslands to reduce use by wildlife species hazardous to aircraft and provide cost-effective risk mitigation. Paired sites of switchgrass monocultures and controls (i.e., extant airfield grasslands) were installed across six installations (3 airfields and 3 civil airports): Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), and Wright-Patterson Air Force Base (WPAF). Bird and mammal use and switchgrass coverage were measured using standard distance sampling, camera trapping, and Daubenmire frame procedures from May 2015 to April 2018.

Percent coverage of switchgrass and other plant species was used to evaluate switchgrass establishment. Despite an expected progression of switchgrass establishment mimicking past observations of 40%, 60%, and at least 80% coverage annually beginning with the planting year, switchgrass establishment failed to achieve intended coverages at most installations, thereby not achieving performance objective 1. Variability in switchgrass establishment was expected during the first few years based on the typical progression of native warm season grass establishment during which most fields transition through a fallow field stage until achieving a preponderance of the planted species. However, switchgrass failure has been observed in ideal situations (i.e., fallow agricultural fields) and can result from late plantings (CAFB and WHIT), excessive moisture (CAFB, DAYT, DTWA) and plant competition (all sites). All attempts were made throughout this effort to improve switchgrass establishment success including additional planting, plant competition control, and planting earlier in the growing season. Despite variable establishment, however, all switchgrass sites experienced plant community changes (i.e., extant turfgrass progressing to a mixture of grasses and broadleaf weeds with or without preponderance of switchgrass) and were managed as tall-grass plots with only 1-2 mowings per year when mowing was used as competition control or for haying.

Successful demonstration of switchgrass as an alternative land cover for airfields included observing reduced risk in switchgrass sites compared to control sites according to the relative population abundance of hazardous bird and mammal. Biologists observed 52 bird species at least 25 times among 1,212 point counts (11,856 birds) and 1,170 line transects (24,599 birds). Monoculture switchgrass was expected to be used by less hazardous bird species, and we expected to observe lower densities of hazardous bird species compared to controls (i.e., less relative population abundance). Bird responses varied substantially between breeding and non-breeding seasons, and whether assessed by installation or among installations. Overall, effect sizes (i.e., size of differences between switchgrass monocultures and controls) were small suggesting minimal differences in bird use between treatments. However, effect sizes did not meet minimum requirements for meeting defined success (15% difference; Performance Objective 2). From a hazard perspective, hazardous species (e.g., ‘High’ to ‘Extremely High’

hazard species) were observed during the demonstration on both treatments but accounted for extremely small proportions of total observations. Only two installations experienced significant cumulative hazard score responses to switchgrass establishment but were single year responses that conflicted between installations. Therefore, switchgrass establishment did not seem to cause any substantial increases or decreases in bird cumulative hazard scores between breeding and non-breeding seasons during the demonstration (Performance Objective 4). Also, transitioning extant airfield grasslands to switchgrass monocultures did not cause substantial changes in bird use or hazards.

Installation-specific mammal presence and responses also varied substantially. Eighteen mammal species were identified from monthly, 14-day camera trapping surveys May 2015 through April 2018 among 22,064 trap nights (e.g., 1 trap night was 1 camera operating for 24 hours). Among installations, coyotes (*Canis latrans*; *n* = 1,573 detections), white-tailed deer (*Odocoileus virginianus*; *n* = 5,114 detections) and both eastern cottontails *(Sylvilagus floridanus*) and unknown rabbits (*Sylvilagus* spp.; n = 1,198 detections) were the most common species. White-tailed deer and coyote had greater occurrences in controls more often than switchgrass sites during installation-specific analyses. However, among year analysis suggested weak directional responses to switchgrass establishment with a slight decrease in coyote and deer use as switchgrass coverage increased. Rabbits were the main species group exhibiting greater use of switchgrass sites than controls. Overall, mammal responses suggest positive but weak support for establishing switchgrass at airfields and airports but did not meet performance objective success criteria (Performance Objective 3). Some installation-specific investigations indicated beneficial outcomes of switchgrass establishment for reducing hazardous mammal use, but among-installation analysis suggested no overall effect (Performance Objective 5).

We forecasted cost-benefit scenarios using estimated mowing and haying costs in addition to potential revenue from the sale of switchgrass hay. For all scenarios, net revenue was calculated sequentially with each year adding the previous year revenue to the current year's revenue. Extant airfield grassland management and switchgrass monoculture management revenues were forecasted as the first 3 years of switchgrass establishment, then out to 20 years (Section 7.3). Although the performance objective was not met (Performance Objective 6), forecasted revenues for switchgrass sites at the most expensive (i.e., cost per acre) switchgrass establishment installation were promising. All participating installations were also provided with installation-specific cost forecasts estimating net gains from not mowing beginning 2025 to 2036 with later years associated with high switchgrass establishment and low mowing costs.

Switchgrass monocultures offered an improvement to existing technology of extant airport grasslands and offered an alternative to leasing property for row crops. Typical airport grassland management outside AOAs involving periodic mowing may be improved by implementing less desirable conditions for wildlife hazardous to aircraft. Despite minimal change in the presence of hazardous wildlife, some switchgrass sites did not begin to transition to monocultures towards the end of the demonstration, a phase during which a greater wildlife response could have been observed. Concomitant to wildlife responses, improvements could also include gradual revenue increases as established switchgrass monocultures provide alternative income via the sale of baled switchgrass hay or leasing airport property to local farmers for haying. Meanwhile, as a safe alternative crop outside AOAs, but on airport property, switchgrass monocultures would likely meet military and FAA recommendations of safe management practices compared to row crops, especially cereal crops. Switchgrass monocultures are not recommended for short-grass management areas such as within the AOA. Grass height recommendations currently conflict with optimal conditions for visibility within AOAs and switchgrass management. Repeated mowing of switchgrass on similar schedules to short grass management can reduce switchgrass establishment and allow for invasion of other plant species in the monoculture. Similar conditions often occur in fallow fields mowed approximately monthly in which perennial grasses, forbs, and woody plants, tolerant of frequent mowing or grazing, become well-established and outcompete annual species.

1.0 INTRODUCTION

1.1 BACKGROUND

Land covers that serve as attractants to birds, particularly on or near air-operations areas (AOAs), can serve to concentrate avian activity within operational airspace, increasing the risk of bird-aircraft collisions (strikes; Blackwell et al. 2009, Martin et al. 2011). As early as 1985-1998, strikes with US Air Force aircraft resulted in an annual average loss of $35 million (Zakrajsek and Bissonette 2005), and from 1960-2010, the Federal Aviation Administration (FAA) reported 160 aircraft destroyed by wildlife strikes (Dolbeer 2013). New land covers that are not strong attractants to hazardous wildlife species would offer cost-effective risk mitigation.

Military airfields and civil airports (airfields) often control large tracts of land outside AOAs (see DeVault et al. 2012 regarding civil airports), and turf grasses (managed, domesticated grass varieties) are commonly planted on these lands but not maintained as monoculture turf grass. Most airfield grasslands are mowed periodically but usually not harvested for hay. Without additional competition control for competing vegetation and fertilizing, most airfield grasslands deteriorate from monoculture turf grass to airfield grasslands comprised mostly of grasses (planted turf grass) and a smaller proportion of forbs, legumes, and woody plants as observed by Schmidt et al. (2013). Many airport biologists and managers believe that extant airport grasslands, especially when maintained at about 15-25 cm in height by mowing (Brough and Bridgman 1980), are the safest possible land cover with regard to their attractiveness to bird species hazardous to aircraft (see Deacon and Rochard 2000, Seamans et al. 2007). However, this assumption has not been addressed adequately (Blackwell et al. 2013b). In the absence of reliable data on alternatives, the widespread use of such grasslands as a land cover has become standard practice on airfields (DeVault et al. 2013).

Managed grassland plant communities (e.g., mowed turf grass) can attract hazardous wildlife such as Canada geese, gulls, and large flocks of European starlings (DeVault et al. 2011, Washburn and Seamans 2013). Mowing does not necessarily confer an enhanced level of aircraft safety with regard to wildlife at airports relative to unmowed grassland (Blackwell et al. 2013b, Schmidt et al. 2013). Mowing is also a major maintenance expense, producing greenhouse gases which counteracts ongoing efforts to improve environmental sustainability at airfields (DeVault et al. 2012). Additional hazardous species such as cattle egrets, European starlings, vultures, and raptors are attracted to mowing activities that provide forage opportunities in the wake of the mowers. Given the economic and environmental drawbacks of maintaining large expanses of managed turf grass, it could be advantageous for some airfields to consider land-cover alternatives, especially outside AOAs, if these land covers also reduced use by wildlife species that are hazardous to aircraft (Blackwell et al. 2009, 2013b, DeVault et al. 2012, 2013, Martin et al. 2013, Conkling et al. 2018).

An obvious alternative to turf grass is agriculture. As land management agencies, service branches within the Department of Defense (DoD) maintain active agriculture out-lease programs for crop production and grazing. For example, the Naval Air Stations at Leemore (CA) and Meridian (MS) produce agricultural commodities via these programs, and several Air National Guard flying units are co-located on public use airports that maintain forage-crop rotations. However, there is no available guidance for airfields regarding the types of agriculture that are most appropriate in these settings (Blackwell et al. 2009, DeVault et al. 2013). In the absence of such guidance, crops are often planted that are known attractants to hazardous wildlife (Cerkal et al. 2009, DeVault et al. 2009). However, in an era when planted agriculture includes food crops, landscaping vegetation, and biofuel feedstocks, potential land covers for airfields are numerous (Sterner et al. 1984; see also Blackwell et al. 2009, DeVault et al. 2012, Martin et al. 2013).

We suggest that one reason for the preponderance of turf grass at airports—as well as the prevalence of agriculture that attracts hazardous wildlife—is the lack of science-based recommendations on safe alternative land covers (DeVault et al. 2013). With support from the FAA (see below), our research group evaluated the potential suitability of several alternative land covers for use at civil airports (largely outside the AOA). Our research determined that one of the most promising candidate alternative land covers is switchgrass, a native and perennial, warm-season grass that can be harvested for biofuel feedstock or high-quality animal forage (Griffin et al. 1980, Wullschleger et al. 2010). We quantified bird and mammal use of large, experimental, monoculture switchgrass fields in Mississippi, and our results (combined with other studies) suggested that conversion of some airfield turf grass areas to switchgrass production would not increase the risk of damaging wildlife strikes and may actually reduce such risks (Conkling et al. 2018). Given that military airfields are similar in many ways to large civil airports (e.g., layout, use of grassland areas in the infield and surrounding runways, as well as boundaries of timber, agriculture, and suburban development), switchgrass could also be a useful alternative land cover for military airfields over a large portion of the eastern U.S. Therefore, our effort described here implemented a paired design comparison of bird and mammal use of switchgrass monoculture and extant airfield grassland plots at multiple military airfields, complemented by civil airports.

1.2 OBJECTIVE OF THE DEMONSTRATION

The demonstration's objective was to validate and demonstrate the efficacy of large-scale production of an alternative land cover, monoculture switchgrass, on military airfields and civil airports over a large portion of the eastern half of the U.S. as a means of reducing 1) wildlife strike risk (e.g., the likelihood of a wildlife strike with a particular species causing damage and the frequency of such strikes), and 2) economic and environmental costs associated with maintaining large expanses of managed grassland. Furthermore, one potential outcome of conversion of managed (i.e., mowed) airfield grasslands to switchgrass, despite the conditions of a monoculture habitat, would be an increase in population sizes of small, at-risk (threatened and endangered) bird species that are not hazardous to aircraft (DeVault et al. 2011, Conkling et al. 2018). Implementation of switchgrass monocultures was a primary technology demonstrated to participating installations concomitant with demonstration of wildlife sampling methodology including but not limited to bird point and line transects, mammal camera surveys, and switchgrass coverage estimates. Throughout the demonstration, installation personnel were kept informed of the project's progress via direct interactions with the project manager and intermittent reports.

1.3 REGULATORY DRIVERS

Current regulations do not provide guidance for alternative land covers but instead focus on unacceptable proximate land uses to the airfield proper (e.g., agriculture, landfills, food outlets; FAA AC 33B, International Civil Aviation Organization 2002, Blackwell et a. 2009), particularly because science-based information is lacking. Hence, current regulations are merely recommendations and guidelines regarding vegetation height, maintenance requirements, soil erosion control and accessibility of emergency vehicles next to AOAs (Transport Canada 2002, FAA 2007, International Civil Aviation Organization 1991, U. S. Air Force Instruction 91-202, 7.11.2.3). Vegetation height has been a primary focus of guidance, but is inconsistent across installations, e.g., 6-10 inches on civil airports (Transport Canada 2002) and 7-14 inches on military airfields (Cleary and Dolbeer 2005). Furthermore, limited knowledge supports these recommendations and wildlife responses to vegetation height vary (Buckley and McCarthy 1994, Barras et al. 2000, Seamans et al. 2007, Washburn and Seamans 2007; Blackwell et al. 2016). Vegetation height preferences also differ among airports and regions, further complicating discussion and development of science-based regulation guidelines (see page 310 of Barras and Seamans 2002).

Budget cuts and interest in alternative fuels were primary drivers for exploring alternative land cover technologies on military airfields and civil airports. Monoculture switchgrass can address both regulatory drivers as a low maintenance land coverage with potential to mitigate airfield risk, and provide biofuel feedstock or quality cattle forage resulting in lower airfield costs and alternative income. Due to the lack of science-based information regarding ideal land coverage for airfields, results from this study could support development of future land use regulations and guidelines.

2.0 TECHNOLOGY/ METHODOLOGY DESCRIPTION

2.1 TECHNOLOGY/METHODOLOGY OVERVIEW

Extant airfield grasslands do not represent a panacea for mitigation of strikes; management of vegetation height, composition, and associated invertebrate communities is necessary and costly (Blackwell et al. 2013b; Blackwell et al. 2016). However, grasslands managed for biofuel production, if converted to appropriate cellulosic feedstocks, offer the potential to reduce strike risk posed by wildlife hazardous to aviation while enhancing revenue opportunities (DeVault et al. 2012). Switchgrass, for example, is a perennial cellulosic biofuel crop with high yields (5.2-12.9 Mg/ha depending on ecotype; Roth et al. 2005, Wullschleger et al. 2010). Technology is available to convert switchgrass biomass and other cellulosic feedstocks to biofuel (Keshwani and Cheng 2009). Another advantage of switchgrass is that it is a high-quality animal forage (e.g., for beef cattle; Griffin et al. 1980). Further, switchgrass is mowed (harvested) only once or twice per year (Griffin et al. 1980, Roth et al. 2005), in contrast to most extant airfield grassland areas which are mowed multiple times each year. Finally, switchgrass is native and grows well over most of the eastern half of the U.S. (natural growth from 55° N to central Mexico) and can thrive on poor soils (Schmer et al. 2008), which are common at military airfields and civil airports. Thus, switchgrass has the potential to be a regional solution for improving aircraft safety and generating revenue.

Two recent, FAA-funded studies prior to the implementation of this demonstration investigated bird and mammal responses to alternative airport land covers such as native warm-season grass polycultures (NWSG) and switchgrass monocultures (Schmidt et al. 2013, Iglay et al. *in press*, Conkling et al. 2018). Summarized in Section 2.2, both studies further supported the use of native grasses as alternative airport land cover through observations of less use by wildlife species hazardous to aircraft. Although switchgrass monocultures often had greater relative abundances of birds during winter months than NWSG in Mississippi, bird species of "very low" hazard to aircraft (Dolbeer and Wright 2009) accounted for 92.4% of all observations (Conkling et al. 2018). Given that use of switchgrass by hazardous birds appears to be even less than that of NWSG, switchgrass is an excellent candidate for demonstration as a safe alternative land cover at military airfields and civil airports. Future application can include conversion of airfield acreage outside of AOAs to monoculture switchgrass.

Implementation of switchgrass monocultures at airfields follows similar methodology to that of row crop agriculture. During the beginning of the demonstration, airfields and airports identified areas suitable for planting switchgrass (e.g., areas meeting Site Selection Criteria, on airport property, outside AOA). Plant competition suppression ensued using a broad-spectrum herbicide (e.g., glyphosate) and then areas were planted via seed-drill or broadcast seed at 9 lbs/acre pure live seed (PLS), considered a very dense planting rate. Variations to this approach among installations included additional herbicides and/or mowing to reduce plant competition or improve seed drill access. These and post-planting switchgrass establishment techniques (e.g., additional plant competition) have been developed and well documented for programs ranging from wildlife conservation to biofuel production across the Midwestern and central United States. Primary challenges among past work and this demonstration included variable site conditions, dependence on weather patterns, and plant competition. However, the intended application of switchgrass monocultures in this demonstration is unique.

2.2 TECHNOLOGY/METHODOLOGY DEVELOPMENT

Recent research (2012-present) indicated potential suitability of a suite of alternative land covers for use at military airfields and civil airports (DeVault et al. 2012, DeVault et al. 2013, Martin et al. 2013, Schmidt et al. 2013, Iglay et al. 2017, 2018, Conkling et al. 2018; Figure 2.2.1). Two of these studies directly supported the demonstration. In the first study, Schmidt et al. (2013) compared bird and mammal communities inhabiting airfield grasslands (turf-grass areas) with those using nearby native warm-season grass mixtures (NWSG; tall-grass prairie remnants) at three locations in Ohio. Species-specific differences in bird abundance and density were evident between the two land-cover types, presumably the result of differences in plant community characteristics. Birds of species categorized as ‘moderate’ to ‘extremely high’ with regard to hazard (severity) level to aircraft (Dolbeer and Wright 2009) accounted for 6% and 2% of all birds observed in airfield grasslands and NWSG areas, respectively (Figure 2.2.2). Thus, results from Schmidt et al. (2013) suggested that NWSG might be considered a viable land cover adjacent to airfields.

Figure 2.2.1. First page of publication (DeVault et al. 2012) by our research group documenting how civil airports and military airfields could provide suitable locations for alternative energy production, including cellulosic biofuels.


Environmental Management (2012) 49:517–522
DOI 10.1007/s00267-011-9803-4

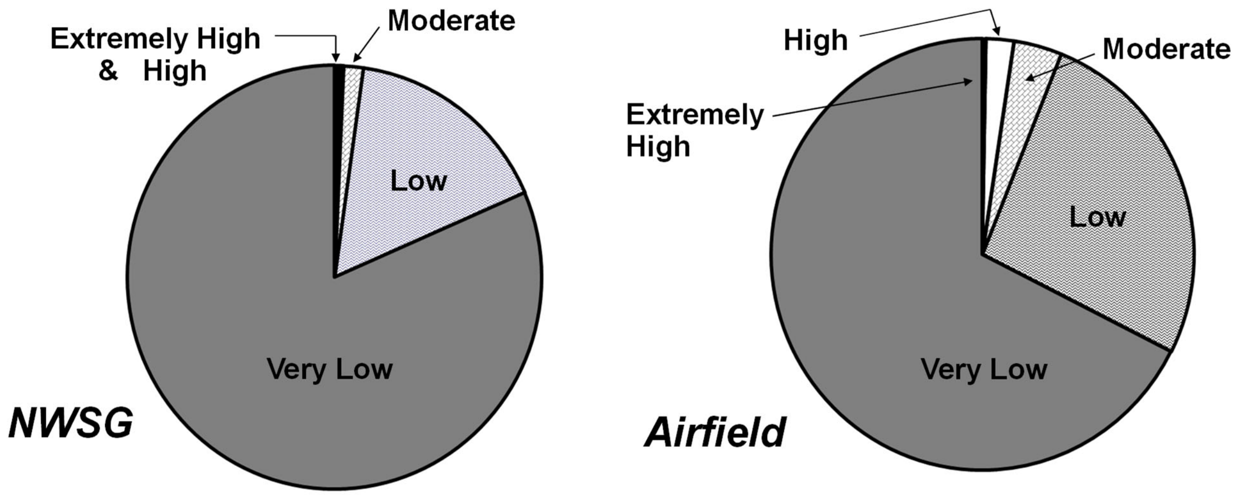
FORUM

Airports Offer Unrealized Potential for Alternative Energy Production

Travis L. DeVault · Jerrold L. Belant · Bradley F. Blackwell · James A. Martin · Jason A. Schmidt · L. Wes Burger Jr · James W. Patterson Jr

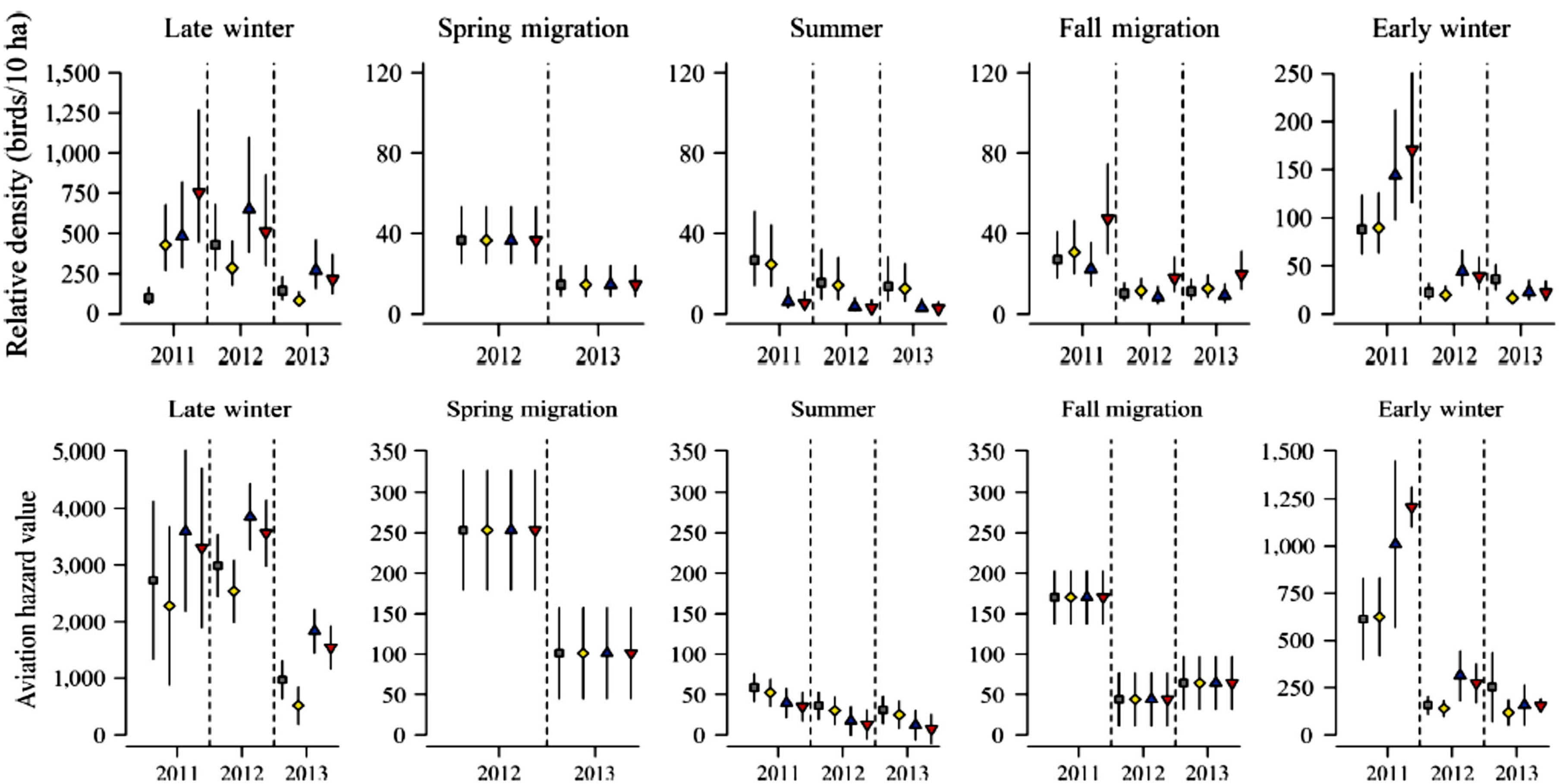
Received: 30 March 2011 / Accepted: 9 December 2011 / Published online: 14 January 2012
© Springer Science+Business Media, LLC (outside the USA) 2012

Figure 2.2.2. Distribution of bird-strike risk categories (as defined by Dolbeer and Wright 2009) for birds observed at NWSG sites adjacent to airports and airfield grasslands on three airports located western Ohio, Dec 2009−Nov 2010. From Schmidt et al. (2013). **s**



Research in Mississippi compared bird and mammal use of experimental (planted) NWSG polycultures to switchgrass monocultures (Iglay et al. 2017, *in press*, Conkling et al. 2018). Main differences between treatments in bird abundance were among seasons with greater bird abundances in switchgrass monocultures during winter months and greater abundances in NWSG polycultures during breeding season (Conkling et al. 2018; Figure 2.2.3). High hazard bird species accounted for < 3% of observations, and aviation risk and bird conservation value did not differ between treatments (Conkling et al. 2018). White-tailed deer (*Odocoileus virginianus*) and coyote (*Canis latrans*) were observed 51% and 27% less in switchgrass monocultures than NWSG polycultures across two years (2011 and 2012) according to camera trap surveys, respectively (Iglay et al. 2017). However, most monthly estimates of mammal use demonstrated minimal differences between treatments especially compared to summer months. Furthermore, nutritional analysis of harvested grasses suggested greater potential for supporting biofuel production than providing quality cattle forage when fields are harvested outside the breeding bird season (e.g., late dormant season and mid-summer; Iglay et al. *in press*).

Figure 2.2.3. Distribution of bird relative abundance and aviation hazard from switchgrass monoculture and Native Warm Season Grass (NWSG) polycultures in Clay County, Mississippi, 2011-2013. Plots were harvested once or multiple times resulting in the following treatments: multiple harvest NWSG (squares), single harvest NWSG (diamonds), multiple harvest switchgrass (triangles), and single harvest switchgrass (inverse triangles). From Conkling et al. (2018).



2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY METHODOLOGY

Alternative technologies and methodologies remained consistent throughout the demonstration. Extant airfield grassland management practices surrounding or adjacent to switchgrass demonstration areas supported desired airfield stewardship outcomes including access for emergency vehicles, monitoring efficiency for hazardous species in AOAs, aesthetics, and emergency landing/run off areas (FAA 2011, Washburn and Seamans 2013). When hazardous wildlife species were detected via current monitoring programs or anticipated based on past observations of animal movements within or nearby AOAs, reactive harassment techniques were implemented, and most participating installations also had proactive exclusion approaches (e.g., fences; Blackwell and Fernandez-Juricic 2013, Clark and Avery 2013, VerCauteren et al. 2013). Planted switchgrass monocultures offered potential additional proactive mitigation complementing existing fences and reactive harassment. In addition, switchgrass harvest at two sites and reduced mowing requirements of switchgrass monocultures demonstrated potential economic advantages despite significant management costs.

Established switchgrass monocultures during the first few years after planting expressed limited potential to reduce wildlife hazards on airfield property but also demonstrated less maintenance requirements towards the end of the demonstration. Switchgrass management costs (e.g., plant competition control, seed, planting) ranged from $490 to $1,076 per hectare ($200-$440 per acre) during establishment compared to $31.00 per hectare per mowing (i.e., airports could mow grasslands outside AOAs 2-5 times per year). However, during the third growing season (2017), some of the most costly switchgrass establishment plots located at Wright-Patterson Air Force Base ($1,076 per hectare) also yielded $450-$641 per hectare ($182-$260 per acre) in hay at approximately $30 per 80 X 88 X 244 cm bale. Conversely, two planting attempts at Columbus Air Force Base and NAS Whiting Field resulted in failed switchgrass establishment at $545-$925 per hectare ($221-$375 per acre) per attempt. Additional limitations of monoculture switchgrass were also observed during the demonstration and expressed by participating installations and concerned biologists regarding the allowable proximity of switchgrass monocultures to AOAs considering its typical maintenance height exceeding current guidelines and switchgrass' low tolerance for intensive, short height maintenance. However, these concerns were only expressed and not realized considering the proximity of switchgrass sites to AOAs during the demonstration (see below). Furthermore, long-term (20 year) comparisons of establishing switchgrass compared to mowing airport grasslands indicates cost savings, even when considering the greatest establishment costs observed in this demonstration and only one mowing per year (Section 7).

3.0 PERFORMANCE OBJECTIVES

The project used the following performance objectives to evaluate the performance and costs of switchgrass monoculture as an alternative land cover for military airfields and civil airports. Primary project objectives included reduced relative population abundance of hazardous wildlife species and absolute maintenance costs for switchgrass monocultures compared to control sites (e.g., extant airfield grasslands). Overall, during the demonstration period, switchgrass establishment slowly progressed to a monoculture at a few installations and demonstrated potential for reducing wildlife strike risk for aircraft. Despite few installations progressing towards a switchgrass monoculture during the demonstration, weak and variable responses did suggest minimal risk associated with establishing switchgrass as an alternative land cover on airfields or airports, outside operation areas.

Table 3.1. Performance objectives for ESTCP Project RC-201415 investigating airstrike hazards and costs between switchgrass monocultures and control sites (i.e., extant airfield grasslands) on military airfields and civil airports in northern, central, and southern regions of the eastern United States.

Quantitative Performance Objectives				
Reference Number	**Performance Objective**	**Metric**	**Data Requirements**	**Success Criteria**
1	Successful establishment of switchgrass fields at each installation	Switchgrass coverage (%)	Switchgrass and other composite species density (% coverage by switchgrass or other species).	40% coverage of switchgrass at the end of first growing season, 60% at the end of the second growing season, and 80% thereafter by installation.
2	Reduced bird hazards in switchgrass sites as compared to control sites by installation	Relative population abundance of hazardous bird species	Species composition of bird communities, density and location of hazardous birds	Significantly fewer hazardous birds using switchgrass sites relative to controls at the end of the first growing season, and 15% fewer hazardous birds using switchgrass sites relative to controls during each subsequent year (i.e., compared to year 1), based on relative population abundance indices by installation ($\alpha < 0.05$).

3	Reduced mammal hazards in switchgrass sites as compared to control sites by installation	Frequency of occurrence of mammal species	Species composition of mammal communities, frequency of use and location of hazardous mammals	Significantly fewer hazardous mammals using switchgrass sites relative to controls at the end of the first growing season, and 15% fewer hazardous mammals using switchgrass sites relative to controls during each subsequent year (i.e., compared to year 1), based on frequency of occurrence indices by installation ($\alpha < 0.05$).
4	Reduced relative hazard score (e.g., rank-based likelihood of a species-specific wildlife strike causing damage or an effect on flight) of birds in switchgrass sites as compared to control sites by installation	Hazard scores of observed bird species	Relative population abundance of observed bird species (potentially only hazardous species of interest) and calculated hazard score based on factors such as body weight and relative contribution to bird strike frequency and damage according to the FAA Wildlife Strike Database	Significantly less average bird hazard score in switchgrass sites relative to controls by the end of the first growing season by installation and every subsequent year thereafter ($\alpha < 0.05$).
5	Reduced relative hazard score of mammals (e.g., rank-based likelihood of a species-specific wildlife strike causing damage or an effect on flight) in switchgrass sites as compared to control sites by installation	Hazard scores of observed mammal species	Frequency of occurrence of observed mammals species (potentially only hazardous species of interest) and calculated hazard score based on factors such as body weight and relative contribution to mammal strike frequency and damage according to the FAA Wildlife Strike Database	Significantly less average mammal hazard score in switchgrass sites relative to controls by the end of the first growing season by installation and every subsequent year thereafter ($\alpha < 0.05$).
6	Reduced cost of required maintenance of switchgrass sites as compared to control sites by installation	Difference in costs between switchgrass establishment and concomitant mowing regime of control sites across all years of study	Cost of maintenance (from installation records) of switchgrass fields and control sites; equipment costs	Net economic gain of at least 10% by the end of the third year after switchgrass establishment with switchgrass sites costing less than controls by installation.
Qualitative Performance Objective				
7	User acceptance of switchgrass	Written notice from airfield managers outlining intention to	Interviews with airfield managers and airport biologists leading to success of a written notice at the six	Willingness as indicated in written notice to maintain

	implementation at installations	maintain switchgrass fields indefinitely	implementation sites. Interviews may include but are not limited to answering questions of concern, site visits, and overviewing project results.	switchgrass fields into the future at five of six installations[1]

[1] Success criteria for less than 6 sites will be 1 less site than the total number of sites willing to maintain switchgrass fields into the future (e.g., 2 of 3 sites, 4 of 5 sites).

4.0 SITE DESCRIPTION

Three military airfields and three civil airports participated in the demonstration. Installation locations provided three latitudinal gradients to the demonstration: southern, central, and northern. Experimental units were located outside AOAs for most sites, NAS Whiting Field (WHIT) being the exception. However, WHIT did not experience any flight activity throughout the demonstration. Each installation reported hazardous wildlife among variable interactions and aircraft strike histories. Airport grassland plant communities also differed among installations based on ancillary observations but were predominately turf grass mowed at least twice per year. Remaining site characteristics adhered to site selection criteria indicated in the Demonstration Plan (Table 4.0.1) and information provided in the following subsections.

4.1 SITE LOCATION AND HISTORY

Participating installations were supportive of the demonstration throughout its tenure. Flight activity, site conditions, access delays, and the availability of land managers were the primary characteristics differentiating installations. Columbus AFB experienced the most frequent use by military aircraft of the three military sites and had a flight training mission. During faunal surveys, airfield activity did not seem to impact land management activities, faunal sampling efforts, or wildlife use. Wright-Patterson AFB and WHIT were predominately used for flight training missions. Wright-Patterson AFB had an average of 1 landing per day, and WHIT was scheduled for low flyovers ($\geq$ 50 feet above ground) only despite no observed flighty activity throughout the demonstration. Demonstration sites comprised most of WHIT's area including some of the AOA. As an auxiliary field, WHIT was limited to runways and taxiways (Appendix B). Columbus AFB had one building near the main entrance, a shed, and two small runway supervisory units but was otherwise comprised of the AOA and surrounding property of managed turf grass and pine plantations. Wright-Patterson AFB had the most complex layout of the participating military airfields. One demonstration site was adjacent to the AOA. A control site was within the housing and office community southeast of the AOA, and the remaining site pair was located just south of the airfield's restricted use area of the AOA.

Detroit Metropolitan Airport had the most air operations per year of the 3 participating civil airports followed by GRFI and DAYT. Each civil airport also transported air cargo. Detroit Metropolitan Airport and GRFI were located in urban areas whereas the western side of DAYT (southwestern to northern borders) neighbored agricultural areas. Multiple runways, taxiways, terminals, and other buildings populated AOAs of each civil airport. Site locations at each civil airport were adjacent to AOAs and outside the main perimeter fence.

Table 4.0.1. Site selection criteria and installation-specific details for switchgrass demonstration project conducted in the eastern U.S. among 3 airfields and 3 airports: Columbus Air force Base's Auxiliary Airstrip in Shuqualak, MS (CAFB), Naval Air Station Whiting Airfield near Foley, AL (WHIT), Wright-Patterson Air Force Base (WPAF) and Dayton International Airport in Dayton, OH (DAYT), Gerald R. Ford International Airport in Grand Rapids, MI (GRFI), and Detroit Metropolitan Airport in Detroit, MI (DTWA).

Site Conditions (units)	Preferred Values	Relative Importance[1]	Southern Region		Central Region		Northern Region	
			CAFB	WHIT	WPAF	DAYT[7]	GRFI[7]	DTWA[7]
Contiguous Acreage for Experimental Units (sites) within allowable space (number of ≥ 8-ha sites)[2]	≥ 4	1	4	4	11	5	4	6
Access for land management equipment (km)[3]	< 0.5	1	0.32	0.03	0.02	0.3	< 0.5	0.15
Permission, access and approval letter (Y/N)	Y	1	Y	Y	Y	Y	Y	N[8]
Diversity of potential large mammal hazards (species)[4]	≥ 2	2	8	5	4	≥ 2	≥ 2	≥ 2
Diversity of potential bird hazards (species)[5]	≥ 5	2	9	20	9	≥ 5	≥ 5	≥ 5
Proximity to waterfowl habitat (km)[6]	≤ 1.5	3	1.41	0.40	0.30	0.12	0.15	0.11
Similar plant communities within site pairs (Y/N)	Y	4	Y	Y	Y	Y	Y	Y
Agricultural crops present or leased within last 5 years (Y/N)	Y	4	N	Y (haying)	N	N	Y (haying)	N
Topography (relief in m)	≤ 10	4	≤ 5.39	≤ 5.78	≤ 2.69	≤ 3.83	≤ 11.84	≤ 2.30
Region (number per region)	2	1	1 of 2	2 of 2	1 of 2	2 of 2	1 of 2	2 of 2

[1] Relative importance is ranked 1-5, greatest to least importance.
[2] Site-specific requirements limited experimental unit placement such as maintaining ≥ 300m between runways and demonstration sites (CAFB and WPAF), no overlap between demonstration sites and flight paths (CAFB and WPAF), low fly height restrictions for pilots (WHIT), and proximity of paired sites to each other (e.g., CAFB sites are adjacent, 1 site pair on WHIT is separated by the primary runway).
[3]The greatest distance from any of the switchgrass sites to a gravel or paved road.
[4]Mammals weighing ≥ 10 kg (Dolbeer et al. 2000) even though white-tailed deer and coyotes are of primary concern on airfields. Wild hogs could be a hazard when present, but to date there have been few reports of wild hog incidents at airports.
[5]Bird species weighing ≥ 100 g (Dolbeer et al. 2000) or with great flocking potential (e.g., European Starling, Common Grackle, etc.).

4.2 SITE CHARACTERISTICS

Columbus AFB was 3.8 km south of Shuqualak, MS. Used primarily for novice pilot training landing and takeoff, Columbus AFB offered 8 possible study sites, but site selection was limited to 4 options based on a site-specific requirement of a 300 m buffer distance between the runway and switchgrass-treated sites. Columbus AFB also requested that switchgrass sites did not intersect with flight paths (Appendix B). A site pair occurred at either end of the runway and each site measured 8 ha. All sites received similar past management (mowing), and plant communities consisted of fallow field species typical of the area including native grasses, sedges, and rushes, no apparent turf grass other than a few common *Paspalum* spp., few forbs and legumes, no apparent semi-woody or woody vegetation and only some exotic but non-invasive forbs. An invasive and exotic grass species, cogongrass (*Imperata cylindrical* L.), was identified during the first growing season of field work (2015) in control sites and treated appropriately by airport personnel. Topography was flat to slightly rolling with relief less than 6 m, and the surrounding landscape was comprised of an intensively managed pine matrix (Table 4.0.1). Hunters frequented the forested areas in fall and winter both on and off the property, away from open areas of the airstrip. Effects on animal movements seemed negligible due to low hunter density and frequency of use (i.e., hunter presence did not significantly influence mammal or bird presence in study sites). Hazardous mammals ($\geq$ 10 kg) in the area included white-tailed deer, coyote, domestic dog (*Canis lupus familiaris*), bobcat (*Lynx rufus*), raccoon (*Procyon lotor*), beaver (*Castor canadensis*), North American river otter (*Lontra canadensis*), bobcat (*Felis rufus*), and red fox (*Vulpes vulpes*). Wild pigs (*Sus scrofa*) were in the county but not proximate to the site. Hazardous bird species in the area included red-tailed, cooper and broad-wing hawks, black and turkey vultures, eastern wild turkey, mourning dove, American crow, and occasional Mississippi kites, Cooper's hawks, and American kestrels.

NAS Whiting Field was located east-southeast of Foley, AL and was an auxiliary airfield not used by aircraft during the demonstration. Limited contiguous area surrounding the airstrips restricted site locations to 4 areas (Appendix B). However, infrequent use of the airfield for flyover exercises prior to the demonstration relaxed restrictions on site proximity to airstrips (e.g., no 300 m buffer between runway and demonstration sites or concern of flight path interference). Due to past haying practices and similar topography and seed banks among sites, plant communities were similar to fallow fields following unmaintained turf with predominate Bahia grass (*Paspalum notatum*) and centipede grass (*Eremochloa ophiuroides*) interspersed by little bluestem (*Schizachyrium scoparium*), yaupon (*Ilex vomitoria*), persimmon (*Diospyros virginiana*), and fleabane (*Erigeron* spp.). Sites ranged in size from 8.05 – 8.39 ha with one control site divided by an access road (Table 4.0.1). Topography was flat ($\leq$ 6 m relief), and the surrounding landscape was intensively managed pine. Public could easily access the western switchgrass site while all other sites were behind a short (< 2 m high), perimeter fence. However, public access to the western switchgrass site was unlikely to occur considering the sparse surrounding human population and posted signs. Hazardous mammal species in the area included white-tailed deer, coyote, red fox, gray fox (*Urocyon cinereoargenteus*), raccoon, and bobcat. Feral hogs have not been observed near the site. Hazardous bird species in the area included red-tailed, Cooper and broad-wing hawks, Mississippi kite, American kestrel, osprey, black and turkey vultures, occasional Canada goose, eastern wild turkey, mourning dove, American and fish crows and potentially shorebirds including herring, ring-billed and laughing gulls, least and common terns, and brown and white pelicans.

Wright-Patterson AFB was located in Dayton, OH. The northern site pair was located on base near the AOA (Appendix B). The southern site pair was located in a public-access area leased for hunting, south of the AOA. However, we observed limited to no use of our sites by hunters given hunting records, proximity to airfields, access restrictions relayed to hunters, and the relative lack of attraction of sites to most game species. Therefore, we did not include hunter influence as a potential impact on mammal and bird presence in our study sites. Wright-Patterson AFB had substantial acreage to use as controls, but preferred to have switchgrass demonstration sites distant from the runway. In addition to this restriction, some areas on base were incompatible with land conversion to switchgrass (e.g., multiple trees, poor drainage similar to wetlands, etc.). The airport's regional biologist inquired about multiple possible sites before the final sites were chosen. Although sites within each pair were similar, the northern site pair was mowed frequently resulting in predominate short, dormant-season turf grass including some sedges and occasional forbs. The southern pair was harvested less often and covered by multiple grass, sedge, and forb species in which grasses were the most common growth form. Our paired study design accounted for this variation between pairs by relying on similarity between sites within pairs. Topography was flat (< 3 m) and the proximate landscape included hardwood forests, two golf courses, fallow fields, suburban developments, and a primary highway (Table 4.0.1). Hazardous mammal species in the area included white-tailed deer, coyote, red fox, house and feral cats, and raccoon. Hazardous bird species in the area included red-tailed hawks, northern harriers, bald eagle, American kestrel, ring-billed gull, great blue heron, barn and tree swallows, mourning dove, European starlings, common grackles, red-winged blackbirds, American crows, black and turkey vultures and Canada goose. Multiple waterfowl species infrequently used ponds immediately south of the runway such as mallard, wood duck, blue-winged teal, double-crested cormorant, gadwall, redheaded duck, ring-necked duck, lesser scaup, and American wigeon species.

Dayton International Airport was also located in Dayton, OH. All sites were located outside the perimeter fence but adjacent to the AOA. The northern site pair was split by the north/south runway. The switchgrass site for this pair was bordered by forest, and the control site was bordered by service and country roads with forested field breaks and agricultural fields across the northern and western borders (Appendix B). The southern pair was located southwest of the terminals. The southern switchgrass site was adjacent to the airport entrance and control site adjacent to agricultural fields. Many of the surrounding agricultural fields were converted to native warm-season grasses during the demonstration, and a field across from the southern control plot was converted to a new airport building. Dayton International Airport has been proactive for land cover alternatives regarding native warm-season grasses restricting potential demonstration areas to 5 sites. All sites were managed by airport personnel in a similar manner to extant airfield grasslands within the AOA, and airport personnel reported similar species compositions among all sites with non-native turf grass as the predominate plant cover. Topography was flat (< 4 m) and the proximate landscape included agricultural fields, native warm-season grass fields, suburban developments, a primary highway, and county and service roads (Table 4.0.1). Hazardous mammal species in the area included white-tailed deer and coyote. Hazardous bird species in the area included red-tailed hawks, American kestrel, barn and tree swallows, mourning dove, European starlings, common grackles, red-winged blackbirds, American crows, turkey vultures and Canada goose.

Gerald R. Ford International Airport (GRFI) was located in Grand Rapids, MI. Airport personnel designated a ~37 ha west of the north/south runway for the demonstration project after investigating 7 other potential site locations with project personnel (Appendix B). Control sites were adjacent to each other (north/south) with the northern switchgrass plot north of the control sites and southern switchgrass plot west of the control sites. All sites were managed as a contiguous unit with a management history of annual mowing and some haying. All sites were outside the airport's perimeter fence and frequented by white-tailed deer and coyote. Coyotes have been a major strike risk for this airport, and deer were very abundant in the area according to the airport's biologist. The airport was also frequented by numerous Canada geese and European starlings in addition to pigeons, Sandhill cranes, turkey vultures, eastern wild turkeys, and other hazardous bird species.

Detroit Metropolitan Airport (DTWA) was located in Detroit, MI. All sits were located outside the perimeter fence. Although airport personnel identified 6 potential sites, two had saturated soils. The northern pair were east of the northern east/west runway and the southern pair to the south of the eastern north/south runway (Appendix B). The area was relatively flat and management histories, and species compositions were similar across all sites (Table 4.0.1). The northern switchgrass site was the only site not bordering forest, but forest was located adjacent to the northeast corner of this site. The northern switchgrass site was also the only site within a buffer of field or forest between it and a road. Similar to GRFI, white-tailed deer and coyote frequented the area, and the same hazardous bird species were common. In 2014, airport biologists also translocated over 150 red-tailed hawks.

5.0 TEST DESIGN

5.1 CONCEPTUAL TEST DESIGN

The conceptual test design was a blocked, paired design in which each airfield (block) had 2 site pairs; a site pair consisted of a switchgrass demonstration site (treatment) and extant airfield grassland site (control). Pairing sites helped reduce within-pair variation and met experimental design recommendations of homogeneous experimental units prior to treatment application including plant composition, topography, and past management regimes within pairs. Increasing the number of samples per airfield beyond 2 pairs was infeasible due to area constraints. Blocking by airfield accounted for variation among airfields caused by differing missions, frequency of use, plant communities, other biotic site conditions, and past site management. However, only slight differences in site preparation treatments and switchgrass varieties occurred among airfields (e.g., herbicide concentration, herbicide type, additional herbicide applications). Sampling procedures and frequencies were the same. Regional differences such as southern sites requiring greater competition control prior to switchgrass planting and preferred switchgrass cultivars suited for each area were also expected and realized throughout the demonstration. Using airfields among multiple regions supported development of management guidelines applicable to a larger sphere of inference than if the demonstration only occurred in one region.

5.2 BASELINE CHARACTERIZATION AND PREPARATION

Baseline characterization began with adhering to site selection criteria. Proximity of within-pair experimental units was of primary concern after initial site selection criteria were met. Otherwise, vegetative cover was compared between paired sites. Although vegetation coverage was not sampled for homogeneity, similarities and differences were obvious (e.g., extant airfield grassland of similar predominant grass species).

Treatment site preparation began prior to switchgrass planting in spring 2015 with broad-spectrum herbicide applications for plant competition control. Some sites (e.g., DAYT, WPAF, WHIT) were mowed prior to herbicide application to ensure adequate herbicide coverage and provide access for planting equipment (e.g., seed drill). Tillage and other ground disturbances were avoided among all sites. Disking is used more often during site preparation than planting by helping express more of the seed bank for plant competition control.

Standard switchgrass establishment guidelines were provided to all land management contractors. However, institutional knowledge of local managers was used throughout the switchgrass establishment process. Primary guideline from project personnel to land managers included preference of a broad-spectrum herbicide (e.g., glyphosate as active ingredient) for plant competition control prior to planting, seed drill for planting, and potential additional selective herbicide spray (e.g., 2, 4-D Amine for broadleaf weed control, metsulfuron methyl for broadleaf weeds and woody plants) during planting and post-planting years for additional broadleaf weed control. All management proposals were approved by the project's principal investigators and project manager prior to implementation and shared with airport and airfield personnel. When required, herbicide application rates were provided to airfield personnel for record keeping. Because control sites were managed according to airfield protocol, we obtained approximate maintenance schedules for maintenance cost comparisons and to inform our management guidelines resulting from this demonstration. Bare seed switchgrass was planted using a seed drill at most sites with the exception of CAFB (e.g., broadcast seed) at a rate of 10.1 kg per hectare [9 lbs./acre pure live seed (PLS)] and approximately spaced 18 cm (7 inches). Aggressive cultivars were preferred to support monoculture switchgrass coverage (e.g., "Cave-in-Rock") as mentioned in Schmer et al. (2006). Switchgrass demonstration sites were not fertilized. The aggressive aspect of these cultivars was primarily their abilities to establish in extreme conditions such as acidic and dry soils, not invasive growth patterns. The extent to which aggressive cultivars may escape and establish in unwanted places was expected to be less than most turf grass species currently used (e.g., Bermuda grass, Bahia grass). Switchgrass presence in control sites did not seem to be a result of invasion from neighboring switchgrass sites but rather an expression of naturally occurring switchgrass in the site's seed bank.

5.3 DESIGN AND LAYOUT OF TECHNOLOGY AND METHODOLOGY COMPONENTS

The main technology of this effort was demonstrating established monoculture switchgrass sites on airfields as a mitigation tool for reducing airfield use by wildlife hazardous to aircraft. Land management and field sampling techniques were well-established prior to the demonstration and have been thoroughly tested on alternative sites. Treatment and control layouts were based on our conceptual design and site availability. We provided each installation with site selection criteria and preferences. We also provide a GIS map of potential and final site locations during site selection. Final site layouts were ultimately determined by each installation based on our provided guidance and airfield restrictions and preferences. For example, the original, random treatment assignment for CAFB had one of the switchgrass demonstration sites intersecting the flight path. Columbus AFB personnel requested that we switch treatment assignments within the pair to avoid this intersection. Additional layout concerns were proximity of within-pair sites. In an ideal situation such as CAFB and the southern pair of WPAF, we were able to delineate neighboring study sites within a pair. Site layout in other installations did not allow for this proximity, but pairing of sites still met our conceptual design requirements and contributed to reduced variation within pairs. Maps of treatment and control layouts are provided in Appendix E.

5.4 FIELD TESTING

The switchgrass demonstration had one phase, post-switchgrass establishment, beginning late spring 2015. Demonstration success was based on by installation analyses, but analysis for near future peer-review manuscripts will also explore differences among installation. Field data collection began May 1, 2015 and ended April 30, 2018 concomitant to switchgrass site preparation and planting. Field biologists were trained in field sampling protocols ranging from direct wildlife observations (e.g., bird point counts and line flush transects) to camera set-up for mammal camera trapping surveys prior to field sampling.

5.5 SAMPLING PROTOCOL

All sampling efforts were coordinated by the project manager at Mississippi State University. Observers (Wildlife Service Biologists) were provided with GIS Maps, coordinates for all sampling points, sampling orders per sampling month (i.e., random sampling order), and a sampling protocol packet with all field sampling methodology, data entry, and instructions for submitting camera trapping photographs (Appendix C). In addition, an instructional video was developed for programming camera traps, and a relational database was used to standardize data entry among multiple biologists (Appendix D). Each installation and site pair had a unique acronym in which northern pairs were labelled with a "1" after acronyms for switchgrass (S) or control (C) and southern pairs were labeled with a "2". For example, the northern pair of sites at Wright-Patterson Air Force Base were labeled WPAF_S1 for the switchgrass demonstration site and WPAF_C1 for the control site. All field equipment and sampling protocols mentioned below followed many standard practices for land management and wildlife monitoring (Appendix E).

5.5.1 Switchgrass Coverage

Switchgrass coverage was measured using a three-sided Daubenmire frame (20 × 50 cm; Daubenmire 1959) during late summer (July-August). A three-sided Daubenmire frame (rectangle with one edge removed) allowed for the frame to encompass tall plants and settle to the ground. Horizontal ocular estimates were then be performed to estimate coverage to avoid obstruction from tall switchgrass. The Daubenmire frame has been used often in forests among dense tree stems, far more difficult conditions to use it than in this demonstration's monoculture switchgrass stands. At 5 sampling points per site (e.g., 3 bird point count and 2 mammal camera trap locations), observers sampled a random point within a 25 m radius of the point. Random points were determined by a random direction and distance from each point. At the random point, a frame was dropped over the observer's right shoulder and visual estimates of percent switchgrass coverage per frame grid recorded. Average percent switchgrass coverage among all sampling points within a site were calculated and represented our performance objective metric. Even though switchgrass was planted only on switchgrass demonstration sites, we collected switchgrass percent coverage data on treatment and control sites. Detroit installations and WHIT had switchgrass recorded on both switchgrass and control sites. Minimal variation in switchgrass coverage was expected among the 5 sampling points given the proposed intensive switchgrass establishment approach (e.g., 9 lbs seed/ acre). Because herbicide-treated areas around cameras and foot traffic suppressed areas near bird count points could bias measurements, observers were instructed to choose the next random point criteria if the original criteria placed them in these areas. Avoiding these types of areas were standard practices in vegetation assessment surveys and acceptable by peer-reviewed journal outlets.

5.5.2 Bird Relative Population Abundance

Bird relative population abundance was sampled using distance sampling consisting of point counts during breeding season (May-July) and line flush transects during non-breeding seasons (August-April). These techniques accounted for different vocal behaviors and bird visibility between seasons (Smith 1984, Gutzwiller 1991).

Three random sampling points were located in each site for bird point counts (Figure 5.5.2.1). Each bird point count location was sampled three times per month for a 5-minute interval after a 2-minute interval during which birds settled (Scott and Ramsey 1981, Rosenstock et al. 2002). Observers recorded all species seen or heard, how they detected the bird (seen or heard), minute interval during which a bird was detected, bird behavior and sex, whether or not the detected bird was an individual or a flock, number of individuals in the flock, bird altitude, whether or not the bird/flock was in the site, direction (e.g., North, West, East, etc.) and distance to the bird (m) from the observer, and any additional ancillary observations (Ralph et al. 1995). Point count locations were sampled in a random order per sampling day. Random sampling order was determined by choosing a random order of initial sampling site, then a random order for sampling points within each site followed by the site's pair, a random order of sampling points within the site pair, and then a repeated random process for the other pair of sites at an installation. Observers were cautioned to avoid double counting individuals, an uncommon occurrence when using experienced observers and a minimum required sampling effort per site (i.e., 3 points per site) that results in maximum distance between points. Birds were not sampled in windy or rainy conditions to avoid additional bias in the data due to variable bird detection conditions (Robbins 1981).

The basis for sampling effort using bird point counts varied considerably in the literature relative to primary drivers of species present in an area, their detectability, and the segregation of points. However, sampling effort (number of visits over a specified time period such as a year) also influenced the number of points required. As species richness increased and detectability of each new species decreased, the greater the necessary sampling effort for increasing species richness. Point count segregation was also a consideration for determining ample sampling points with many studies suggesting > 250 m between points. We determined 3 points per plot as adequate for precise estimates of common species using airfields, our 8-ha site size, and past experiences monitoring switchgrass monocultures and turf grass land coverage. Further, when our expectation was that a majority of species using a site would be detected frequently (>50%), which was likely for these sites, a survey effort of 3 times per defined season was recommended (MacKenzie and Royle 2005).

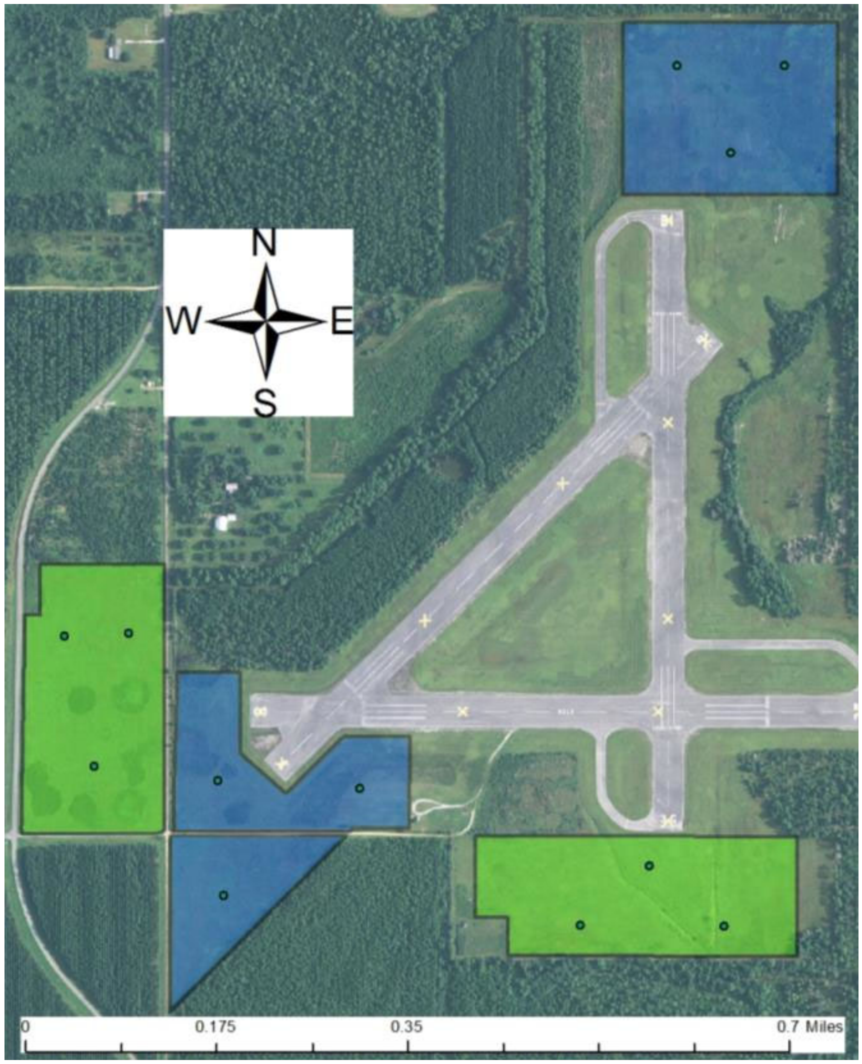


Figure 5.5.2.1. Bird point count locations at NAS Whiting Field near Foley, AL, for the switchgrass demonstration project. Green sites represent switchgrass demonstration areas and blue sites will represent control sites.

Bird line flush transects followed a sawtooth pattern of zigzagging lines crossing each site (Strindberg and Buckland 2004; Figure 5.5.2.2). Line transects for each site originated in a random corner and crisscrossed the site to cover the majority of the site for a total length of 750-950 m. We determined 750 m as an optimal length for 8-ha areas based on bird detections in our Mississippi study (Conkling et al. 2018). Longer transects were the result of non-rectangular sites, but all observations were standardized by transect length. Random sampling order was based on a random order of sites similar to bird point counts but then a random starting end of the transect for each site. All line vertices were GPS-marked for observers to orient themselves to while walking the transect.

Each line flush transect was sampled three times per month. Observers walked the line at a slow pace (1-2 mph) scanning for birds. For each bird or flock detected, observers recorded the same information as for point counts but replaced time interval of detection with a measurement of the time period during which the line transect was conducted (e.g., interval between the starting time and ending time of the line transect). To determine actual locations of each detected bird during analysis, observers GPS-marked the location on the line transect where they made the detection. Species-specific relative population abundance were calculated from each bird sampling method accounting for detection probability as well.

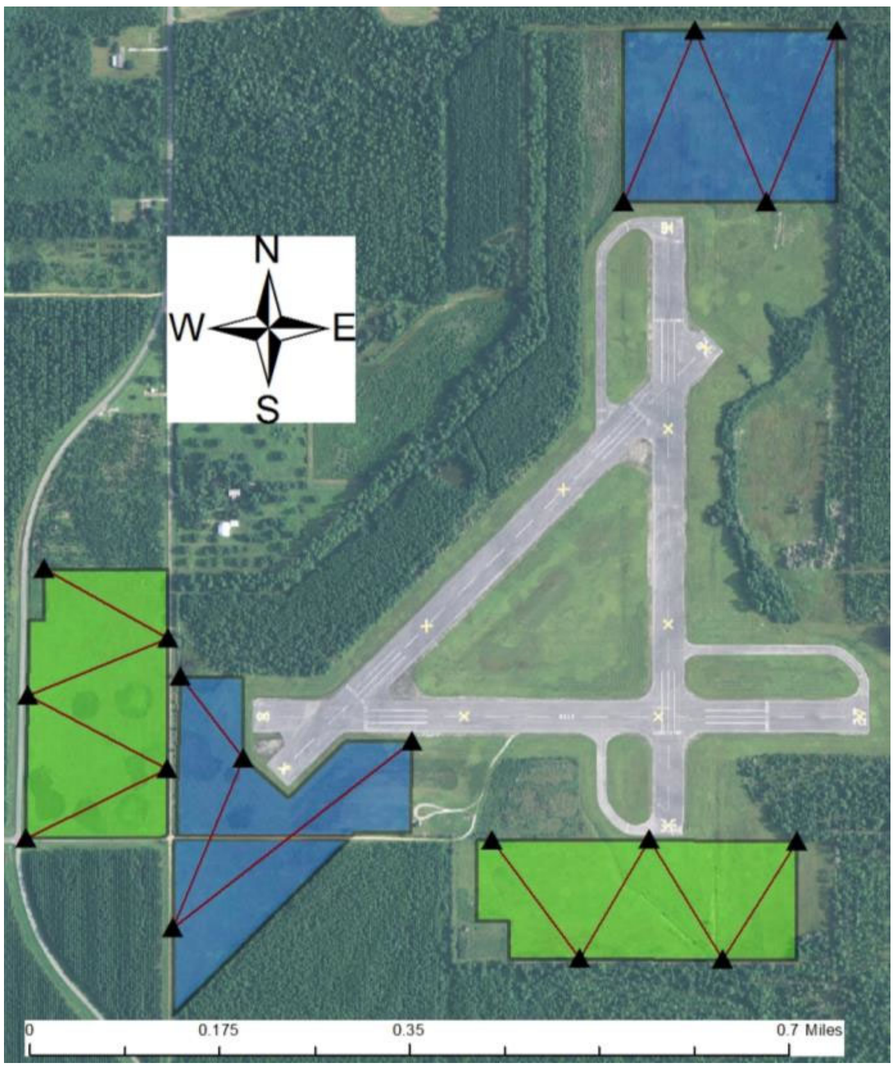


Figure 5.5.2.2. Bird line flush transect arrangement for NAS Whiting Field near, Foley, AL, for the switchgrass demonstration project. Green sites represent switchgrass demonstration areas and

blue sites will represent control sites. Black triangles represent waypoints along the line used to direct observers during sampling.

Both bird sampling methods generated a list of recorded distances to birds observed, and we used these distances to calculate relative population abundance. Specifically, the observed distances delineated a sampled area that extended out from the transect, and we approximated the density of birds within this area via a known distribution fit to the observed area (see below). By also including the identification of birds to species, we were able to discern hazardous species and calculate hazard scores. Recording which direction from the observer that a bird or flock was detected was combined with either a point count's location or a GPS-marked point on a line transect to determine the specific location of the detected bird or flock. Additional information such as time of detection (minute interval or time period), weather variables, and bird behavior were also recorded and used as covariates if necessary to investigate differences in detection probabilities among plots (e.g., do time of day or time since count began affect the probability of detecting a bird). Collection of this additional information followed standard practice during bird sampling and did not significantly affect point count or line transect sampling times.

Detection probability is the probability of a bird being detected by an observer if it is present in the sampling area. As mentioned in Section 3, information collected during sampling can be divided into primary and additional information groups. Primary information collected by both methods includes recorded distances from the observer to all detected birds, direction from observer of each detection, flock size, and bird species. Additional information such as time of detection (minute interval or time period), weather variables, and bird behavior assist with investigating differences in detection probability among plots. Most distance-based analyses can determine detection probability based on the distance of detected birds from the observer. The underlying assumption is that birds closer to the observer have a greater probability of being detected than birds further away (Buckland et al. 2001). Additional information can be included in these analyses to account for factors that may affect detection probability among sampling conditions and species compositions such as bird behavior and site treatment. For example, territorial male birds are more easily detected during the breeding season than females because they tend to be very active, call frequently, and have noticeable plumage. These characteristics can increase the probability of an observer detecting a calling male compared to a quiet female during breeding season. Accounting for detection probability differences among treatment sites helped reduce any potential collected data bias.

5.5.3 Mammal Frequency of Occurrence

Frequency of occurrence for mammals was collected using camera trap scent stations (Linhart and Knowlton 1975, Curtis et al. 2009). Two camera trap stations were located in each site to maximize viewing area of site and distance from edge while maintaining a 120 m buffer between cameras (i.e., placed at each end of rectangular sites and facing interior; Figure 5.5.3.1).

At each camera trap station, we placed cameras approximately 30 cm above the ground (~12”) on a metal fence post. We ground anchored any cameras in public access areas to prevent theft. A predator scent disk was then placed on the ground 5 m in front of the camera (fatty acid scent). Fatty acid predator scent discs were mild attractants that helped direct nearby mammals to the camera’s trigger sensitive range. We chose this lure because of minimal chance of attracting animals from outside site boundaries compared to other available predator scents or mammal feed (e.g., corn). To avoid excessive false triggers (i.e., blank pictures) due to warm vegetation triggering cameras, we adjusted camera angles to only trigger for movement within 3 m of the predator discs resulting in an 8-m radius in front of the camera. We also sprayed the same area in front of the camera with a broad-spectrum herbicide (e.g., glyphosate as active ingredient) to further minimize false triggers from plant movements. Observers conducted walk tests to ensure camera triggers for any movement between it and 3 m past the lure (i.e., any movements within the 8-m radius area). Cameras were active for 14 days after which time they were removed from the sites (i.e., camera body and SD card, mount may stay depending on airfield regulations). Pictures were arranged in folders by sites with appropriate labels of site acronym, start date, and end date (e.g., WPAF_C1_07-04-2014_07-18-2014) and then uploaded to the project’s SharePoint folder or shipped to the project manager on a jump drive. Reconyx PC900 Hyperfire Professional Semi-covert IR cameras (Reconyx Inc., Holmen, WI) were used and set to take 3 pictures for every trigger, wait 1 second between subsequent pictures, and have no quiet period between triggers. Because we used infrared (IR) cameras, mammals were detected day and night. Individual detections were defined as the camera being triggered by ≥1 individual of a target (i.e., mammal species of ≥ 10 kg) non-target mammal. If >1 individual was observed in an image when triggered, the number of detections was equal to the number of individuals observed. Consecutive pictures of the same species were considered independent when either a ≥15 minute time interval had passed, or the individual(s) was identifiably different from the previous image.

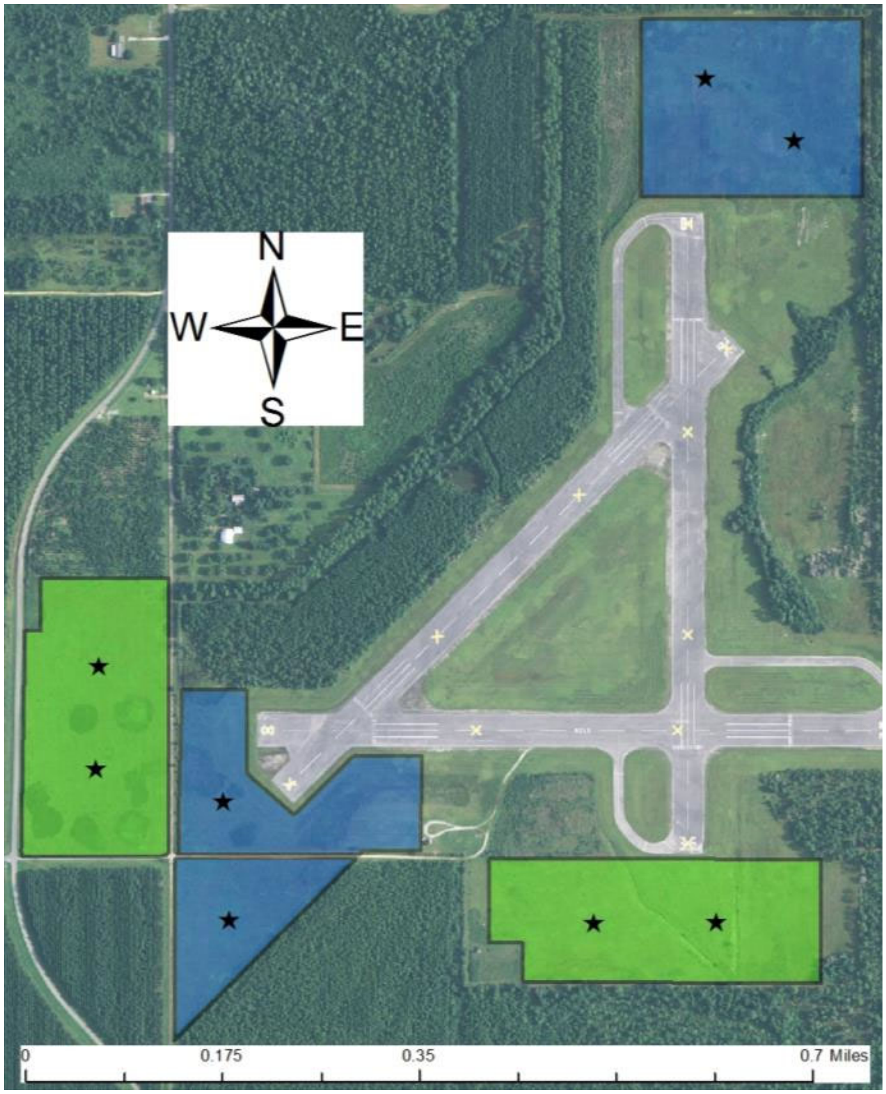


Figure 5.5.3.1. Mammal camera trap locations for NAS Whiting Field near, Foley, AL, for the switchgrass demonstration project. Green sites represent switchgrass demonstration areas and blue sites will represent control sites. Black stars represent camera trap locations. Cameras will face the interior of each site in most cases. For the southern camera trap location of the southwestern control site, the camera will face the northeast to maximize coverage of the site.

5.5.4 Maintenance Costs Assessment

Maintenance costs for switchgrass sites was collected during each management action. Maintenance costs for controls was harder to obtain as most installations were unable to track specific mowing maintenance costs. In most instances, mowing activities were included in a broad maintenance budget that accounted for variations in mowing conditions (e.g., grass height, mowing equipment used, equipment maintenance, etc.). Therefore, airport grassland maintenance costs were based on mowing costs associated with switchgrass maintenance by GRFI airport personnel, conversations with other airport personnel, and land manager costs for site preparation or post-establishment mowings.

5.6 DATA ANALYSIS

We used modern data-analysis techniques to determine how switchgrass coverage, populations of hazardous species, and maintenance costs compared within and across switchgrass fields and airfield grasslands (Blackwell et al. 2013a). For analysis by installation, we compared switchgrass and control sites using paired t-tests. This approach supported the evaluation of our performance objectives. We calculated z-scores to test for differences between treatment plots within each pair. By focusing on each installation, we were not concerned about regional effects or differences across installations as we were when conducting among installation analyses. Aspects of our conceptual design support using a mixed models approach including treatment fixed effects (e.g., switchgrass or control) and random effects of region, study installation, site pair, and species use by month interactions. Except for maintenance costs, multiple subsamples were collected for each response variable and per site resulting in a distribution of means for analysis. A distribution of means tends to be normal according to the central limit theorem in addition to helping reduce sampling and experimental error in analysis. The following descriptions pertain to each performance objective with special attention to the response variable(s) of interest and specific analysis procedures. Power analyses were conducted using $\alpha = 0.05$ and power $(1-\beta) = 0.80$.

As with any investigation, inference was constrained to the locations and time period the work was conducted. However, our design covered the primary growing range for switchgrass, thus allowing inference to its application across installations and mission types. Furthermore, the demonstration's experimental design and sampling framework accounted for variation in bird and mammal use both spatially and temporally, allowing adequate inference for making informed recommendations on use of switchgrass at military installations throughout the eastern U.S. The monthly sampling approach also allowed us to analyze data by year and seasons. Seasonal differences are expected such as bird use and local assemblages depending on bird behavior associated with breeding, fall and spring migration, and overwintering. Mammal use can depend on breeding, changes in food resources, and ambient temperature.

5.6.1 Switchgrass Coverage

Annual percent switchgrass coverage per site was calculated as the mean of 5 Daubenmire frame subsamples within each site. We used pair t-tests in program R to compare switchgrass coverage between switchgrass and control sites by installation to evaluate performance objectives (function *t.test*; R Core Team 2018). To meet performance objectives, we set alternative hypothesis limits of <40% coverage in year 1 after switchgrass planting (2015 or 2016), < 60% in year 2, and < 80% every year thereafter. Power analysis using standard deviations derived from Schmer et al. (2006) data suggested sample sizes should be > 5 pairs to observe a true difference in means of 40% during year 1 and > 3 pairs in year 2 to detect a 60% difference between means during the second year. We did not have statistics to explore sample sizes needed for detecting 80% differences after year 2. However, we only expected less than 80% coverage if switchgrass did not establish as was observed in CAFB and WHIT.

5.6.2 Bird Relative Population Abundance

We calculated mean relative population abundance bird species per month from 3 sampling events per month. We determined species-specific relative hazard scores using a combination of recent publications regarding interspecific variation in hazards and the Federal Aviation Administration's (FAA) Wildlife Strike Database (DeVault et al. 2011, 2018). We used the most current reported relative hazard scores in DeVault et al. (2011, 2018) per species or species group or calculated relative hazard scores using the log of average body mass (Cornell Lab of Ornithology 2018) when species or species groups were not mentioned in the literature. We limited species or species groups to those with $\geq$ 25 detections across all installations and sampling years during analyses. We evaluated the success of performance objectives 2 and 4 by comparing total abundance of birds, species richness, cumulative bird hazard score, and relative abundance of bird hazard categories between switchgrass and control sites by installation using paired t-tests with raw bird data (e.g., all birds detected in plots and species with $\geq$ 25 detections). Despite the possibility of dependence among plots within an installation, we assumed minimal effects on observed bird use. For further investigation of bird responses, we attempted to determine if bird relative abundances differed among treatments when accounting for avian detection probabilities using the generalized linear sampling model (*gdistsamp* function in program R; Royle 2004, Chandler et al. 2011, R Core Team 2018) in a model selection format. However, breeding (point counts) and non-breeding (line transects) bird data were zero-inflated among the 6 installations. Although *gdistsamp* and other package *unmarked* functions can handle different data distributions, zero-inflated Poisson data did not comply. We attempted multiple temporal fragments of the data and other alterations to data compilations (e.g., birds grouped by hazard category) that would increase detections per time period but were unsuccessful. Models would not converge. We also could not determine installation-specific strike risk as proposed in the Demonstration Plan. Strike reports were lacking for most participating installations (Table 6.2.1), especially BASH records for military airfields, restricting our ability to calculate strike risk as proposed in the Demonstration Plan. However, relative hazard scores and relative abundance estimates can support the development of BASH mitigation approaches by airport and airfield personnel using their institutional knowledge and any historic strike records not reported to FAA.

We evaluated the success of our performance objectives 2 and 4 by comparing total abundance of birds, species richness, and average bird hazard score between switchgrass and control sites by installation using paired t-tests. Despite the possibility of dependence among sites within an installation, we assumed minimal effects on observed bird use. For among installation evaluations, we used a multivariate generalized linear mixed model using package MCMCglmm in program R to evaluate overall bird use and hazard rate, and a univariate MCMCglmm to evaluate strike risk between switchgrass and control sites. Our multivariate responses were bird hazard categories representing bird community treatment responses. We specified treatment as switchgrass coverage due to the variable switchgrass establishment observed across installations. We specified species use and month interaction, block interaction, region, year and site interaction as random effects. We used deviance information criterion (DIC) to select the best random structure and model to be analyzed (Spiegelhalter et al. 2002). Models were run for 100,000 iterations, with a burn-in phase of 50,000 and a thinning interval of 10. Each model was run three times to assess error (Hadfield 2010) and convergence, and we selected the respective models with the least average DIC value. Success for this performance objective was demonstrated by the top model including the treatment fixed effect and an effect size indicating ≥ 15% less relative population abundance and hazard rates on switchgrass sites than controls in years 2 and 3 with 95% credible intervals of effect sizes not overlapping 0 (i.e., strong directional response to treatment).

Comparison of strike risk was not needed to meet performance objective criteria but complemented hazard rates and provided an interpretable metric for airfield managers to consider during interviews regarding our qualitative performance objective. For strike risk, success was indicated by the top model including the treatment effect and effect sizes indicating less strike risk in switchgrass sites than controls per year with 95% credible intervals not overlapping 0. Prior to the demonstration, we had calculated low (0.29), medium (0.41), and high (0.52) sample standard deviations from the "total birds" category in Schmidt et al. (2013) for power analysis. Schmidt et al. (2013) compared relative bird abundances in native warm season grass plots to airfield grasslands. Three, 4, and 6 pairs were required for a power ≥ 0.80 at low, medium, and high sample standard deviations, respectively. For the dove and pigeon category, ≥ 3 pairs would have achieved power ≥ 0.80. Considering Schmidt et al. (2013) only had 3 total pairs, and we installed 2 pairs per installation, we expected smaller standard deviations. In addition, we used average bird abundance per month during MCMCglmms which helped reduce variation and better meet normality assumptions.

Edge effects were investigated using the spatially-explicit data collected during point counts and line transects (e.g., distance and direction from observer of each bird or flock detected and GPS information from line transects). Using this information, we converted distance data to coordinates of bird and flock locations (i.e., latitude and longitude) in program R. We then determined distances from the nearest plot edge based on imported shapefiles of each installation's plots in program R. We plotted the frequency of bird detections as a function of distance from site edge and analyzed this function using regression. We limited analyses to bird hazard categories in which all species with $\geq$ 25 detections among all installations were assigned a bird hazard category as mentioned above. We also analyzed the top 10 most abundant species among installations (Table 5.6.2.6). Similarly, 'very high' and 'extremely high' bird species were combined to help meet model assumptions. Edge species were identified as species with decreasing frequency of detections as distance from edge increased ($\beta < 0$). Species with no change in frequency of detection or increasing detections as distance from edge increased were considered interior species unaffected by edge ($\beta \geq 0$). Results from this analysis complemented interpretation of bird results (e.g., differentiated how each species used each treatment).

5.6.3 Mammal Frequency of Occurrence

We calculated mammal frequency of occurrence from individual detections during monthly camera trapping surveys. Relative hazard scores of each species detected were calculated using log body mass similar to bird species (g; DeVault et al. 2011, Schwarz et al. 2014). Only mammal species or species groups with ≥ 25 detections were used in installation statistical analyses. Through use of an experimental block design (installation = block), we controlled for dependence of mammals among study installations (i.e., populations of mammals among sites within each installation are dependent). Edge effects were accounted for by placing cameras > 50 m from site edges. We used frequency of occurrence as an index of relative population abundance (Linhart and Knowlton 1975). Statistical analysis was similar to bird relative population abundance using paired t-tests and MCMCglmms. However, among installation analyses were limited to mammal species occurring in all installations (e.g., coyotes, rabbits, white-tailed deer) to avoid biased results due to species absence. Cumulative hazard scores for among installation analysis were also limited to the two species and one species group present among all sites). Success for this performance objective was demonstrated by an effect size > 15% indicating less frequency of occurrence of mammal species and hazard rates on switchgrass sites than controls in years 2 and 3. For MCMCglmms, success was determined by the top model including the switchgrass coverage effect with 95% credible intervals of effect sizes not overlapping 0 (i.e., a strong directional response to treatment). An overall treatment effect without a year effect was also accepted as representing success. As with bird relative population abundance, comparison of strike risk between switchgrass sites and controls was not needed to meet performance objective criteria but complemented hazard rates and provide an interpretable metric for airfield managers to consider during interviews regarding our qualitative performance objective (Reference number 5, 3.0 Performance Objectives).

5.6.4 Maintenance Cost Assessment

We summarized maintenance costs of treatment and control sites across all study years (2015-2017). Data was not available for an *a priori* power analysis. However, a primary success criterion for this performance objective seeks a 10% net economic gain by the third year after switchgrass establishment. We calculated net economic gain for each site as the cost difference between control and switchgrass sites divided by the total cost of switchgrass sites. We also calculated average net economic gain across installations for comparison.

6.0 PERFORMANCE ASSESSMENT

Field sampling began during bird breeding season 2015 for all installations prepared and planted and continued through April 30, 2018. Sampling effort adhered to proposed sampling frequencies resulting in nearly 3,000 samples (Table 6.0.1). The following subsections provide detailed sampling results from the above effort and data analysis.

Table 6.0.1. Number and type of samples collected per treatment site during the switchgrass demonstration project among 3 military airfields and 3 civil airports in the eastern United States from May 1, 2015 to April 20, 2018.

Sampling Protocol	Frequency of Data Collection	Total Samples[1]
Switchgrass Coverage	1 sample/year after spring 2015	68 (n=3/site)
Bird Point Counts	3 samples/breeding season month	635 (n=27/site)
Bird Line Flush Transects	3 samples/non-breeding season month	1,836 (n=81/site)
Mammal Camera Trapping	1 sample/month	816 (n=36/site)
Maintenance Cost	≥ one record/year	68 (n=3/site)

[1] Detroit Metropolitan Airport (DTWA) was not sampled until 2016 due to excessive soil moisture during summer 2015 precluding switchgrass site preparation and planting.

6.1 SWITCHGRASS COVERAGE

Switchgrass establishment efforts began in early summer 2015 for most participating installations with the exception of Detroit Metropolitan Airport (DTWA) due to excessive soil moisture (planted in 2016). Site preparation and planting techniques varied among sites (Table 6.1.1) but focused on similar goals of perpetuating optimal planting conditions for switchgrass to thrive by reducing plant competition, and for most sites, seed drilling at a relative high planting rate. Dayton International Airport (DAYT: southern plot) and Wright-Patterson Air Force Base (WPAF) in Dayton, OH, and the Gerald R. Ford International Airport (GRFI; northern plot) in Grand Rapids, MI had the best switchgrass establishment (Figure 6.1.1). Extreme soil moisture was noticeable in patches at CAFB, DAYT, and GRR in addition to some excessive plant competition at Columbus Air Force Base (CAFB), NAS Whiting Field (WHIT), and WPAF. For example, almost a quarter of DAYT's southern switchgrass site had scarce switchgrass due to wet soils in 2015, whereas the remainder of the plot had some of the tallest switchgrass throughout the remainder of the project. At WPAF, poison hemlock (*Conium maculatum*) invaded the site despite substantial competition control prior to planting. In mid-June 2016, WPAF was mowed followed by herbicide application later that month to help reduce plant competition and support switchgrass dominance. The southern switchgrass site at WHIT was covered in rattlebox (*Crotalaris* spp.), and at CAFB, foxtail (*Setaria* spp.) took advantage of reduce plant competition at germinated throughout the northern plot and part of the southern plot in addition to myriad native plants in the seed bank. A second round of planting occurred in both southern sites (CAFB and WHIT) in summer 2016 due to failed switchgrass establishment in 2015 with better establishment in WHIT than CAFB. The northern plot at DAYT was also replanted but not until June 2017 due to field conditions delaying planting in 2016.

Post-establishment management also varied among sites. In most instances, post-establishment management techniques and approaches were dependent on the local land manager providing insight and recommendations to the project manager regarding switchgrass establishment and plant competition. Ohio sites received the most post-establishment management likely supporting their success in switchgrass coverage. However, mowing at DTWA and GRFI helped with competition control of Canada thistle (*Cirsium arvense*) and other species along with switchgrass establishment. Furthermore, grass species were the primary plant competition in southern sites after the 2016 planting for which no selective herbicide exists that would control the grass competition without hurting the switchgrass.

Switchgrass coverage was measured at all sites beginning with the first October after planting (e.g., October 2015 for most sites, October 2016 for DTWA). Establishment success depended on achieving at least 40%, 60%, and 80% switchgrass coverage estimates annually beginning with the planting year and following each year thereafter. Therefore, alternative hypotheses for paired t-tests were set as coverages less than each goal (Tables 6.1.2-6.1.4). At $\alpha = 0.05$, total switchgrass coverage (e.g., planted and natural occurring) achieved 40% coverage at DAYT, DTWA (2016) and WHIT (2015 and 2016) during the first year post-planting despite high plant competition at WHIT and a relatively failed crop across the plot. However, the upper confidence interval for WHIT suggests 40% switchgrass coverage was not achieved during both October periods following planting efforts suggesting results were spurious due to high variance among samples. Both Ohio sites (DAYT and WPAF) and DTWA achieved 60% switchgrass coverage during October of the second year post-planting (Tables 6.1.2 and 6.1.3) but none of the sites, initially planted in 2015, achieved at least 80% switchgrass coverage by October 2017 (Table 6.1.4). However, DAYT's plots were not separated for analysis to account for the late replanting of the northern plot in 2017 (i.e., 2017 and 2018 switchgrass coverage of the northern switchgrass plot evaluated at 40% and 60% switchgrass coverage).

Table 6.1.1. Switchgrass establishment schedules and application rates for five airports and airfields comparing bird and mammal use between switchgrass monocultures and extant airfield grasslands in east-central United States, May-October 2015.

Year	Activity	Site[1]	Date	Rate
2015	First Herbicide Application	CAFB	May 8	1 gallon/acre glyphosate, 1/2 ounce/acre Escort
		DAYT	May 20	1.5 quart/acre glyphosate 5.4, 1 pint/acre LV6 2,4-D with 2 quarts/tank each of water conditioner and surfactant 90 N.I.S.
		GRFI	May 23	1.41 quarts/acre Roundup Powermax and 2.125 pounds/acre Ammonium Sulfate
		WHIT	July 14	1 gallon/acre Ranger Pro (glyphosate), 0.25 gallon/acre Hel-fire water conditioner
		WPAF	May 13	1.5 quart/acre glyphosate 5.4, 1 pint/acre LV6 - 2,4-D with 2 quarts/tank each of water conditioner and surfactant 90 N.I.S.
	Second Herbicide Application	CAFB	June 4	1 quart glyphosate/acre, 5 ounce/acre Plateau
		DAYT	June 2	1.25 quarts/acre glyphosate 5.4, 4 ounces Clopyralid 3, 1 quart/100 gallons each of water conditioner, Alligare surfactant
		WHIT	July 28	1 gallon/acre Ranger Pro (glyphosate), 0.25 ounces Escort/acre, 0.25 gallons/acre Hel-fire water conditioner
		WPAF	June 4, 10	1.25 quarts/acre glyphosate and 4 ounces/acre Clopyralid 3
	Switchgrass Seed Drilling[2]	CAFB	July 15	
		DAYT	June 5	
		GRFI[3]	May 27 June 9	9 pounds PLS per acre
		WHIT	August 15	
		WPAF	June 14 July 7	
	Mowing	DAYT	August 31	
		WPAF	August 25[4]	
2016	Herbicide Application[5]	CAFB	May 13	1 gallon/acre glyphosate, 1/2 ounces/acre Escort
		DAYT	May 30	1 quart/acre 2, 4-D spot-spray in southern plot
			July 1,5	1 gallon/acre Everett
		DTWA	May 23	66 ounces/acre glyphosate
		GRFI		*No 2016 management needed to date*
		WHIT	July 14	

		WPAF	June 24, 25	1 gallon/acre Everett
	Switchgrass Seed Drilling[6]	CAFB	May 13	
		DTWA	May 24, June 3	9 pounds PLS per acre
		WHIT	June 13	
	Mowing	DTWA	August 1	
		GRFI	October 11	
		WPAF	June 12[7]	
2017	Herbicide Application	DAYT	April 24	2 qts/acre Alligare Everett Herbicide (Generic Crossbow) at 15 gallons/acre plus 1.5 qts/acre glyphosate spot spray *northern plot*
			April 25	1.5 qts/acre Alligare Everett Herbicide + LV-6 2,4 D + 3 oz. Anti-Drift per 110 gallons at 15 gallons/acre *southern plot*
		WPAF	April 17	2 qts/acre Alligare Everett Herbicide (Generic Crossbow) at 15 gallons/acre
	Switchgrass Seed Drilling	DAYT	June 22	9 pounds PLS per acre – *northern plot*
	Haying	DAYT	July 26	3' X 3' X 5.5' (68 bales) and 7' diameter (46 bales) *southern plot*
		WPAF	August 12	31.5" X 34.5" X 96" bales, approximately 780 lbs each *northern plot* 120 bales *southern plot* 171 bales

[1] Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[2] Columbus Air Force Base switchgrass seed was broadcast due to soil moisture limiting equipment access.
[3] Weather restricted planting both switchgrass sites during the same day.
[4] Only the southern switchgrass site required mowing for competition (pokeweed) at WPAF.
[5] Competition control spray for existing switchgrass release (DAYT, GRFI, WPAF), burndown for planting at replanting or newly planted plots (e.g., CAFB, DTW, WHIT).
[6] Columbus Air Force Base switchgrass seed was broadcast due to soil moisture limiting equipment access.
[7] Only the southern switchgrass site required mowing for competition (poison hemlock and Canadian thistle) at WPAF.

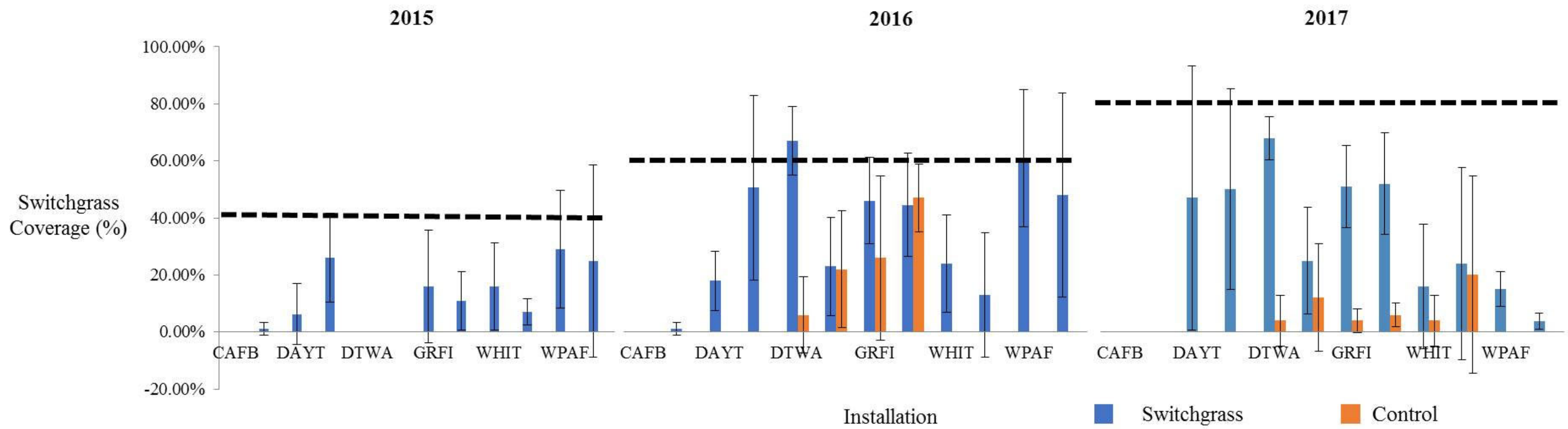


Figure 6.1.1. Switchgrass coverage in airfield grasslands and switchgrass monocultures during the first two years of switchgrass establishment, measured by Daubenmire frame in October 2015-2017. Each installation had 2 sites per treatment. Dotted horizontal lines represent switchgrass coverage goals per year of 40%, 60%, and $\geq$ 80 %. Installations included Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF). Switchgrass coverage at DTWA, CAFB, and WHIT during 2016 and 2017 were evaluated at 40% and 60% because of delayed planting (DTWA) or failed switchgrass (CAFB and WHIT) in 2015. Controls were composed of extant airfield grasslands managed according to airport or airfield common practices.

Table 6.1.2. Comparing switchgrass coverage during the first growing season of newly planted switchgrass monocultures and extant airfield grasslands, measured using Daubenmire frames in October 2015 with the null hypothesis of at least 40% coverage ($H_0 \geq 40\%$). All plots were included despite observed switchgrass establishment.

Site[1]	df	t-stat	*P*-value[2]	Upper 95%
CAFB	1	-79.00	**0.004**	0.037
DAYT	1	-2.41	0.125	0.786
GRFI	1	-10.60	**0.030**	0.293
WHIT	1	-6.33	0.050	0.399
WPAF	1	-6.50	0.049	0.396

[1] Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[2] Significant effects are in **bold** (*P*-value ≤ 0.05).

Table 6.1.3. Comparing switchgrass coverage during the first growing season of newly planted switchgrass monocultures and extant airfield grasslands, measured using Daubenmire frames in October 2016 with the null hypothesis of at least 60% coverage[1] ($H_0 \geq 60\%$). All plots were included despite lack of observed switchgrass establishment at some sites.

Site[2]	df	t-stat	*P*-value[3]	Upper 95%
CAFB	1	-79.00	**0.004**	0.037
DAYT	1	-1.58	0.180	1.372
DTWA	1	0.23	0.571	1.839
GRFI	1	-21.00	**0.015**	0.497
WHIT	1	-3.91	0.080	0.532
WPAF	1	-0.85	0.276	0.955

[1] Detroit Metropolitan Airport (DTWA) was not planted until 2016 and NAS Whiting Field (WHIT) were replanted. Hence, switchgrass coverage was tested against at least 40% coverage were these sites.
[2] Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[3] Significant effects are in **bold** (*P*-value ≤ 0.05).

Table 6.1.4. Comparing switchgrass coverage during the first growing season of newly planted switchgrass monocultures and extant airfield grasslands, measured using Daubenmire frames in October 2016 with the null hypothesis of at least 80% coverage[1] ($H_0 \geq 80\%$).. All plots were included despite lack of observed switchgrass establishment at some sites.

Site[2]	df	t-stat	*P*-value[3]	Upper 95%
CAFB	1	-	-	-
DAYT	1	-21.00	**0.015**	0.580
DTWA	1	-0.628	0.321	1.822
GRFI	1	-57.00	**0.006**	0.547
WHIT	1	-10.00	**0.032**	0.453
WPAF	1	-12.61	**0.025**	0.448

[1] Detroit Metropolitan Airport (DTWA) was not planted until 2016 and NAS Whiting Field (WHIT) were replanted in 2016. Hence, switchgrass coverage was tested against at least 60% coverage were these sites.
[2] Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[3] Significant effects are in **bold** (*P*-value ≤ 0.05).

6.2.0 Switchgrass Coverage Summary and Conclusions

Attempts to establish switchgrass followed our proposed approach of switchgrass planting, establishment, and maintenance. Similar to past studies, percent coverage of switchgrass and other species was used metric to evaluate switchgrass establishment. Following past protocols, we expected the progression of switchgrass establishment to mimic observations by Schmer et al. (2006) in which percent coverage of switchgrass would have achieved 40% of total vegetation coverage at the end of the first growing season (early fall 2015 or 2016) and 60% of total vegetation coverage by the end of the second growing season (early fall 2016 or 2017). Following this observed trend, at least 80% total vegetation coverage was likely every year thereafter. However, switchgrass establishment failed to achieve intended coverages at most installations. Switchgrass establishment efforts followed standard protocols among all sites. With the exception of Detroit Metropolitan Airport (DTWA), most sites were planted in 2015. Columbus Air Force Base (CAFB) and NAS Whiting (WHIT) were replanted in 2016 due to failed switchgrass establishment in 2015. Dayton International Airport's (DAYT) northern switchgrass site was also replanted in 2017 (see Section 5.6.1 for additional details). Wright-Patterson Air Force Base (WPAF) was only planted once.

Across all installations, switchgrass coverage did not meet performance objective #1. Variability in switchgrass establishment was expected during the first few years based on the typical progression of native warm season grass establishment during which most fields transition through a fallow field stage until achieving a preponderance of the planted species. Switchgrass failure has also been observed even in ideal situations (i.e., fallow agricultural fields; Iglay et al. *in press*) further suggesting difficulty with switchgrass establishment. Late plantings (CAFB and WHIT), excessive moisture (CAFB, DAYT, DTWA) and plant competition (all sites) interacted with establishment attempts throughout the demonstration. All attempts were made to improve switchgrass establishment success including additional planting, plant competition control, and planting earlier in the growing season. Despite variable establishment, however, all switchgrass sites experienced plant community changes (i.e., extant turfgrass progressing to mix of grasses and broadleaf weeds with or without preponderance of switchgrass) were managed as tall-grass plots with only 1-2 mowings per year when mowing was used as competition control or for haying.

6.2 BIRD RELATIVE POPULATION ABUNDANCE

Bird point counts and line flush transects were used to determine bird relative abundance (i.e., bird use) of switchgrass monoculture and control sites. Biologists observed 52 bird species at least 25 times among all point counts and line flush transects and across all sites. Biologists detected 11,856 birds using sites during 1,212 point counts. Red-winged blackbirds, European starlings, bobolinks, barn swallows, and savannah sparrows were the most abundant species observed in both treatments during the breeding season among all sites (Table 6.2.1). Overall, cumulative hazard score did not differ between treatments at any sites during bird breeding seasons (Table 6.2.2). We determined species-specific relative hazard scores using a combination of recent publications regarding interspecific variation in hazards and the Federal Aviation Administration's (FAA) Wildlife Strike Database (DeVault et al. 2011, 2018). We used the most current reported relative hazard scores in DeVault et al. (2011, 2018) per species or species group, or calculated relative hazard scores using the log of average body mass (Cornell Lab of Ornithology 2018) when species or species groups were not mentioned in the literature as suggested by DeVault et al. (2011). Total bird abundance and species richness differed between treatments during most years at DAYT and WHIT and during 2017 at CAFB (Table 6.2.2; Figure 6.2.1). For DAYT, species richness was often greater in switchgrass sites than controls (all years, 2015 and 2016), but total bird abundance was greater in switchgrass sites during 2015 and 2016 but less in switchgrass sites during 2017. Because DAYT was replanted in 2017, bird use may have changed in the northern plot from previous years causing the change in total bird abundance pattern and a lack of differences in species richness between treatments. The biologist for DAYT had noticed a small water body in the northern switchgrass site often attracting waterfowl prior to the 2017 replanting. NAS Whiting Field supported greater species richness in controls during 2015 and 2016, and across all years of study. Total bird abundance was also greater in control sites during 2016 and across all years of study. Columbus Air Force Base and WPAF both had greater species richness in control sites during 2017 in addition to CAFB having greater total bird abundance in control sites during the same year.

Table 6.2.1. Top 10 species with the most detections using point counts during breeding season (May-July 2015-2017) among 3 airfields and 3 airports comparing bird used between switchgrass monocultures and extant airfield grassland. Only identified species using a treatment plot (switchgrass or control) were included. Detections of transient individuals (i.e., flyovers) were excluded.

		Count (*n*)				
Site[1]	Species	Total	Switchgrass	Control	Hazard Category[2]	Hazard Score[3]
All	Red-winged blackbird	2764	1672	1092	Low	12
	European starling	2219	1478	741	Moderate	11
	Bobolink	1007	217	790	Moderate	5
	Barn swallow	971	482	489	Very low	3
	Savannah sparrow	804	359	445	Low	6
	Eastern meadowlark	709	200	509	Low	7
	Killdeer	457	386	71	Low	7
	American robin	417	251	166	High	7
	American goldfinch	351	233	118	Very low	5
	Tree swallow	296	75	221	Very low	1
CAFB	Eastern meadowlark	172	77	95	Low	7
	Barn swallow	57	23	34	Very low	3
	Bobolink	10	0	10	Moderate	5
	Mourning dove	10	6	4	Moderate	9
	Red-winged blackbird	5	1	4	Low	12
	Killdeer	4	3	1	Low	7
	Brown-headed cowbird	2	1	1	Very low	3
	Carolina wren	2	1	1	Very low	3
	Tree swallow	2	1	1	Very low	1
	American crow	1	0	1	High	69
DAYT	Red-winged blackbird	931	515	416	Low	12
	European starling	854	696	158	Moderate	11
	Savannah sparrow	317	99	218	Low	6
	Eastern meadowlark	303	30	273	Low	7
	Barn swallow	288	141	147	Very low	3
	Killdeer	175	168	7	Low	7
	Song sparrow	102	41	61	Very low	0
	American goldfinch	82	76	6	Very low	5
	Mourning dove	72	35	37	Moderate	9
	Long-billed dowitcher	68	68	0	Very low	11
DTWA	Barn swallow	346	158	188	Very low	3
	Red-winged blackbird	248	137	111	Low	12
	European starling	170	71	99	Moderate	11

	Savannah sparrow	160	73	87	Low	6
	Bobolink	126	84	42	Moderate	5
	Chipping sparrow	90	37	53	Very low	4
	Eastern meadowlark	81	29	52	Low	7
	American goldfinch	77	52	25	Very low	5
	Killdeer	68	11	57	Low	7
	Mourning dove	37	20	17	Moderate	9
GRFI	Bobolink	797	121	676	Moderate	5
	Red-winged blackbird	360	198	162	Low	12
	Savannah sparrow	271	170	101	Low	6
	Chipping sparrow	129	78	51	Very low	4
	Barn swallow	109	65	44	Very low	3
	Eastern meadowlark	99	45	54	Low	7
	American goldfinch	36	34	2	Very low	5
	Field sparrow	31	16	15	Very low	4
	European starling	23	13	10	Moderate	11
	Mourning dove	17	6	11	Moderate	9
WHIT	Savannah sparrow	39	0	39	Low	6
	Barn swallow	34	9	25	Very low	3
	Eastern meadowlark	26	10	16	Low	7
	Turkey vulture	21	4	17	Extremely high	94
	Mourning dove	20	6	14	Moderate	9
	Tree swallow	20	5	15	Very low	1
	European starling	17	3	14	Moderate	11
	Canada goose	12	0	12	Extremely high	87
	Killdeer	10	4	6	Low	7
	Eastern wild turkey	10	7	3	Very high	66
WPAF	Red-winged blackbird	1220	821	399	Low	12
	European starling	1155	695	460	Moderate	11
	American robin	337	190	147	High	7
	Tree swallow	273	69	204	Very low	1
	Killdeer	197	197	0	Low	7
	American goldfinch	156	71	85	Very low	5
	Barn swallow	137	86	51	Very low	3
	Chimney swift	84	38	46	Very low	2
	House finch	78	49	29	Very low	3
	Mourning dove	78	62	16	Moderate	9

[1] Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTW), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

[2] Hazard categories were determined following Dolbeer and Wright (2009) recommendations and using reported civil bird airstrikes from 1990 to April 30, 2018 from the Federal Aviation Administration's Wildlife Strike Database. Bird strike records from within the airport environment (e.g., < 457 m above ground; Dolbeer and Begier 2012), excluding carcasses (e.g., "Carcass Found" recorded in 'Person' column of under in FAA's Wildlife Strike Database), were included.

[3] Species-specific relative hazard scores were determined using a combination of recent publications regarding interspecific variation in hazards and the Federal Aviation Administration's (FAA) Wildlife Strike Database (DeVault et al. 2011, 2018) or calculated relative hazard scores using the log of average body mass (Cornell Lab of Ornithology 2018) when species or species groups were not mentioned in the literature.

Table 6.2.2. Bird community characteristics from morning point counts in switchgrass monocultures and extant airfield grasslands on 3 airfields and 3 airports in the eastern United States from May-July 2015 - 2017. Positive responses indicated greater values in controls than switchgrass monocultures.

Site[1]	Year	Response Variable	df	t-stat	*P*-value[2]	95% Confidence Interval		Mean Difference
CAFB	All	Total Abundance	50	1.61	0.114	-0.19	1.76	0.78
		Species Richness	50	1.44	0.156	-0.10	0.61	0.25
		Cumulative Hazard Score	50	1.01	0.318	-44.21	133.58	44.69
	2015	Total Abundance	16	-0.30	0.771	-1.44	1.09	-0.18
		Species Richness	16	0.49	0.632	-0.39	0.63	0.12
		Cumulative Hazard Score	16	-0.06	0.950	-167.32	157.56	-4.88
	2016	Total Abundance	15	-0.13	0.897	-2.15	1.90	-0.13
		Species Richness	15	-0.37	0.718	-0.85	0.60	-0.13
		Cumulative Hazard Score	15	0.90	0.381	-121.80	300.80	89.50
	2017	Total Abundance	17	3.01	**0.008**	0.75	4.25	2.50
		Species Richness	17	2.32	**0.033**	0.07	1.38	0.72
		Cumulative Hazard Score	17	0.92	0.370	-66.77	170.10	51.67
DAYT	All	Total Abundance	49	-1.75	0.086	-30.47	2.07	-14.20
		Species Richness	49	-3.89	**≤ 0.001**	-2.12	-0.68	-1.40
		Cumulative Hazard Score	49	1.33	0.191	-30.44	148.44	59.00
	2015	Total Abundance	13	-2.36	**0.035**	-94.43	-4.14	-49.29
		Species Richness	13	-2.67	**0.019**	-2.71	-0.29	-1.50
		Cumulative Hazard Score	13	0.76	0.460	-185.52	387.80	101.14
	2016	Total Abundance	17	-2.13	**0.048**	-43.44	-0.23	-21.83
		Species Richness	17	-3.17	**0.006**	-3.79	-0.76	-2.28
		Cumulative Hazard Score	17	0.88	0.390	-39.18	95.52	28.17
	2017	Total Abundance	17	3.85	**≤ 0.001**	9.36	32.08	20.72
		Species Richness	17	-0.91	0.374	-1.47	0.58	-0.44
		Cumulative Hazard Score	17	0.88	0.393	-80.18	194.29	57.06

DTWA	Both	Total Abundance	35	0.55	0.584	-4.01	7.01	1.50
		Species Richness	35	0.28	0.778	-0.68	0.91	0.11
		Cumulative Hazard Score	35	-1.17	0.249	-113.11	30.33	-41.39
	2016	Total Abundance	16	0.73	0.474	-7.12	14.65	3.76
		Species Richness	16	0.35	0.733	-0.90	1.26	0.18
		Cumulative Hazard Score	16	-1.79	0.093	-201.90	17.31	-92.29
	2017	Total Abundance	17	-0.62	0.540	-5.59	3.04	-1.28
		Species Richness	17	-0.34	0.736	-1.59	1.15	-0.22
		Cumulative Hazard Score	17	0.08	0.941	-99.15	106.48	3.67
GRFI	Both	Total Abundance	35	1.71	0.096	-1.81	21.31	9.75
		Species Richness	35	-0.09	0.932	-0.69	0.63	-0.03
		Cumulative Hazard Score	35	-1.51	0.141	-330.30	49.02	-140.64
	2016	Total Abundance	17	1.33	0.201	-8.63	38.07	14.72
		Species Richness	17	-0.98	0.341	-1.23	0.45	-0.39
		Cumulative Hazard Score	17	-1.38	0.184	-244.16	50.71	-96.72
	2017	Total Abundance	17	1.66	0.114	-1.28	10.83	4.78
		Species Richness	17	0.65	0.523	-0.75	1.41	0.33
		Cumulative Hazard Score	17	-1.05	0.308	-554.99	185.88	-184.56
WHIT	All	Total Abundance	25	4.27	**≤ 0.001**	2.29	6.55	4.42
		Species Richness	25	5.19	**≤ 0.001**	0.74	1.72	1.23
		Cumulative Hazard Score	25	-0.86	0.396	-169.40	69.32	-50.04
	2015	Total Abundance	5	1.85	0.123	-1.55	9.55	4.00
		Species Richness	5	2.71	**0.042**	0.04	1.62	0.83
		Cumulative Hazard Score	5	-0.22	0.835	-430.92	363.26	-33.83
	2016	Total Abundance	13	3.50	**0.004**	2.02	8.55	5.29
		Species Richness	13	5.06	**≤ 0.001**	0.94	2.34	1.64
		Cumulative Hazard Score	13	-0.13	0.898	-173.51	153.80	-9.86
	2017	Total Abundance	5	1.45	0.207	-2.20	7.86	2.83
		Species Richness	5	1.20	0.286	-0.77	2.10	0.67
		Cumulative Hazard Score	5	-1.53	0.186	-428.07	108.07	-160.00

WPAF	All	Total Abundance	49	-1.72	0.092	-28.20	2.20	-13.00
		Species Richness	49	1.79	0.079	-0.07	1.27	0.60
		Cumulative Hazard Score	49	-1.38	0.173	-278.88	51.60	-113.64
	2015	Total Abundance	13	-1.84	0.088	-91.68	7.25	-42.21
		Species Richness	13	1.05	0.315	-0.76	2.19	0.71
		Cumulative Hazard Score	13	0.99	0.342	-58.82	157.82	49.50
	2016	Total Abundance	17	-1.04	0.312	-25.89	8.78	-8.56
		Species Richness	17	-1.14	0.269	-1.42	0.42	-0.50
		Cumulative Hazard Score	17	0.11	0.910	-145.43	162.10	8.33
	2017	Total Abundance	17	1.22	0.239	-3.85	14.40	5.28
		Species Richness	17	2.97	**0.009**	0.47	2.76	1.61
		Cumulative Hazard Score	17	-1.78	0.093	-792.76	67.76	-362.50

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

[2] Significant effects are in **bold** (*P*-value ≤ 0.05).

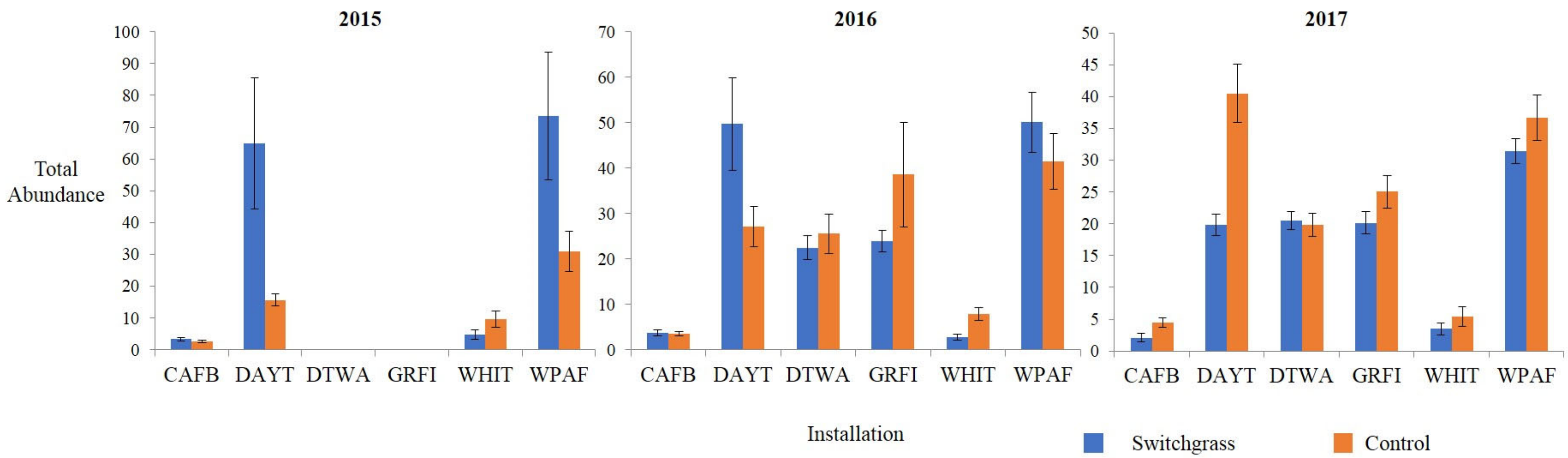


Figure 6.2.1. Total abundance of bird communities observed during morning point counts in switchgrass monocultures and extant airfield grasslands on 3 airfields and 3 airports in the eastern United States from May-July 2015 - 2017. Installations included Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

Cumulative hazard scores (CHS) can also reveal extreme observations during which the cumulative hazard score per point count indicates observations of large flocks and or many individuals of high hazard to aircraft. Across all breeding bird seasons (2015-2017), three levels (e.g., Low, Medium, High; Dolbeer and Wright 2009) of CHS were summarized by treatment (Figure 6.2.2). Among 1,212 point counts, 579 High CHS observations were made with slightly more in switchgrass monocultures (*n* = 292 observations) than control sites (*n* = 287 observations). Most (n = 65 point counts) point counts with High CHS occurred during 2016 followed by 2017 (n = 35 point counts) and 2015 (n = 30 point counts) and at Ohio sites (83.8%). Despite 37 bird species contributing to observations of High CHS, 15 bird species had $\geq$ 300 CHS contributed per year (see below). European starlings and mallards contributed to High CHS all study years whereas Canada goose, Killdeer, Red-winged blackbirds, and Turkey vultures contributed in 2 years only. The maximum species-specific CHS per point count were European starlings at a WPAF switchgrass site in 2015 (CHS=2,750) and DAYT control site in 2017 (CHS = 715), and Bobolinks at a GRFI control site in 2016 (CHS = 1005). Across all years, Red-winged blackbirds and European starlings were always in the top 5 species contributing to High CHS. In 2015, extreme observations (High CHS) of Red-winged blackbirds (84.6%) and European starlings (94.1%) were almost exclusively in DAYT and WPAF switchgrass sites (i.e., switchgrass establishment year) similar to 2016 [Red-winged blackbirds (78.3%) and European starlings (65.5%)] and 2017 [Red-winged blackbirds (40.0%) and European starlings (0.0%)].

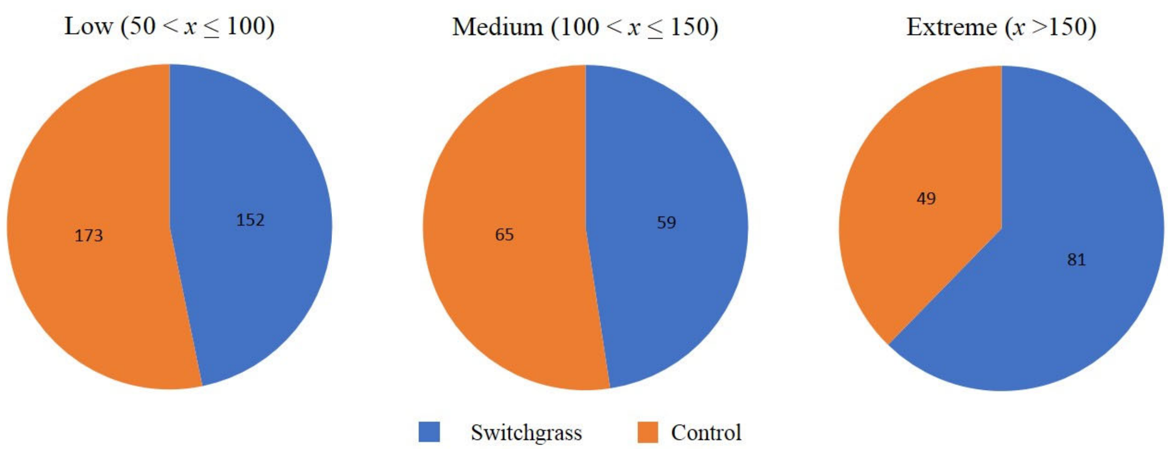


Figure 6.2.2. Number of extreme observations (number in each slice) indicated by the Cumulative Hazard Score (CHS) per point count from morning point counts between switchgrass monocultures and extant airfield grasslands in east central United States from May-July 2015-2017.

Investigations of bird community differences between treatments also included representing bird species by hazard category (Dolbeer and Wright 2009). Species with greater percentages of reported damaging strikes were assigned a greater hazard category (e.g., 'extremely high') compared to species with fewer damaging impacts or interactions with aircraft (e.g., 'very low'; Table 6.2.4). Hazard categories were based on reported civil bird airstrikes from 1990 to April 30, 2018 from the Federal Aviation Administration's Wildlife Strike Database. We only included bird strike records from within the airport environment (e.g., ≤ 457 m above ground; Dolbeer and Begier 2012) and excluded carcasses (e.g., "Carcass Found" recorded in 'Person' column of under in FAA's Wildlife Strike Database).

Table 6.2.4. Hazard category classifications from Dolbeer and Wright (2009) based on the percentage of bird strikes per species causing damage and reported in the Federal Aviation Administration's Wildlife Strike Database.

Hazard Category	Percentage of Total Strikes Causing Damage
Extremely High	> 40 %
Very High	20% ≤ x ≤ 40%
High	10% ≤ x < 20%
Moderate	4% ≤ x < 10%
Low	1% < x < 4%
Very Low	≤ 1%

'Very high' and 'high' hazard species differed between treatments at DAYT and DTWA (Table 6.2.5; Figure 6.2.3). For DAYT, 'very high' hazard species were more abundant in switchgrass sites during 2015 and across all years of data. 'High' hazard species were greater in switchgrass sites in 2017 and across all years. 'Moderate' hazard species were greater in switchgrass sites in 2015. Across 2016 and 2017, DTWA observed greater relative abundance of 'high' hazard species in switchgrass sites. 'Moderate' hazard species abundances were greater in switchgrass sites in DAYT during 2015 but greater in controls at GRFI and WHIT during 2017. 'Low' hazard species were more abundant in control sites at DAYT in 2017 and WHIT during most years while WPAF had greater abundances of 'low' hazard species in switchgrass during all years. 'Very low' hazard species were more abundance in switchgrass sites at GRFI across all years and in 2016 but more abundance in control sites during 2015 at WPAF and 2017 at CAFB.

Table 6.2.5. Comparing relative abundance of birds by hazard categories (Dolbeer and Wright 2009) from morning point counts between switchgrass monocultures and extant airfield grasslands in east central United States from May-July 2015-2017. Positive responses indicated greater values in controls than switchgrass monocultures.

Site[1]	Year	Hazard Category	df	t-stat	P-value[2]	95% Confidence Interval		Mean Difference
CAFB	All	Extremely High	50	1.00	0.322	-0.02	0.06	0.02
		Very High	50	1.00	0.322	-0.02	0.06	0.02
		High	50	1.00	0.322	-0.02	0.06	0.02
		Moderate	50	0.69	0.495	-0.30	0.62	0.16

		Low	50	1.04	0.305	-0.33	1.04	0.35
		Very Low	50	1.18	0.242	-0.15	0.58	0.22
	2015	Extremely High	16	1.00	0.332	-0.07	0.18	0.06
		Very High	16	1.00	0.332	-0.07	0.18	0.06
		High	16	1.00	0.332	-0.07	0.18	0.06
		Low	16	-0.61	0.552	-1.59	0.88	-0.35
		Very Low	16	0.00	1.000	-0.51	0.51	0.00
	2016	Moderate	15	-0.72	0.483	-0.99	0.49	-0.25
		Low	15	0.47	0.647	-1.11	1.74	0.31
		Very Low	15	-0.47	0.646	-1.04	0.67	-0.19
	2017	Moderate	17	1.19	0.250	-0.52	1.85	0.67
		Low	17	2.08	0.053	-0.02	2.13	1.06
		Very Low	17	2.96	**0.009**	0.22	1.33	0.78
DAYT	All	Extremely High	49	-1.00	0.322	-0.06	0.02	-0.02
		Very High	49	-2.82	**0.007**	-2.98	-0.50	-1.74
		High	49	-3.26	**0.002**	-0.84	-0.20	-0.52
		Moderate	49	-1.65	0.105	-23.91	2.35	-10.78
		Low	49	0.50	0.622	-4.09	6.77	1.34
		Very Low	49	-1.34	0.186	-6.20	1.24	-2.48
	2015	Very High	13	-2.36	**0.035**	-2.87	-0.13	-1.50
		High	13	-0.56	0.583	-0.35	0.20	-0.07
		Moderate	13	-2.23	**0.044**	-86.47	-1.39	-43.93
		Low	13	-0.89	0.390	-9.80	4.09	-2.86
		Very Low	13	-0.63	0.538	-4.10	2.25	-0.93
	2016	Extremely High	17	-1.00	0.331	-0.17	0.06	-0.06
		Very High	17	-1.96	0.066	-6.46	0.24	-3.11
		High	17	-1.83	0.085	-1.32	0.10	-0.61
		Moderate	17	-0.13	0.902	-11.87	10.53	-0.67
		Low	17	-1.85	0.081	-19.01	1.24	-8.89
		Very Low	17	-1.99	0.063	-17.52	0.52	-8.50
	2017	Very High	17	-1.71	0.106	-1.24	0.13	-0.56
		High	17	-2.96	**0.009**	-1.33	-0.22	-0.78
		Moderate	17	1.38	0.185	-2.58	12.36	4.89
		Low	17	4.35	**≤ 0.001**	7.64	22.02	14.83

		Very Low	17	1.14	0.271	-2.00	6.66	2.33
DTWA	All	Extremely High	35	1.36	0.183	-0.04	0.21	0.08
		Very High	35	0.15	0.884	-0.36	0.41	0.03
		High	35	-2.19	**0.035**	-0.70	-0.03	-0.36
		Moderate	35	-0.12	0.906	-4.53	4.03	-0.25
		Low	35	1.38	0.175	-0.74	3.91	1.58
		Very Low	35	0.39	0.702	-1.77	2.61	0.42
	2016	Very High	16	1.32	0.206	-0.18	0.77	0.29
		High	16	-1.14	0.269	-0.50	0.15	-0.18
		Moderate	16	-0.26	0.796	-10.12	7.89	-1.12
		Low	16	1.62	0.126	-0.86	6.39	2.76
		Very Low	16	1.32	0.204	-1.20	5.20	2.00
	2017	Extremely High	17	1.37	0.187	-0.09	0.42	0.17
		Very High	17	-0.78	0.449	-0.83	0.38	-0.22
		High	17	-1.53	0.145	-1.32	0.21	-0.56
		Moderate	17	0.14	0.889	-2.31	2.64	0.17
		Low	17	0.37	0.718	-2.37	3.37	0.50
		Very Low	17	-1.10	0.287	-3.89	1.23	-1.33
GRFI	All	Extremely High	35	-1.43	0.160	-0.40	0.07	-0.17
		Very High	35	1.78	0.083	-0.01	0.18	0.08
		High	35	-1.21	0.233	-0.59	0.15	-0.22
		Moderate	35	2.74	**0.010**	3.97	26.81	15.39
		Low	35	-3.22	**0.003**	-4.57	-1.04	-2.81
		Very Low	35	-3.36	**0.002**	-4.06	-1.00	-2.53
	2016	Extremely High	17	-1.00	0.331	-0.52	0.18	-0.17
		Very High	17	1.46	0.163	-0.05	0.27	0.11
		High	17	-1.16	0.261	-1.10	0.32	-0.39
		Moderate	17	1.97	0.066	-1.55	44.55	21.50
		Low	17	-2.55	**0.021**	-6.70	-0.63	-3.67
		Very Low	17	-2.68	**0.016**	-4.76	-0.57	-2.67
	2017	Extremely High	17	-1.00	0.331	-0.52	0.18	-0.17
		Very High	17	1.00	0.331	-0.06	0.17	0.06
		High	17	-0.37	0.717	-0.37	0.26	-0.06
		Moderate	17	3.60	**0.002**	3.84	14.71	9.28
		Low	17	-1.97	0.065	-4.02	0.13	-1.94

		Very Low	17	-2.06	0.055	-4.84	0.06	-2.39
WHIT	All	Extremely High	25	1.77	0.088	-0.15	2.08	0.96
		Very High	25	0.00	1.000	-0.68	0.68	0.00
		High	25	-0.27	0.788	-0.33	0.25	-0.04
		Moderate	25	1.69	0.104	-0.19	1.88	0.85
		Low	25	5.09	**≤ 0.001**	1.08	2.54	1.81
		Very Low	25	1.09	0.287	-0.76	2.45	0.85
	2015	Extremely High	5	1.19	0.287	-2.71	7.37	2.33
		Very High	5	1.00	0.363	-0.79	1.79	0.50
		High	5	-1.00	0.363	-1.79	0.79	-0.50
		Moderate	5	0.79	0.465	-0.75	1.42	0.33
		Low	5	3.58	**0.016**	0.80	4.87	2.83
		Very Low	5	-1.14	0.304	-4.87	1.87	-1.50
	2016	Extremely High	13	0.98	0.346	-0.60	1.60	0.50
		Very High	13	-0.25	0.807	-1.38	1.09	-0.14
		High	13	1.00	0.336	-0.17	0.45	0.14
		Moderate	13	1.70	0.113	-0.40	3.40	1.50
		Low	13	4.48	**≤ 0.001**	1.07	3.07	2.07
		Very Low	13	1.26	0.229	-0.86	3.29	1.21
	2017	Extremely High	5	1.00	0.363	-1.05	2.38	0.67
		Very High	5	-1.00	0.363	-0.60	0.26	-0.17
		Moderate	5	-0.54	0.611	-0.96	0.62	-0.17
		Low	5	1.00	0.363	-0.26	0.60	0.17
		Very Low	5	1.14	0.305	-2.92	7.59	2.33
WPAF	All	Very High	49	-1.14	0.261	-0.17	0.05	-0.06
		High	49	0.32	0.747	-2.08	2.88	0.40
		Moderate	49	-0.60	0.552	-17.86	9.66	-4.10
		Low	49	-4.55	**≤ 0.001**	-18.77	-7.27	-13.02
		Very Low	49	2.60	**0.012**	0.86	6.70	3.78
	2015	Very High	13	-1.75	0.104	-0.64	0.07	-0.29
		High	13	-1.07	0.306	-12.11	4.11	-4.00
		Moderate	13	-1.29	0.221	-75.19	19.05	-28.07
		Low	13	-2.37	**0.034**	-29.33	-1.38	-15.36
		Very Low	13	2.37	**0.034**	0.48	10.52	5.50

2016	Very High	17	1.00	0.331	-0.06	0.17	0.06
	High	17	1.79	0.092	-0.45	5.45	2.50
	Moderate	17	0.23	0.822	-12.79	15.90	1.56
	Low	17	-2.70	**0.015**	-25.75	-3.14	-14.44
	Very Low	17	0.66	0.520	-3.93	7.48	1.78
2017	High	17	2.29	0.035	0.13	3.31	1.72
	Moderate	17	3.07	**0.007**	2.78	15.00	8.89
	Low	17	-2.96	0.009	-16.75	-2.80	-9.78
	Very Low	17	1.82	0.086	-0.71	9.60	4.44

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTW), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

[2] Significant effects are in **bold** (*P*-value $\leq$ 0.05).

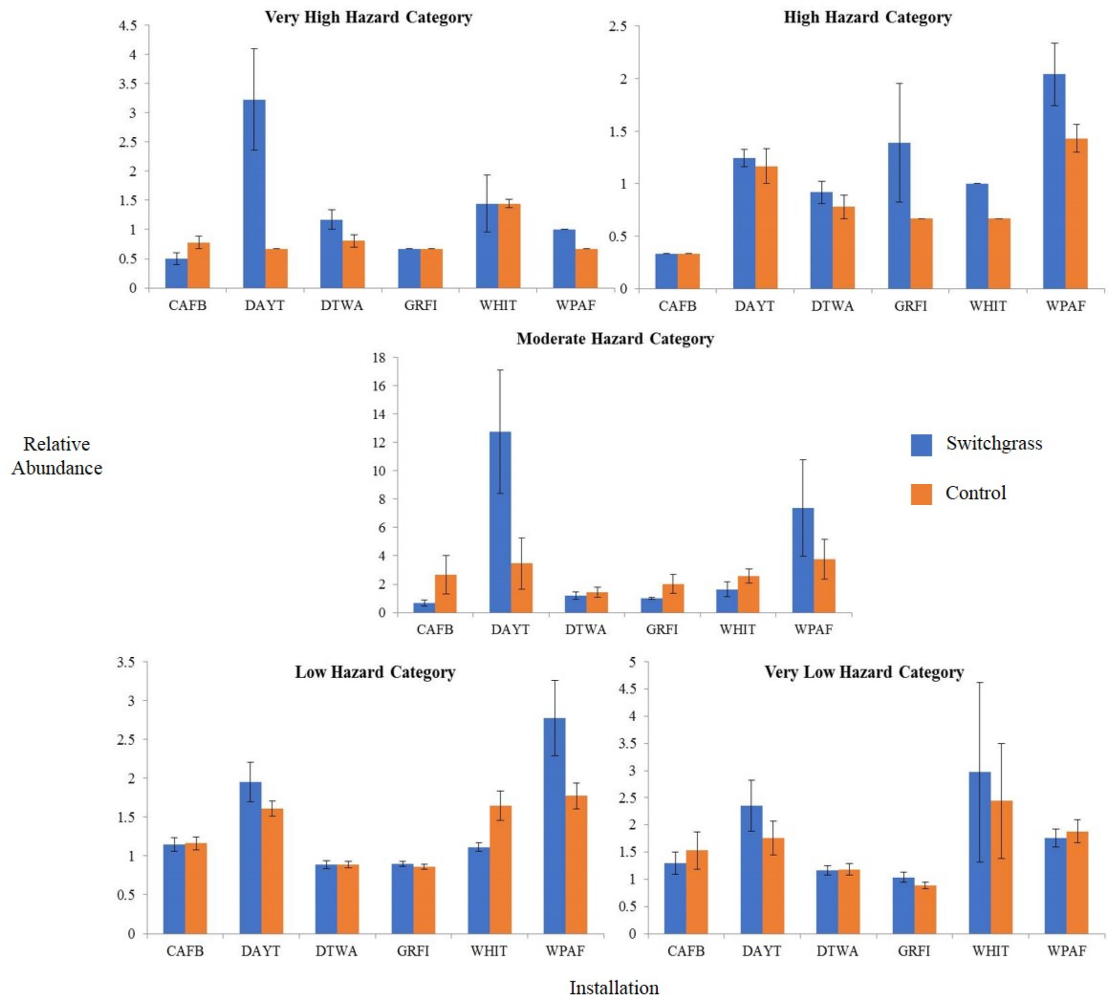


Figure 6.2.3. Average relative abundance across all years per observation of birds by hazard categories (Dolbeer and Wright 2009) from morning point counts between switchgrass monocultures and extant airfield grasslands in east central United States from May-July 2015-2017. Installations included Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

Biologists detected 24,599 birds in sites during 1,170 line transects. European starlings, Red-winged blackbirds, Eastern meadowlarks, Savannah sparrows and American robins were the most abundant species observed in both treatments during the non-breeding season among all sites (Table 6.2.6). Cumulative hazard score differed between treatments at DAYT and WPAF during the bird non-breeding season (August through April: Table 6.2.7; Figure 6.2.4). Cumulative hazard score was greater in controls in DAYT during August – December 2015 but greater in switchgrass sites at WPAF during January-April and August – December 2016. Species richness was greater in control sites at DTWA and WHIT across all years and during January-April and August – December 2016 (Figure 6.2.4). Species richness was greater in switchgrass sites for CAFB (all years, January-April and August – December 2017 and January-April 2018) and DAYT (all years, January-April and August – December 2016 and 2017, January-April 2018). Total bird abundance was greater in controls at WHIT across all years and January-April and August – December 2016-2017 (Figure 6.2.4). However, total bird abundance was greater in switchgrass at CAFB across all years and during January-April and August – December 2016 and 2017 and January-April 2018.

Table 6.2.6. Top 10 species with the most detections from line transects during non-breeding season (August-April) among 3 airfields and 3 airports comparing bird used between switchgrass monocultures and extant airfield grassland in east central United States from August-December 2015 and January-April and August-December 2016-2017 and January-April 2018. Only identified species using a treatment plot (switchgrass or control) were included. Detections of transient individuals (i.e., flyovers) were excluded.

		Count (*n*)				
Site[1]	Species	Total	Switchgrass	Control	Hazard Category[2]	Hazard Score[3]
All	European starling	5138	1942	3196	Moderate	11
	Red-winged blackbird	4614	4047	567	Low	12
	Eastern meadowlark	2082	614	1468	Low	7
	Savannah sparrow	2024	1304	720	Low	6
	American robin	1635	713	922	High	7
	Song sparrow	1391	1275	116	Very low	0
	Black-capped chickadee	1388	1360	28	Moderate	7
	Mourning dove	985	713	272	Moderate	9
	Killdeer	550	442	108	Low	7
	Barn swallow	525	254	271	Very low	3
CAFB	Eastern meadowlark	497	213	284	Low	7
	Savannah sparrow	448	398	50	Low	6
	Song sparrow	382	337	45	Very low	0
	Wilson's snipe	120	53	67	Moderate	11
	Barn swallow	117	86	31	Very low	3
	American robin	75	75	0	High	7
	Tree swallow	71	30	41	Very low	1

	Killdeer	34	32	2	Low	7
	Mourning dove	22	20	2	Moderate	9
	Brown-headed cowbird	17	17	0	Very low	3
DAYT	European starling	2355	687	1668	Moderate	11
	Eastern meadowlark	951	143	808	Low	7
	Savannah sparrow	739	475	264	Low	6
	Red-winged blackbird	560	418	142	Low	12
	Mourning dove	421	345	76	Moderate	9
	Song sparrow	418	366	52	Very low	0
	American tree sparrow	389	389	0	Very low	1
	Killdeer	274	254	20	Low	7
	Brown-headed cowbird	259	259	0	Very low	3
	Black-capped chickadee	243	243	0	Moderate	7
DTWA	European starling	393	258	135	Moderate	11
	Mourning dove	202	127	75	Moderate	9
	Red-winged blackbird	183	110	73	Low	12
	Field sparrow	134	55	79	Very low	4
	Barn swallow	127	85	42	Very low	3
	Savannah sparrow	79	35	44	Low	6
	Canada goose	76	13	63	Extremely high	87
	Killdeer	75	16	59	Low	7
	American goldfinch	74	32	42	Very low	5
	Eastern meadowlark	62	25	37	Low	7
GRFI	European starling	351	307	44	Moderate	11
	Savannah sparrow	326	215	111	Low	6
	Red-winged blackbird	187	84	103	Low	12
	Eastern meadowlark	185	59	126	Low	7
	Field sparrow	138	91	47	Very low	4
	Bobolink	122	57	65	Moderate	5
	Barn swallow	57	5	52	Very low	3
	Canada goose	49	9	37	Extremely high	87
	Wilson’s snipe	33	13	20	Moderate	11
	American goldfinch	24	4	20	Very low	5
WHIT	Eastern meadowlark	318	199	119	Low	7
	Savannah sparrow	317	128	189	Low	6
	Mourning dove	89	29	60	Moderate	9
	Common grackle	88	52	36	Moderate	11
	Barn swallow	78	27	51	Very low	3
	Turkey vulture	60	34	26	Extremely high	94
	Killdeer	58	54	4	Low	7
	Purple martin	50	4	46	Moderate	12
	American crow	45	23	22	High	69

	Northern bobwhite	18	14	4	Very high	18
WPAF	Red-winged blackbird	3677	3428	249	Low	12
	European starling	2039	690	1349	Moderate	11
	American robin	1417	538	879	High	7
	Black-capped chickadee	1145	1117	28	Moderate	7
	Song sparrow	569	564	5	Very low	0
	Bobolink	251	251	0	Moderate	5
	Mourning dove	228	160	68	Moderate	9
	Eastern bluebird	211	22	189	Very low	5
	Tree swallow	184	42	142	Very low	1
	Chipping sparrow	159	8	151	Very low	4

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTW), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[2] Hazard categories were determined following Dolbeer and Wright (2009) recommendations and using reported civil bird airstrikes from 1990 to April 30, 2018 from the Federal Aviation Administration's Wildlife Strike Database. Bird strike records from within the airport environment (e.g., < 457 m above ground; Dolbeer and Begier 2012), excluding carcasses (e.g., "Carcass Found" recorded in 'Person' column of under in FAA's Wildlife Strike Database), were included.
[3] Species-specific relative hazard scores were determined using a combination of recent publications regarding interspecific variation in hazards and the Federal Aviation Administration's (FAA) Wildlife Strike Database (DeVault et al. 2011, 2018) or calculated relative hazard scores using the log of average body mass (Cornell Lab of Ornithology 2018) when species or species groups were not mentioned in the literature.

Table 6.2.7. Bird community characteristics from morning line transects in switchgrass monocultures and extant airfield grasslands on 3 airfields and 2 airports in east central United States from August-December 2015-2017 and January-April 2016-2018. Positive responses indicated greater values in controls than switchgrass monocultures.

Site[1]	Year	Response Variable	df	t-stat	*P*-value[2]	95% Confidence Interval		Mean Difference
CAFB	All	Total Abundance	157	-6.09	**≤ 0.001**	-0.007	-0.004	-0.005
		Species Richness	157	-5.20	**≤ 0.001**	-0.795	-0.357	-0.576
		Cumulative Hazard Score	157	-1.322	0.188	-0.813	0.161	-0.326
	2015	Total Abundance	27	-0.81	0.426	-0.006	0.003	-0.002
		Species Richness	27	-0.59	0.557	-0.794	0.437	-0.179
		Cumulative Hazard Score	27	-0.748	0.461	-0.070	0.033	-0.019
	2016	Total Abundance	53	-3.77	**≤ 0.001**	-0.009	-0.003	-0.006
		Species Richness	53	-1.80	0.077	-0.782	0.041	-0.370
		Cumulative Hazard Score	53	0.242	0.809	-0.222	0.283	0.031
	2017	Total Abundance	52	-4.93	**≤ 0.001**	-0.011	-0.005	-0.008
		Species Richness	52	-4.74	**≤ 0.001**	-1.101	-0.446	-0.774

		Cumulative Hazard Score	52	-1.087	0.282	-2.103	0.625	-0.739
	2018	Total Abundance	52	-4.93	**$\leq$ 0.001**	-0.011	-0.005	-0.008
		Species Richness	52	-4.74	**$\leq$ 0.001**	-1.101	-0.446	-0.774
		Cumulative Hazard Score	52	-1.087	0.282	-2.103	0.625	-0.739
DAYT	All	Total Abundance	132	-1.05	0.294	-0.022	0.007	-0.008
		Species Richness	132	-7.28	**$\leq$ 0.001**	-1.702	-0.975	-1.338
		Cumulative Hazard Score	132	-1.195	0.234	-0.179	0.044	-0.067
	2015	Total Abundance	29	-1.44	0.162	-0.036	0.006	-0.015
		Species Richness	29	-1.81	0.081	-1.492	0.092	-0.700
		Cumulative Hazard Score	29	2.246	**0.032**	0.007	0.143	0.075
	2016	Total Abundance	27	-1.84	0.076	-0.037	0.002	-0.018
		Species Richness	27	0.78	0.444	-0.037	0.082	0.023
		Cumulative Hazard Score	27	0.592	0.558	-0.061	0.111	0.025
	2017	Total Abundance	50	-1.98	0.054	-0.022	0.000	-0.011
		Species Richness	50	-4.02	**$\leq$ 0.001**	-1.853	-0.618	-1.235
		Cumulative Hazard Score	50	-1.496	0.141	-0.487	0.071	-0.208
	2018	Total Abundance	23	-2.05	0.052	-0.054	0.000	-0.027
		Species Richness	23	-3.41	**0.002**	-1.472	-0.361	-0.917
		Cumulative Hazard Score	23	-0.801	0.431	-0.195	0.086	-0.054
DTWA	All	Total Abundance	77	-0.89	0.376	-0.008	0.003	-0.002
		Species Richness	77	2.10	**0.039**	0.022	0.850	0.436
		Cumulative Hazard Score	77	-0.858	0.393	-0.203	0.081	-0.061
	2016	Total Abundance	34	0.94	0.353	-0.003	0.009	0.003
		Species Richness	34	2.79	**0.009**	0.179	1.135	0.657
		Cumulative Hazard Score	34	-0.743	0.463	-0.360	0.167	-0.096
	2017	Total Abundance	35	-1.51	0.140	-0.017	0.002	-0.007
		Species Richness	35	0.69	0.496	-0.489	0.989	0.250
		Cumulative Hazard Score	35	-0.202	0.841	-0.199	0.163	-0.018
	2018	Total Abundance	6	-0.78	0.466	-0.012	0.006	-0.003
		Species Richness	6	0.38	0.715	-1.542	2.113	0.286
		Cumulative Hazard Score	6	-1.315	0.236	-0.305	0.092	-0.107

GRFI	All	Total Abundance	83	-1.49	0.140	-0.009	0.001	-0.004
		Species Richness	83	0.94	0.351	-0.200	0.557	0.179
		Cumulative Hazard Score	83	1.733	0.087	-0.008	0.121	0.056
	2016	Total Abundance	39	-1.52	0.138	-0.018	0.003	-0.007
		Species Richness	39	1.96	0.057	-0.013	0.913	0.450
		Cumulative Hazard Score	39	1.637	0.110	-0.016	0.150	0.067
	2017	Total Abundance	33	-0.35	0.726	-0.008	0.005	-0.001
		Species Richness	33	-0.18	0.862	-0.740	0.623	-0.059
		Cumulative Hazard Score	33	0.845	0.404	-0.074	0.178	0.052
	2018	Total Abundance	9	0.05	0.961	-0.004	0.004	0.000
		Species Richness	9	-0.15	0.882	-1.587	1.387	-0.100
		Cumulative Hazard Score	9	0.391	0.705	-0.128	0.182	0.027
WHIT	All	Total Abundance	100	3.96	**≤ 0.001**	0.002	0.005	0.003
		Species Richness	100	3.74	**≤ 0.001**	0.242	0.788	0.515
		Cumulative Hazard Score	100	-0.375	0.708	-0.177	0.121	-0.028
	2015	Total Abundance	27	2.39	**0.024**	0.001	0.008	0.004
		Species Richness	27	1.55	0.133	-0.128	0.914	0.393
		Cumulative Hazard Score	27	1.438	0.162	-0.052	0.297	0.123
	2016	Total Abundance	46	2.77	**0.008**	0.001	0.006	0.004
		Species Richness	46	4.65	**≤ 0.001**	0.519	1.311	0.915
		Cumulative Hazard Score	46	-0.926	0.359	-0.437	0.162	-0.138
	2017	Total Abundance	3	6.97	**0.006**	0.003	0.009	0.006
		Species Richness	3	0.58	0.604	-2.256	3.256	0.500
		Cumulative Hazard Score	3	-0.282	0.796	-0.121	0.102	-0.010
	2018	Total Abundance	21	0.31	0.762	-1.31	1.77	0.23
		Species Richness	21	-0.70	0.492	-0.72	0.36	-0.18
		Cumulative Hazard Score	21	0.159	0.875	-0.133	0.155	0.011
WPAF	All	Total Abundance	125	-1.62	0.107	-0.092	0.009	-0.042
		Species Richness	125	1.53	0.129	-0.117	0.910	0.397
		Cumulative Hazard Score	125	-0.498	0.620	-0.132	0.079	-0.027

2015	Total Abundance	29	0.14	0.893	-0.053	0.060	0.004
	Species Richness	29	1.68	0.104	-0.160	1.626	0.733
	Cumulative Hazard Score	29	1.235	0.227	-0.069	0.279	0.105
2016	Total Abundance	27	-1.17	0.253	-0.330	0.090	-0.120
	Species Richness	27	-0.99	0.329	-1.970	0.685	-0.643
	Cumulative Hazard Score	27	-2.338	**0.027**	-0.220	-0.014	-0.117
2017	Total Abundance	48	-1.72	0.091	-0.092	0.007	-0.042
	Species Richness	48	1.30	0.199	-0.288	1.350	0.531
	Cumulative Hazard Score	48	-0.667	0.508	-0.302	0.152	-0.075
2018	Total Abundance	18	0.26	0.800	-0.024	0.031	0.003
	Species Richness	18	1.62	0.123	-0.315	2.420	1.053
	Cumulative Hazard Score	18	0.183	0.857	-0.252	0.300	0.024

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTW), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[2]Significant tests are in **bold** (P-value ≤ 0.05).

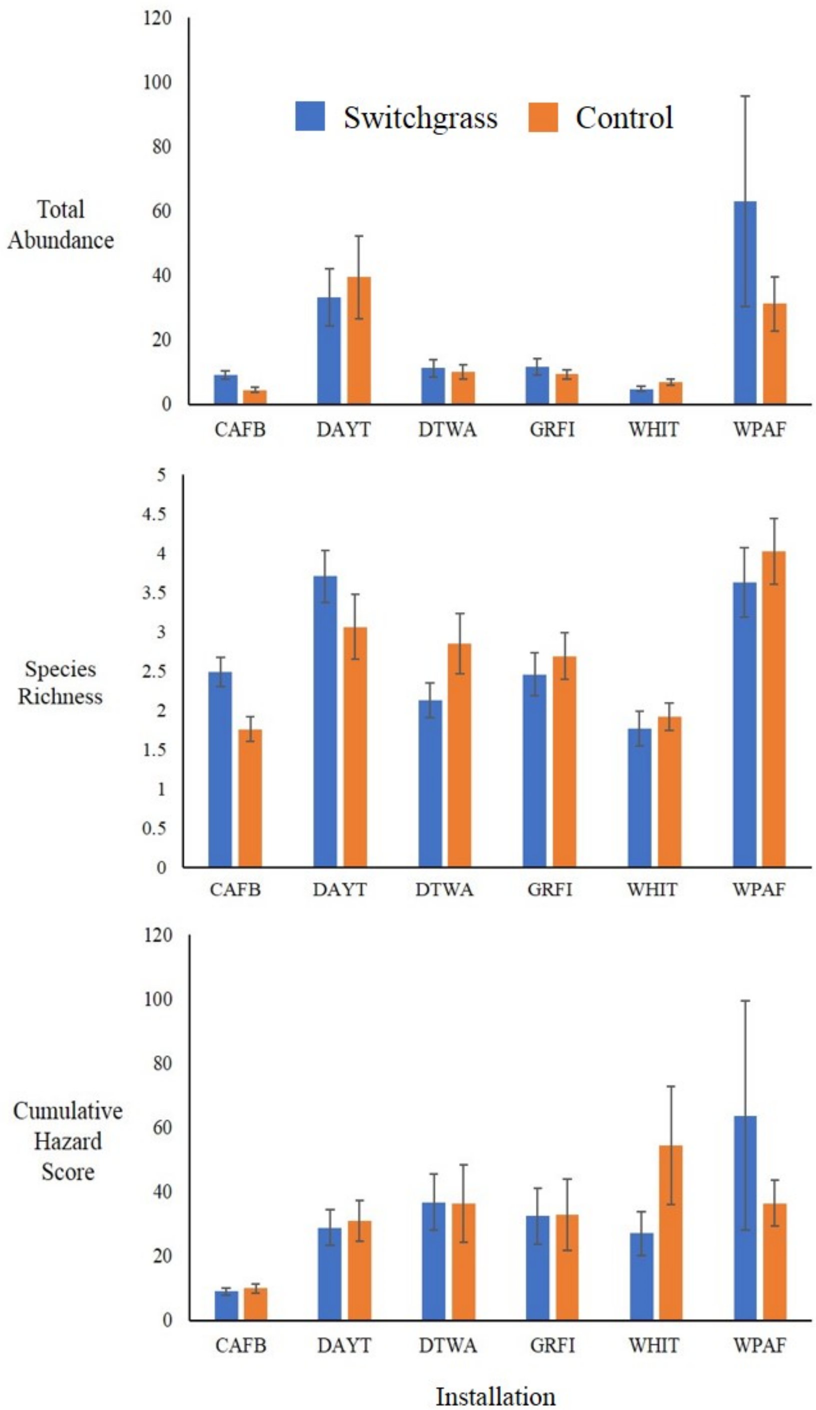


Figure 6.2.4. Bird community characteristics from morning line transects in switchgrass monocultures and extant airfield grasslands on 3 airfields and 3 airports in east central United States from August-December 2015-2017 and January-April 2016-2018. Installations included Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

Extreme observations during non-breeding seasons (2015-2018) occurred during 52.6% of line transects (*n* = 615 High CHS observations) compared to 47.8% of point counts with 50 species detected during extreme observations (Table 6.2.8; Figure 6.2.5). Similar to breeding season point counts, slightly more High CHS observations (*n* = 317) were made in switchgrass sites than control sites (*n* =298) across all sampling years. Most (*n* = 97) line transects with High CHS occurred during 2016 followed by 2017 (*n* = 90), 2015 (*n* = 61), and 2018 (*n* = 36) even when accounting for the number of installations online. Ohio sites still had the majority of extreme observations (65.1%) during non-breeding season. Fourteen bird species had $\geq$ 300 CHS contributed per year. Of these species, European starlings, Red-winged blackbirds, and American robins contributed to High CHS all years whereas Canada goose, Mallards, Eastern meadowlarks, and Mourning doves contributed during 3 years. The maximum species-specific CHS per line transect was due to Red-winged blackbirds at a WPAF switchgrass site in 2016 (CHS=26,580), in addition to European starlings at DAYT control site in 2016 (CHS = 5,500). European starlings were always in the top 5 species contributed to High CHS across all years and mostly in Ohio sites.

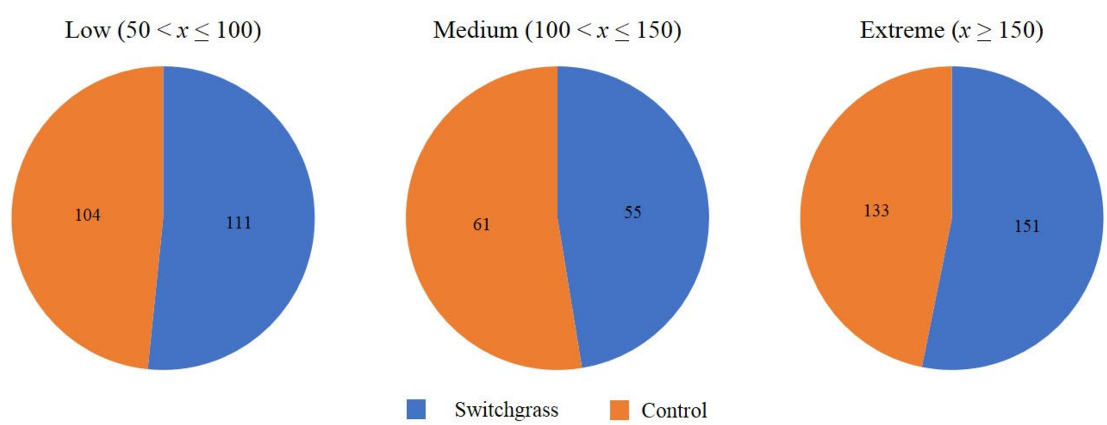


Figure 6.2.5. Number of extreme observations (number in each slice) indicated by the Cumulative Hazard Score (CHS) per point count from morning line transects between switchgrass monocultures and extant airfield grasslands in east central United States from August-December 2015 and January-April and August-December 2016-2017 and January-April 2018.

'Very high' hazard species had greater abundance in controls at WPAF across all years during the bird non-breeding season (Table 6.2.9; Figure 6.2.6). 'High' hazard species were more abundant in controls at DTWA during 2016 but more abundant in switchgrass sites at GRFI across all years. 'Moderate' hazard species were more abundant in controls at WHIT and WPAF during 2018 but more abundant greater in switchgrass sites at CAFB and DAYT during 2015. 'Low' hazard species had greater abundance in control sites at DTWA in 2016 and WHIT across all years and during 2015 and 2016. However, 'low' hazard species had greater abundance in switchgrass at WHIT in 2018, CAFB during all years and 2016-2018. 'Very low' hazard species were more abundant in controls at WHIT across all years but more abundant in switchgrass sites at DAYT and CAFB across all years in addition to during 2015 and 2017 at DAYT and 2015 and 2017-2018 at CAFB.

Table 6.2.9. Comparing relative abundance of birds by hazard categories (Dolbeer and Wright 2009) from morning line transects between switchgrass monocultures and extant airfield grasslands in east central United States from August-December 2015 and January-April and August-December 2016-2017 and January-April 2018. Positive responses indicated greater values in controls than switchgrass monocultures.

Site[1]	Year	Hazard Category	df	t-stat	*P*-value[2]	95% Confidence Interval		Mean Difference
CAFB	All	Extremely High	157	-1.00	0.319	-0.00002	0.00001	-0.00001
		Very High	157	-1.74	0.083	-0.00005	0.00000	-0.00002
		High	157	-1.75	0.082	-0.00120	0.00007	-0.00057
		Moderate	157	-0.24	0.813	-0.00033	0.00026	-0.00004
		Low	157	-3.37	**≤ 0.001**	-0.00351	-0.00092	-0.00221
		Very Low	157	-6.13	**≤ 0.001**	-0.00331	-0.00170	-0.00250
	2015	High	27	-0.44	0.663	-0.00045	0.00029	-0.00008
		Moderate	27	-2.92	**0.007**	-0.00115	-0.00020	-0.00068
		Low	27	1.43	0.163	-0.00089	0.00504	0.00208
		Very Low	27	-2.17	0.039	-0.00574	-0.00016	-0.00295
	2016	Extremely High	53	-1.00	0.322	-0.00006	0.00002	-0.00002
		Very High	53	-1.43	0.159	-0.00010	0.00002	-0.00004
		High	53	-1.73	0.089	-0.00348	0.00025	-0.00161
		Moderate	53	-0.30	0.768	-0.00081	0.00060	-0.00010
		Low	53	-3.69	**≤ 0.001**	-0.00530	-0.00157	-0.00344
		Very Low	53	-1.81	0.075	-0.00196	0.00010	-0.00093
	2017	Moderate	52	1.22	0.229	-0.00018	0.00073	0.00027
		Low	52	-3.16	**0.003**	-0.00686	-0.00153	-0.00420
		Very Low	52	-4.87	**≤ 0.001**	-0.00527	-0.00219	-0.00373
	2018	Moderate	52	1.22	0.229	-0.00018	0.00073	0.00027
		Low	52	-3.16	**0.003**	-0.00686	-0.00153	-0.00420
		Very Low	52	-4.87	**≤ 0.001**	-0.00527	-0.00219	-0.00373
DAYT	All	Extremely High	132	1.00	0.319	-0.00003	0.00009	0.00003
		Very High	132	-1.69	0.094	-0.00110	0.00009	-0.00051

		High	132	-1.62	0.108	-0.00118	0.00012	-0.00053
		Moderate	132	0.74	0.460	-0.00750	0.01649	0.00449
		Low	132	-0.29	0.770	-0.00557	0.00413	-0.00072
		Very Low	132	-3.39	**≤ 0.001**	-0.01658	-0.00437	-0.01047
	2015	Very High	29	0.03	0.975	-0.00012	0.00012	0.00000
		High	29	-0.99	0.331	-0.00422	0.00147	-0.00138
		Moderate	29	-2.89	**0.007**	-0.02770	-0.00475	-0.01622
		Low	29	1.01	0.319	-0.00790	0.02344	0.00777
		Very Low	29	-2.15	**0.040**	-0.00998	-0.00024	-0.00511
	2016	Very High	27	1.00	0.326	-0.00005	0.00014	0.00005
		High	27	-1.53	0.136	-0.00154	0.00022	-0.00066
		Moderate	27	1.45	0.157	-0.01598	0.09385	0.03894
		Low	27	0.65	0.518	-0.00365	0.00707	0.00171
		Very Low	27	-1.84	0.076	-0.03699	0.00199	-0.01750
	2017	Extremely High	50	1.00	0.322	-0.00008	0.00023	0.00008
		Very High	50	-1.67	0.102	-0.00281	0.00026	-0.00127
		High	50	-1.66	0.104	-0.00043	0.00004	-0.00019
		Moderate	50	-0.26	0.793	-0.00761	0.00584	-0.00088
		Low	50	-1.12	0.270	-0.00951	0.00272	-0.00340
		Very Low	50	-2.80	**0.007**	-0.00908	-0.00149	-0.00528
	2018	Very High	23	-0.66	0.519	-0.00062	0.00032	-0.00015
		High	23	-0.34	0.734	-0.00035	0.00025	-0.00005
		Moderate	23	1.96	0.062	-0.00009	0.00333	0.00162
		Low	23	-1.36	0.188	-0.02139	0.00445	-0.00847
		Very Low	23	-1.67	0.108	-0.04478	0.00477	-0.02001
DTWA	All	Extremely High	77	0.89	0.378	-0.00100	0.00261	0.00080
		Very High	77	-1.10	0.273	-0.00055	0.00016	-0.00020
		High	77	-0.31	0.761	-0.00086	0.00063	-0.00011
		Moderate	77	-1.23	0.222	-0.00670	0.00158	-0.00256
		Low	77	0.54	0.592	-0.00099	0.00172	0.00037
		Very Low	77	-0.58	0.561	-0.00274	0.00150	-0.00062
	2016	Extremely High	34	0.92	0.362	-0.00224	0.00597	0.00187
		Very High	34	0.85	0.399	-0.00014	0.00035	0.00010
		High	34	2.15	**0.038**	0.00004	0.00145	0.00075
		Moderate	34	-0.19	0.849	-0.00526	0.00435	-0.00045

		Low	34	2.10	**0.043**	0.00006	0.00372	0.00189
		Very Low	34	-1.18	0.248	-0.00377	0.00100	-0.00138
	2017	Extremely High	35	-1.00	0.324	-0.00022	0.00008	-0.00007
		Very High	35	-1.54	0.132	-0.00127	0.00017	-0.00055
		High	35	-1.06	0.299	-0.00197	0.00062	-0.00067
		Moderate	35	-1.29	0.205	-0.01288	0.00286	-0.00501
		Low	35	-0.75	0.461	-0.00297	0.00138	-0.00080
		Very Low	35	-0.02	0.985	-0.00413	0.00405	-0.00004
	2018	Very High	6	0.31	0.769	-0.00078	0.00100	0.00011
		High	6	-0.88	0.411	-0.00578	0.00271	-0.00153
		Moderate	6	-0.89	0.406	-0.00193	0.00090	-0.00052
		Low	6	-0.54	0.611	-0.00698	0.00447	-0.00125
		Very Low	6	1.00	0.356	-0.00026	0.00062	0.00018
GRFI	All	Extremely High	83	1.40	0.166	-0.00022	0.00127	0.00053
		Very High	83	-0.03	0.975	-0.00024	0.00023	0.00000
		High	83	-2.09	**0.040**	-0.00033	-0.00001	-0.00017
		Moderate	83	-1.80	0.076	-0.00821	0.00042	-0.00390
		Low	83	-0.46	0.646	-0.00266	0.00166	-0.00050
		Very Low	83	0.06	0.953	-0.00117	0.00124	0.00004
	2016	Extremely High	39	1.08	0.287	-0.00071	0.00232	0.00081
		Very High	39	1.67	0.103	-0.00002	0.00024	0.00011
		High	39	0.04	0.966	-0.00008	0.00009	0.00000
		Moderate	39	-1.61	0.116	-0.01524	0.00174	-0.00675
		Low	39	-0.43	0.669	-0.00455	0.00295	-0.00080
		Very Low	39	-1.09	0.284	-0.00250	0.00075	-0.00087
	2017	Extremely High	33	0.29	0.775	-0.00023	0.00031	0.00004
		Very High	33	-0.06	0.956	-0.00031	0.00029	-0.00001
		High	33	-1.65	0.109	-0.00058	0.00006	-0.00026
		Moderate	33	-0.71	0.480	-0.00558	0.00268	-0.00145
		Low	33	-0.40	0.695	-0.00379	0.00256	-0.00062
		Very Low	33	1.03	0.310	-0.00115	0.00352	0.00118
	2018	Extremely High	9	1.12	0.291	-0.00107	0.00319	0.00106
		Very High	9	-0.52	0.615	-0.00237	0.00148	-0.00044
		High	9	-1.46	0.177	-0.00142	0.00030	-0.00056
		Moderate	9	-1.79	0.108	-0.00184	0.00022	-0.00081

		Low	9	0.96	0.361	-0.00147	0.00364	0.00109
		Very Low	9	-1.05	0.322	-0.00076	0.00028	-0.00024
WHIT	All	Extremely High	100	1.13	0.260	-0.00011	0.00039	0.00014
		Very High	100	1.55	0.125	-0.00006	0.00051	0.00022
		High	100	0.37	0.713	-0.00035	0.00051	0.00008
		Moderate	100	-0.16	0.870	-0.00120	0.00102	-0.00009
		Low	100	3.72	**≤ 0.001**	0.00103	0.00337	0.00220
		Very Low	100	2.53	**0.013**	0.00015	0.00124	0.00069
	2015	Extremely High	27	-0.37	0.711	-0.00052	0.00036	-0.00008
		Very High	27	1.16	0.254	-0.00031	0.00113	0.00041
		High	27	-1.00	0.326	-0.00156	0.00054	-0.00051
		Moderate	27	0.81	0.425	-0.00040	0.00092	0.00026
		Low	27	2.44	**0.021**	0.00065	0.00749	0.00407
		Very Low	27	1.39	0.175	-0.00011	0.00059	0.00024
	2016	Extremely High	46	1.58	0.121	-0.00010	0.00081	0.00035
		Very High	46	1.15	0.257	-0.00019	0.00071	0.00026
		High	46	1.32	0.195	-0.00024	0.00113	0.00045
		Moderate	46	-0.76	0.451	-0.00321	0.00145	-0.00088
		Low	46	5.11	**≤ 0.001**	0.00184	0.00424	0.00304
		Very Low	46	0.83	0.411	-0.00050	0.00120	0.00035
	2017	High	3	0.61	0.585	-0.00266	0.00392	0.00063
		Moderate	3	0.47	0.671	-0.00424	0.00570	0.00073
		Very Low	3	2.22	0.113	-0.00199	0.01117	0.00459
	2018	Extremely High	21	0.01	0.990	-0.00037	0.00037	0.00000
		Very High	21	-1.00	0.329	-0.00017	0.00006	-0.00005
		High	21	-1.00	0.329	-0.00016	0.00005	-0.00005
		Moderate	21	2.11	**0.047**	0.00002	0.00197	0.00099
		Low	21	-2.48	**0.022**	-0.00291	-0.00026	-0.00158
		Very Low	21	1.89	0.073	-0.00013	0.00272	0.00129
WPAF	All	Extremely High	125	0.69	0.491	-0.00009	0.00019	0.00005
		Very High	125	2.53	**0.013**	0.00003	0.00023	0.00013
		High	125	1.34	0.182	-0.00201	0.01049	0.00424
		Moderate	125	-1.21	0.230	-0.02290	0.00555	-0.00867
		Low	125	-1.46	0.146	-0.08225	0.01230	-0.03497
		Very Low	125	-1.48	0.142	-0.00568	0.00082	-0.00243

2015	Very High	29	1.11	0.277	-0.00011	0.00036	0.00013
	High	29	1.43	0.165	-0.00714	0.03993	0.01640
	Moderate	29	-0.32	0.749	-0.05167	0.03756	-0.00705
	Low	29	-1.35	0.186	-0.01396	0.00284	-0.00556
	Very Low	29	-0.08	0.940	-0.00425	0.00394	-0.00015
2016	Extremely High	27	1.00	0.326	-0.00034	0.00098	0.00032
	Very High	27	1.69	0.103	-0.00004	0.00040	0.00018
	High	27	2.06	0.049	0.00002	0.00792	0.00397
	Moderate	27	-1.03	0.312	-0.02919	0.00968	-0.00976
	Low	27	-1.05	0.305	-0.31294	0.10171	-0.10561
	Very Low	27	-1.96	0.060	-0.01801	0.00039	-0.00881
2017	Very High	48	2.00	0.051	0.00000	0.00037	0.00018
	High	48	1.43	0.159	-0.00107	0.00636	0.00264
	Moderate	48	-1.53	0.134	-0.04039	0.00555	-0.01742
	Low	48	-1.19	0.239	-0.06807	0.01736	-0.02535
	Very Low	48	-0.81	0.422	-0.00821	0.00350	-0.00235
2018	Extremely High	18	-1.46	0.163	-0.00034	0.00006	-0.00014
	Very High	18	-1.00	0.331	-0.00021	0.00008	-0.00007
	High	18	-1.29	0.214	-0.02742	0.00656	-0.01043
	Moderate	18	2.16	0.045	0.00035	0.02550	0.01292
	Low	18	-0.85	0.406	-0.00739	0.00313	-0.00213
	Very Low	18	1.31	0.205	-0.00191	0.00829	0.00319

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[2]Significant tests are in **bold** (*P*-value ≤ 0.05).

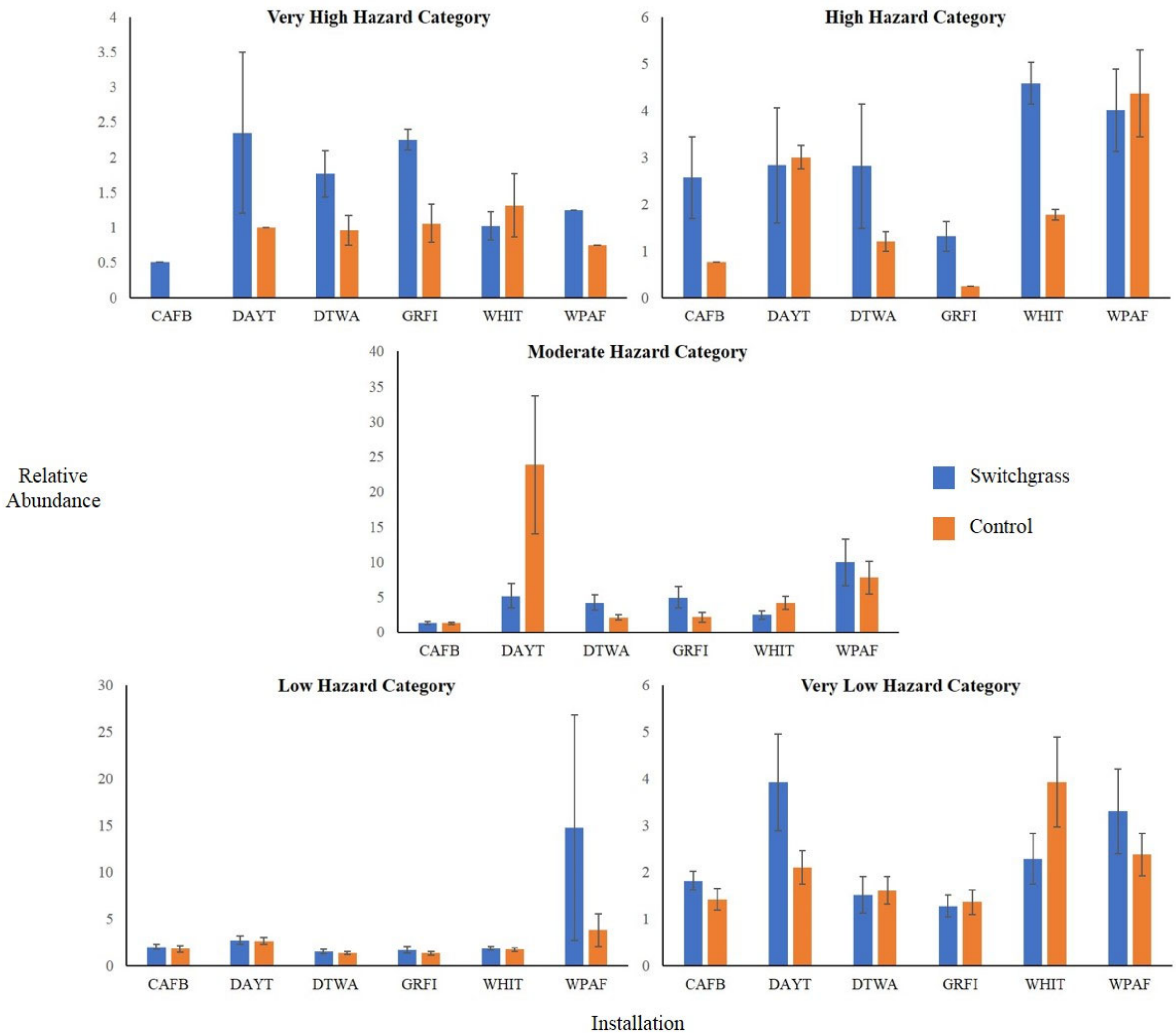


Figure 6.2.6. Average relative abundance across all years per observation of birds by hazard categories (Dolbeer and Wright 2009) from morning line transects between switchgrass monocultures and extant airfield grasslands in east central United States from August-December 2015 and January-April and August-December 2016-2017 and January-April 2018. Installations included Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

Bird responses among installations were investigated using multivariate and univariate generalized linear mixed models in a Bayesian framework with a Markov Chain Monte Carlo sampler. Although no hazard category demonstrated an absolute positive or negative response to switchgrass coverage during breeding season, 'Very low', 'Low', 'Moderate' and 'Very High' hazard species demonstrated slight positive increases in relative abundance as switchgrass coverage increased in addition to species richness (Table 6.2.10). However, increasing switchgrass coverage also coincided with the latitudinal gradient of south to north with northern sites not only having greater switchgrass coverage but also greater bird hazards within local and migrant bird communities. Model selection also favored a response of cumulative hazard score to increasing switchgrass coverage, but there was greater overlap across 0 of 95% credible intervals of the posterior distribution suggesting weak treatment effects. The null model (i.e., no switchgrass effect) was the top model for total bird abundance during breeding season. During non-breeding season, among installation analysis indicated no strong directional response of observed species to switchgrass coverage.

Table 6.2.10. Descriptive statistics of Markov chain Monte Carlo posterior distributions of bird responses to increasing switchgrass coverage determined by multivariate and univariate generalized linear mixed models used to investigate bird community responses to switchgrass monocultures as an alternative land cover on airfields to mitigate bird strikes with aircraft among 6 airports and airfields from Alabama to Michigan during breeding season (May-July 2015-2017).

						95% Credible Interval	
Season	Hazard Category	Mean	SE	Mode	Proportion > 0	Lower	Upper
Breeding	Very Low	0.004	0.00005	0.004	0.902	-0.002	0.010
	Low	0.005	0.00004	0.005	0.969	0.000	0.011
	Moderate	0.010	0.00009	0.011	0.967	-0.001	0.020
	High	-0.001	0.00031	-0.002	0.473	-0.014	0.013
	Very High	0.018	0.00060	0.017	0.946	-0.004	0.039
	Extremely High	-0.005	0.00283	-0.008	0.417	-0.050	0.041
Species Richness		0.014	0.00008	0.015	0.989	0.002	0.025
Cumulative Hazard Score		0.003	0.00004	0.003	0.765	-0.004	0.009

Bird locations were determined based on distance data collected by biologists during each sampling period. The different sampling approaches implemented in this demonstration coincided with changes in bird behavior throughout the year. During breeding season, territorial male songbirds typically call often to establish territories and attract mates. Male calling behavior supports point count methods during which most bird detections are aural. Less vocal individuals during non-breeding seasons favor using line flush transects because observers often actively flush birds near the transect that would otherwise be undetected during a point count. Prior to hazard category or bird species edge effect analysis, correlations between bird locations and sampling point/line locations were investigated. As expected, bird locations were uncorrelated to point count locations (adjusted $R^2 = 0.042$) but demonstrated greater correlation to line transect locations (adjusted $R^2 = 0.581$) suggesting that many bird detections were the result of where the line transect was located and the observer’s movement during line flush transects “flushing” nearby birds.

Most hazard category responses were non-linear and suggested either quadratic or cubic distributions of detections suggesting a buffer between observers and detections such that detections either plateaued after a certain distance from the observer (e.g., quadratic response) or most detections fell within an average distance causing detections to follow a bell-shaped response curve (e.g., cubic). Therefore, it was impossible to identify most hazard categories as edge or interior species. However, 'high' hazard species during breeding seasons had decreasing detections away from site edges suggesting them as edge-preferring species (Table 6.2.11). Species-specific responses were also best modeled as polynomial responses for most species following overall similar results to explanations above regarding quadratic and cubic trends (Table 6.2.12). Black-capped chickadees during breeding season had linear responses with a positive trend of greater detections as one moves away from site edges (i.e., potential interior species). However, during non-breeding season, European starlings and tree swallows were the only species with significant linear trends of distances from site edges that suggested potential edge preferences (i.e., these species may not have used either land cover as much as preferring the ecotone created by neighboring land covers). Therefore, edge versus interior preferences of species did not seem to influence overall bird responses to the demonstration.

Table 6.2.11. Investigation of edge effects (i.e., distance from edge) on bird detections from morning point counts (May-July 2015-2017) and line transects (August-January 2015-2017, January – April 2016-2018) in switchgrass monocultures and extant airfield grasslands in east central United States among 3 military airfields and 3 public airports with bird species grouped by hazard category (Dolbeer and Wright 2009[1]). Participating installations included Columbus Air Force Base, Dayton International Airport, Detroit Metropolitan Airport, Gerald R. Ford International Airport, Naval Air Station Whiting Field, and Wright-Patterson Air Force Base.

Sampling Approach	Hazard Category	Model	Estimate	SE	t-value	P-value[2]	Adj. R^2
Point Counts	Very Low	Intercept	1.053	1.824	0.58	0.565	0.639
		Distance from Edge	0.422	0.137	3.08	**0.003**	
		Distance from Edge^2	0.001	0.003	0.21	0.831	
		Distance from Edge^3	0.000	0.000	-2.63	**0.010**	
	Low	Intercept	3.080	2.056	1.50	0.137	0.698
		Distance from Edge	1.085	0.075	14.38	**≤ 0.001**	
		Distance from Edge^2	-0.009	0.001	-16.25	**≤ 0.001**	
	Moderate	Intercept	1.756	0.932	1.88	0.062	0.560
		Distance from Edge	0.344	0.034	10.05	**≤ 0.001**	
		Distance from Edge^2	-0.003	0.000	-11.70	**≤ 0.001**	
	High	Intercept	4.585	0.262	17.51	**≤ 0.001**	0.390
		Distance from Edge	-0.033	0.004	-8.85	**≤ 0.001**	
	Very and Extremely High	Intercept	0.104	0.251	0.41	0.680	0.050
		Distance from Edge	0.023	0.010	2.35	**0.020**	
		Distance from Edge^2	0.000	0.000	-2.68	**0.009**	
Line Transects	Very Low	Intercept	8.432	1.119	7.54	**≤ 0.001**	0.758

	Distance from Edge	0.528	0.069	7.60	**≤ 0.001**	
	Distance from Edge^2	-0.008	0.001	-7.22	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	5.42	**≤ 0.001**	
Low	Intercept	9.803	1.318	7.44	**≤ 0.001**	0.805
	Distance from Edge	0.801	0.083	9.65	**≤ 0.001**	
	Distance from Edge^2	-0.013	0.001	-9.04	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	6.89	**≤ 0.001**	
Moderate	Intercept	6.356	0.915	6.95	**≤ 0.001**	0.628
	Distance from Edge	0.261	0.058	4.53	**≤ 0.001**	
	Distance from Edge^2	-0.005	0.001	-4.84	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	3.88	**≤ 0.001**	
High	Intercept	3.320	0.497	6.68	**≤ 0.001**	0.424
	Distance from Edge	0.062	0.036	1.74	0.084	
	Distance from Edge^2	-0.002	0.001	-2.30	**0.023**	
	Distance from Edge^3	0.000	0.000	1.94	0.054	
Very and Extremely High	Intercept	1.071	0.169	6.33	**≤ 0.001**	0.134
	Distance from Edge	-0.006	0.006	-0.99	0.322	
	Distance from Edge^2	0.000	0.000	-0.19	0.848	

[1] Hazard categories were determined following Dolbeer and Wright (2009) recommendations and using reported civil bird airstrikes from 1990 to April 30, 2018 from the Federal Aviation Administration's Wildlife Strike Database. Bird strike records from within the airport environment (e.g., < 457 m above ground; Dolbeer and Begier 2012), excluding carcasses (e.g., "Carcass Found" recorded in 'Person' column of under in FAA's Wildlife Strike Database), were included.
[2] Significant tests are in **bold** (*P*-value ≤ 0.05).

Table 6.2.12. Investigation of edge effects (i.e., distance from edge) on bird detections from morning point counts (May-July 2015-2017) and line transects (August-January 2015-2017, January – April 2016-2018) in switchgrass monocultures and extant airfield grasslands in east central United States among 3 military airfields and 3 public airports among the top 10 most abundant species per participating installation. Participating installations included Columbus Air Force Base, Dayton International Airport, Detroit Metropolitan Airport, Gerald R. Ford International Airport, Naval Air Station Whiting Field, and Wright-Patterson Air Force Base.

Sampling Approach	Species	Model	Estimate	SE	t-value	P-value[1]	Adj. R^2
Point Counts	American goldfinch	Intercept	-0.454	0.387	-1.170	0.245	0.234
		Distance from Edge	0.102	0.018	5.738	**≤ 0.001**	
		Distance from Edge^2	-0.001	0.000	-5.536	**≤ 0.001**	
	American robin	Intercept	0.983	0.430	2.286	**0.024**	0.152
		Distance from Edge	0.065	0.017	3.838	**≤ 0.001**	
		Distance from Edge^2	-0.001	0.000	-4.447	**≤ 0.001**	
	American tree sparrow	Intercept	-0.088	0.112	-0.785	0.442	0.395
		Distance from Edge	0.069	0.043	1.605	0.124	
		Distance from Edge^2	-0.010	0.004	-2.169	**0.042**	
		Distance from Edge^3	0.000	0.000	2.646	**0.016**	
	Barn swallow	Intercept	-0.551	0.732	-0.754	0.453	0.400
		Distance from Edge	0.250	0.029	8.587	**≤ 0.001**	
		Distance from Edge^2	-0.002	0.000	-8.904	**≤ 0.001**	
	Black-capped chickadee	Intercept	-0.033	0.054	-0.606	0.546	0.044
		Distance from Edge	0.002	0.001	2.211	**0.030**	
	Bobolink	Intercept	-1.029	0.694	-1.483	0.141	0.363
		Distance from Edge	0.227	0.028	8.077	**≤ 0.001**	

	Distance from Edge^2	-0.002	0.000	-8.152	**≤ 0.001**	
Brown-headed cowbird	Intercept	0.262	0.146	1.796	0.075	0.045
	Distance from Edge	-0.022	0.012	-1.855	0.067	
	Distance from Edge^2	0.001	0.000	2.240	**0.027**	
	Distance from Edge^3	0.000	0.000	-2.315	**0.023**	
Canada goose	Intercept	0.006	0.030	0.185	0.854	-0.003
	Distance from Edge	0.000	0.000	0.802	0.424	
Chipping sparrow	Intercept	-0.269	0.569	-0.474	0.637	0.448
	Distance from Edge	-0.012	0.043	-0.283	0.778	
	Distance from Edge^2	0.002	0.001	2.756	**0.007**	
	Distance from Edge^3	0.000	0.000	-4.194	**≤ 0.001**	
Eastern bluebird	Intercept	0.107	0.185	0.577	0.565	0.024
	Distance from Edge	0.016	0.008	1.965	0.052	
	Distance from Edge^2	0.000	0.000	-2.112	0.037	
Eastern meadowlark	Intercept	1.545	0.574	2.694	**0.008**	0.334
	Distance from Edge	0.151	0.022	6.790	**≤ 0.001**	
	Distance from Edge^2	-0.001	0.000	-7.563	**≤ 0.001**	
European starling	Intercept	1.181	0.460	2.569	**0.011**	0.176
	Distance from Edge	0.067	0.018	3.689	**≤ 0.001**	
	Distance from Edge^2	-0.001	0.000	-4.492	**≤ 0.001**	
Field sparrow	Intercept	-0.060	0.270	-0.223	0.824	0.201
	Distance from Edge	0.005	0.022	0.235	0.814	

	Distance from Edge^2	0.001	0.000	1.158	0.250	
	Distance from Edge^3	0.000	0.000	-1.954	0.053	
Killdeer	Intercept	-0.742	0.427	-1.736	0.085	0.186
	Distance from Edge	0.144	0.033	4.342	**≤ 0.001**	
	Distance from Edge^2	-0.002	0.001	-3.571	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	2.854	**0.005**	
Mourning dove	Intercept	1.332	0.456	2.920	**0.004**	0.040
	Distance from Edge	-0.032	0.039	-0.824	0.412	
	Distance from Edge^2	0.001	0.001	1.221	0.225	
	Distance from Edge^3	0.000	0.000	-1.552	0.124	
Red-winged blackbird	Intercept	3.701	1.476	2.507	**0.013**	0.667
	Distance from Edge	0.618	0.102	6.066	**≤ 0.001**	
	Distance from Edge^2	-0.007	0.002	-3.940	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	1.661	0.099	
Savannah sparrow	Intercept	-1.525	1.398	-1.091	0.278	0.480
	Distance from Edge	0.117	0.102	1.145	0.255	
	Distance from Edge^2	0.003	0.002	1.533	0.128	
	Distance from Edge^3	0.000	0.000	-3.220	**0.002**	
Song sparrow	Intercept	-0.352	0.422	-0.835	0.406	0.345
	Distance from Edge	0.027	0.034	0.787	0.433	
	Distance from Edge^2	0.001	0.001	1.181	0.240	
	Distance from Edge^3	0.000	0.000	-2.358	**0.020**	
Tree swallow	Intercept	0.706	0.348	2.032	**0.045**	0.114

		Distance from Edge	0.043	0.015	2.818	**0.006**	
		Distance from Edge^2	0.000	0.000	-3.424	**≤ 0.001**	
Line Transects	American goldfinch	Intercept	0.547	0.148	3.704	**≤ 0.001**	-0.006
		Distance from Edge	0.001	0.002	0.575	0.567	
	American robin	Intercept	2.616	0.462	5.666	**≤ 0.001**	0.401
		Distance from Edge	0.056	0.033	1.700	0.092	
		Distance from Edge^2	-0.001	0.001	-2.326	**0.022**	
		Distance from Edge^3	0.000	0.000	2.046	**0.043**	
	American tree sparrow	Intercept	0.112	0.102	1.098	0.275	0.022
		Distance from Edge	0.004	0.002	1.672	0.098	
	Barn swallow	Intercept	0.950	0.358	2.656	**0.009**	0.173
		Distance from Edge	0.041	0.013	3.121	**0.002**	
		Distance from Edge^2	0.000	0.000	-4.112	**≤ 0.001**	
	Black-capped chickadee	Intercept	1.680	0.365	4.605	**≤ 0.001**	0.171
		Distance from Edge	0.024	0.015	1.538	0.127	
		Distance from Edge^2	0.000	0.000	-2.679	**0.009**	
	Bobolink	Intercept	0.178	0.084	2.129	0.036	-0.009
		Distance from Edge	0.000	0.001	0.099	0.922	
	Brown-headed cowbird	Intercept	0.439	0.108	4.070	**≤ 0.001**	0.023
		Distance from Edge	-0.003	0.002	-1.935	0.055	
	Canada goose	Intercept	0.151	0.063	2.384	**0.019**	-0.008

	Distance from Edge	0.000	0.001	-0.274	0.785	
Chipping sparrow	Intercept	0.241	0.198	1.215	0.227	0.008
	Distance from Edge	0.014	0.008	1.661	0.100	
	Distance from Edge^2	0.000	0.000	-1.676	0.097	
Eastern bluebird	Intercept	0.980	0.168	5.839	**≤ 0.001**	-0.004
	Distance from Edge	-0.002	0.002	-0.717	0.475	
Eastern meadowlark	Intercept	4.241	0.603	7.036	**≤ 0.001**	0.401
	Distance from Edge	0.101	0.020	4.908	**≤ 0.001**	
	Distance from Edge^2	-0.001	0.000	-6.843	**≤ 0.001**	
European starling	Intercept	2.942	0.272	10.816	**≤ 0.001**	0.123
	Distance from Edge	-0.017	0.004	-4.153	**≤ 0.001**	
Field sparrow	Intercept	0.784	0.339	2.316	**0.022**	0.108
	Distance from Edge	0.047	0.014	3.380	**≤ 0.001**	
	Distance from Edge^2	0.000	0.000	-3.787	**≤ 0.001**	
Killdeer	Intercept	0.445	0.306	1.455	0.149	0.182
	Distance from Edge	0.057	0.023	2.436	**0.016**	
	Distance from Edge^2	-0.001	0.000	-2.140	**0.035**	
	Distance from Edge^3	0.000	0.000	1.573	0.119	
Mourning dove	Intercept	1.835	0.401	4.575	**≤ 0.001**	0.350
	Distance from Edge	0.055	0.025	2.167	**0.032**	
	Distance from Edge^2	-0.001	0.000	-2.432	**0.016**	
	Distance from Edge^3	0.000	0.000	1.943	0.054	

Red-winged blackbird	Intercept	3.688	0.686	5.376	**≤ 0.001**	0.538
	Distance from Edge	0.179	0.049	3.698	**≤ 0.001**	
	Distance from Edge^2	-0.003	0.001	-3.445	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	2.398	**0.018**	
Savannah sparrow	Intercept	1.135	0.846	1.341	0.182	0.613
	Distance from Edge	0.447	0.053	8.378	**≤ 0.001**	
	Distance from Edge^2	-0.007	0.001	-7.806	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	6.369	**≤ 0.001**	
Song sparrow	Intercept	2.953	0.704	4.193	**≤ 0.001**	0.647
	Distance from Edge	0.327	0.044	7.484	**≤ 0.001**	
	Distance from Edge^2	-0.006	0.001	-7.612	**≤ 0.001**	
	Distance from Edge^3	0.000	0.000	6.476	**≤ 0.001**	
Tree swallow	Intercept	0.808	0.127	6.373	**≤ 0.001**	0.078
	Distance from Edge	-0.006	0.002	-3.369	**≤ 0.001**	

1 Significant tests are in **bold** (*P*-value ≤ 0.05)

6.3.0 Bird Relative Population Abundance Summary and Conclusions

Successful demonstration of switchgrass as an alternative land cover for airfields included observing reduced risk in switchgrass sites compared to control sites according to the relative population abundance of hazardous bird species. Monoculture switchgrass was expected to be used by less hazardous bird species, and we expected to observe lower densities of hazardous bird species compared to controls (i.e., less relative population abundance). Bird use was represented by their relative population abundance (number of detected individuals by species per site) which was recorded for each site every month using bird point counts or bird line flush transects. Species-specific relative population abundances of birds in switchgrass and control sites were compared and strike risk calculated. We proposed successful criteria as a significant difference between relative population abundance of hazardous bird species in switchgrass sites and those in controls the first year after switchgrass planting (i.e., breeding season 2015) and a minimum of 15% less relative population abundance of hazardous bird species in switchgrass sites than controls for remaining sampling years. For among-installation comparisons (MCMCglmm), we revised successful criteria to better assess bird response by changing treatment site comparison to switchgrass coverage because switchgrass plots did not meet switchgrass coverage success criteria and some natural (i.e., non-planted) switchgrass occurred on control sites.

Bird responses varied substantially between breeding and non-breeding season, and whether assessed by installation or among installations. Overall, effect sizes (i.e., size of differences between switchgrass monocultures and controls) were small suggesting minimal differences in bird use between treatments. However, effect sizes did not meet minimum requirements for meeting success (15%; Performance Objective 2). From a hazard perspective, hazardous species (e.g., 'High' to 'Extremely High' hazard species) were observed during the demonstration on both treatments but accounted for extremely small proportions of total observations. Only two installations experienced significant cumulative hazard score responses to switchgrass establishment but were single year responses that conflicted between installations. Therefore, switchgrass establishment did not seem to cause any substantial increases or decreases in bird cumulative hazard scores between breeding and non-breeding seasons during the demonstration (Performance Objective 4). However, transitioning extant airfield grasslands to switchgrass monocultures did not cause substantial changes in bird use or hazards.

6.3 MAMMAL FREQUENCY OF OCCURRENCE

Eighteen mammal species were identified from monthly, 14-day camera trapping surveys May 2015 through April 2018 among 22,064 trap nights (e.g., 1 trap night was 1 camera operating for 24 hours). Michigan installations were the only installations with less than 3 years of camera trapping due to initial sampling errors (GRFI; n = 3,136 trap nights, January 2016 –

April 2018) and delayed planting (DTWA; n = 2,800, May 2016-April 2018). A few months were missing from DTWA sampling as well causing less than 2 years of camera trapping. Among installations, coyotes (*Canis latrans*), white-tailed deer (*Odocoileus virginianus*) and both eastern cottontails *(Sylvilagus floridanus*) and unknown rabbits (*Sylvilagus* spp.; n = 1,198 detections) were the most common species (Table 6.3.1).

Table 6.3.1. Mammal species detected among 3 military airfields and 3 civil airports from Alabama to Michigan using monthly 14-day camera trapping periods from May 2015-April 2018. Unique detections were determined as the most individuals per species during a 15-minute period or an identifiably different individual from recent images. Only species with > 25 detections were listed for installation-specific detections.

Sites[1]	Common Name	Species	Detections
All	Bobcat	*Lynx rufus*	13
	Coyote	*Canis latrans*	1573
	Domestic dog	*Canis lupus familiaris*	15
	Eastern cottontail	*Sylvilagus floridanus*	656
	Feral or domestic cat	*Felis catus*	27
	Fox squirrel	*Sciurus niger*	1
	Gray fox	*Urocyon cinereoargenteus*	1
	Eastern gray squirrel	*Sciurus carolinensis*	2
	Nine-banded armadillo	*Dasypus novemcinctus*	64
	Northern raccoon	*Procyon lotor*	306
	Red fox	*Vulpes vulpes*	59
	Eastern spotted skunk	*Spilogale putorius*	1
	Striped skunk	*Mephitis mephitis*	182
	Unknown mammal		22
	Unknown rabbit	*Sylvilagus* spp.	542
	Virginia possum	*Didelphis virginiana*	463
	Woodchuck	*Marmota monax*	85
	White-tailed deer	*Odocoileus virginianus*	5114
CAFB	Coyote	*Canis latrans*	279
	Northern raccoon	*Procyon lotor*	46
	Unknown rabbit	*Sylvilagus* spp.	177
	Virginia possum	*Didelphis virginiana*	45
	White-tailed deer	*Odocoileus virginianus*	772
DAYT	Coyote	*Canis latrans*	459
	Eastern cottontail	*Sylvilagus floridanus*	192
	Virginia possum	*Didelphis virginiana*	94

	White-tailed deer	*Odocoileus virginianus*	247
DTWA	Coyote	*Canis latrans*	248
	Eastern cottontail	*Sylvilagus floridanus*	33
	Virginia possum	*Didelphis virginiana*	43
	White-tailed deer	*Odocoileus virginianus*	534
GRFI	Coyote	*Canis latrans*	162
	Eastern cottontail	*Sylvilagus floridanus*	237
	Northern raccoon	*Procyon lotor*	159
	Striped skunk	*Mephitis mephitis*	46
	Virginia possum	*Didelphis virginiana*	54
	White-tailed deer	*Odocoileus virginianus*	1297
WHIT	Coyote	*Canis latrans*	165
	Nine-banded armadillo	*Dasypus novemcinctus*	44
	Striped skunk	*Mephitis mephitis*	44
	Unknown rabbit	*Sylvilagus* spp.	332
	White-tailed deer	*Odocoileus virginianus*	1578
WPAF	Coyote	*Canis latrans*	260
	Eastern cottontail	*Sylvilagus floridanus*	227
	Northern raccoon	*Procyon lotor*	62
	Red fox	*Vulpes vulpes*	57
	Striped skunk	*Mephitis mephitis*	79
	Virginia possum	*Didelphis virginiana*	213
	Woodchuck	*Marmota monax*	78
	White-tailed deer	*Odocoileus virginianus*	686

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

Within installations, cumulative hazard score was greater in controls at CAFB during 2017, DAYT across all years, and WHIT across all years and during 2016-2018 (Table 6.3.2; Figure 6.3.1). Total detections were greater in controls at DAYT and WHIT across all years and WHIT during 2017. However, total detections were greater in switchgrass sites at CAFB during 2015. Mammal species richness was greater in switchgrass sites at DAYT during 2017, DTWA during 2018, and GRFI across all years and during 2016 and 2017.However, mammal species richness was greater in controls at DAYT during 2015. Coyotes and white-tailed deer were the most hazardous mammal species to aircraft of all mammals observed. White-tailed deer occurred more in control sites across all years at CAFB, DAYT, and WHIT in addition to individual years of 2017 at CAFB and 2015-2018 at WHIT (Table 6.3.3). However, white-tailed deer occurred more in switchgrass sites at DTWA during 2016. Coyotes occurred more in control sites at

DAYT and GRFI across all years and during 2015 at DAYT. In contrast, coyotes occurred more at WPAF in switchgrass sites across all years and during 2018. Mammal detections at WPAF were most unique among installations, likely due to the placement of the northern control site within the suburban community on base contributing to greater occurrences of red fox, woodchucks, and northern raccoons in control sites. Rabbits, whether identified to species or unidentifiable between swamp rabbits (*Sylvilagus aquaticus*) and eastern cottontails, occurred more in switchgrass sites than controls when significant differences were found (Table 6.3.3).

Table 6.3.2. Mammal frequency of occurrence from monthly, 14-day camera trapping surveys in switchgrass monocultures and extant airfield grasslands on 3 airfields and 3 airports in the eastern United States from May 2015 – April 2018. Positive responses indicated greater values in controls than switchgrass monocultures. Only mammals with ≥ 25 detections were included in analysis.

Site[1]	Year	Response Variable	df	t-stat	*P*-value[2]	95% Confidence Interval		Mean Difference
CAFB	All	Cumulative Hazard Score	71	-1.32	0.191	-455.96	92.74	-181.61
		Total detections	69	0.31	0.757	-2.72	3.72	0.50
		Species Richness	69	-1.97	0.052	-0.69	0.00	-0.34
	2015	Cumulative Hazard Score	15	-1.73	0.105	-924.85	96.85	-414.00
		Total detections	15	-2.25	**0.040**	-17.28	-0.47	-8.88
		Species Richness	15	-2.91	**0.011**	-1.52	-0.23	-0.88
	2016	Cumulative Hazard Score	23	1.57	0.129	-62.00	457.34	197.67
		Total detections	23	-0.72	0.478	-5.16	2.49	-1.33
		Species Richness	23	-0.64	0.527	-0.88	0.46	-0.21
	2017	Cumulative Hazard Score	23	2.92	**0.008**	257.67	1511.91	884.79
		Total detections	23	1.98	0.060	-0.33	14.67	7.17
		Species Richness	23	-1.05	0.307	-0.87	0.29	-0.29
	2018	Cumulative Hazard Score	7	-0.13	0.902	-289.78	260.03	-14.88
		Total detections	7	0.13	0.899	-6.37	7.12	0.38
		Species Richness	7	-0.37	0.722	-1.85	1.35	-0.25
DAYT	All	Cumulative Hazard Score	67	2.22	**0.030**	20.94	392.50	206.72
		Total detections	67	0.41	0.684	-2.29	3.46	0.59
		Species Richness	67	-0.92	0.361	-0.47	0.17	-0.15
	2015	Cumulative Hazard Score	13	2.00	0.067	-54.82	1436.25	690.71
		Total detections	13	2.38	**0.034**	0.88	18.41	9.64

		Species Richness	13	5.64	**≤ 0.001**	0.57	1.28	0.93
	2016	Cumulative Hazard Score	21	0.79	0.438	-131.72	293.36	80.82
		Total detections	21	0.05	0.957	-3.36	3.54	0.09
		Species Richness	21	-0.40	0.693	-0.56	0.38	-0.09
	2017	Cumulative Hazard Score	23	1.23	0.231	-102.23	402.15	149.96
		Total detections	23	-0.95	0.354	-5.44	2.02	-1.71
		Species Richness	23	-2.58	**0.017**	-1.43	-0.16	-0.79
	2018	Cumulative Hazard Score	7	-1.96	0.091	-273.10	25.60	-123.75
		Total detections	7	-1.64	0.146	-17.11	3.11	-7.00
		Species Richness	7	-0.55	0.598	-1.32	0.82	-0.25
DTWA	All	Cumulative Hazard Score	47	-0.75	0.455	-314.38	143.09	-85.65
		Total detections	47	-0.50	0.616	-4.15	2.49	-0.83
		Species Richness	47	-0.56	0.579	-0.48	0.27	-0.10
	2016	Cumulative Hazard Score	20	-2.08	0.051	-661.10	1.67	-329.71
		Total detections	20	-1.40	0.176	-9.00	1.76	-3.62
		Species Richness	20	-0.15	0.883	-0.71	0.62	-0.05
	2017	Cumulative Hazard Score	19	1.84	0.082	-34.16	520.06	242.95
		Total detections	19	1.93	0.069	-0.30	7.10	3.40
		Species Richness	19	0.18	0.863	-0.55	0.65	0.05
	2018	Cumulative Hazard Score	6	-1.24	0.262	-869.54	284.96	-292.29
		Total detections	6	-1.62	0.157	-11.49	2.35	-4.57
		Species Richness	6	-2.50	0.047	-1.41	-0.02	-0.71
GRFI	All	Cumulative Hazard Score	41	0.69	0.493	-318.87	651.20	166.17
		Total detections	41	-0.47	0.643	-8.11	5.06	-1.52
		Species Richness	41	-3.76	**≤ 0.001**	-1.35	-0.41	-0.88
	2016	Cumulative Hazard Score	15	-0.45	0.656	-1009.74	654.87	-177.44
		Total detections	15	-1.61	0.129	-19.93	2.80	-8.56
		Species Richness	15	-3.37	**0.004**	-2.04	-0.46	-1.25
	2017	Cumulative Hazard Score	17	0.82	0.426	-400.63	905.85	252.61
		Total detections	17	0.10	0.923	-7.96	8.73	0.39
		Species Richness	17	-2.61	**0.018**	-1.21	-0.13	-0.67

	2018	Cumulative Hazard Score	7	0.91	0.394	-1055.40	2373.15	658.88
		Total detections	7	0.86	0.416	-14.31	30.81	8.25
		Species Richness	7	-0.76	0.472	-2.57	1.32	-0.63
WHIT	All	Cumulative Hazard Score	62	3.83	**≤ 0.001**	382.47	1215.94	799.21
		Total detections	62	3.56	**≤ 0.001**	4.02	14.30	9.16
		Species Richness	62	0.00	1.000	-0.39	0.39	0.00
	2015	Cumulative Hazard Score	13	2.11	0.055	-12.21	988.35	488.07
		Total detections	13	1.31	0.212	-2.68	10.97	4.14
		Species Richness	13	-0.94	0.365	-0.94	0.37	-0.29
	2016	Cumulative Hazard Score	19	2.44	**0.025**	78.09	1013.01	545.55
		Total detections	19	0.79	0.437	-5.81	12.91	3.55
		Species Richness	19	-1.42	0.172	-1.36	0.26	-0.55
	2017	Cumulative Hazard Score	21	2.55	**0.019**	237.05	2348.22	1292.64
		Total detections	21	3.15	**0.005**	6.44	31.38	18.91
		Species Richness	21	2.02	0.057	-0.02	1.57	0.77
	2018	Cumulative Hazard Score	6	3.35	**0.015**	160.70	1030.15	595.43
		Total detections	6	1.77	0.127	-1.74	10.89	4.57
		Species Richness	6	-0.60	0.569	-1.45	0.87	-0.29
WPAF	All	Cumulative Hazard Score	65	0.03	0.978	-221.92	228.26	3.17
		Total detections	65	-0.73	0.470	-5.17	2.41	-1.38
		Species Richness	65	0.93	0.358	-0.23	0.62	0.20
	2015	Cumulative Hazard Score	15	0.64	0.532	-394.66	733.03	169.19
		Total detections	15	2.05	0.059	-0.28	13.66	6.69
		Species Richness	15	1.71	0.109	-0.20	1.83	0.81
	2016	Cumulative Hazard Score	20	0.44	0.667	-282.94	432.66	74.86
		Total detections	20	-0.79	0.441	-11.49	5.21	-3.14
		Species Richness	20	-0.26	0.800	-0.87	0.68	-0.10
	2017	Cumulative Hazard Score	21	-0.34	0.737	-437.18	314.18	-61.50
		Total detections	21	-1.12	0.277	-14.84	4.47	-5.18
		Species Richness	21	0.41	0.684	-0.55	0.82	0.14

2018	Cumulative Hazard Score	6	-1.61	0.159	-979.16	202.87	-388.14
	Total detections	6	-0.55	0.601	-13.96	8.82	-2.57
	Species Richness	6	-0.15	0.887	-2.50	2.21	-0.14

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[2] Significant tests are in **bold** (*P*-value ≤ 0.05).

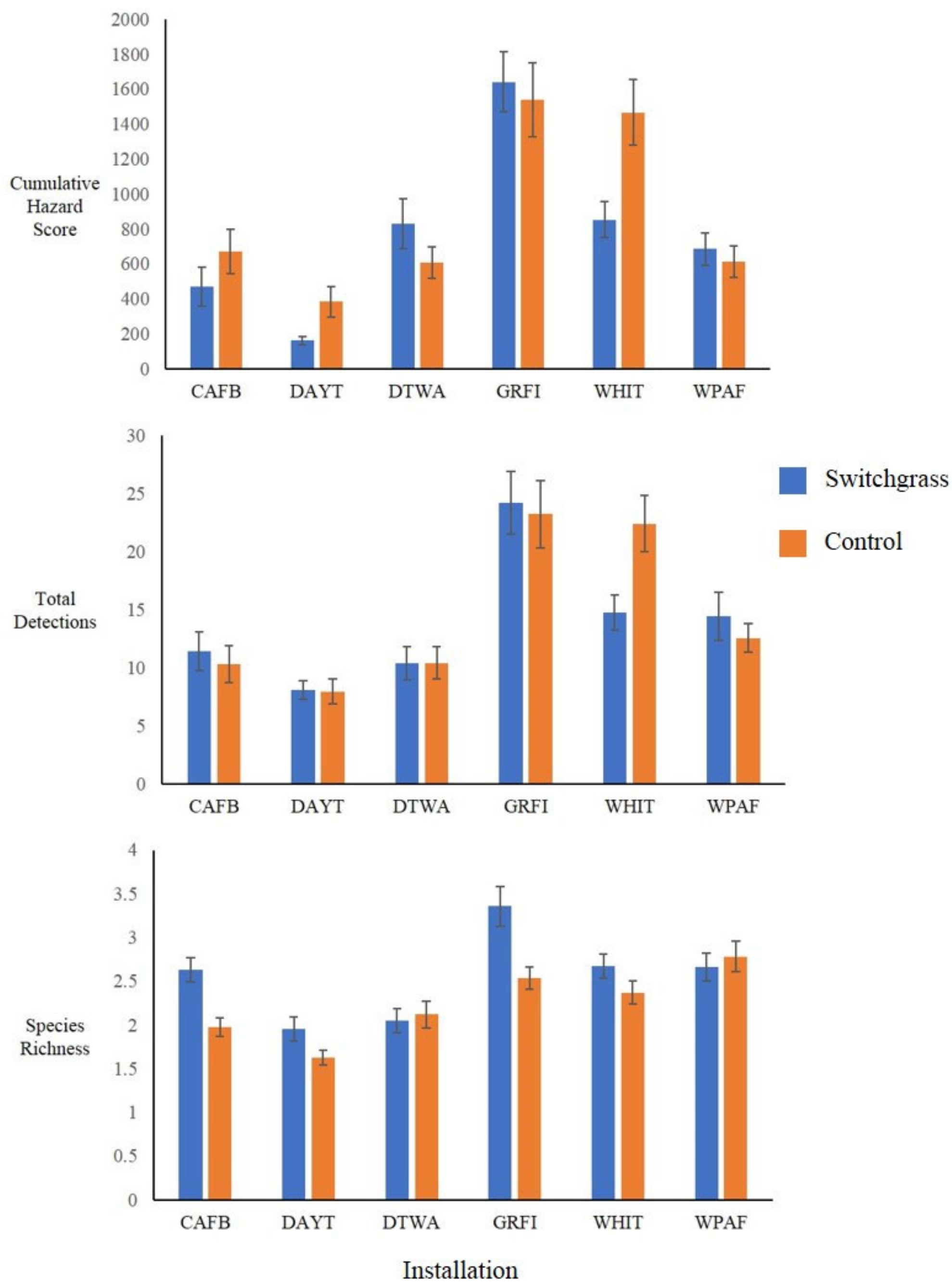


Figure 6.3.1. Mammal frequency of occurrence from monthly, 14-day camera trapping surveys in switchgrass monocultures and extant airfield grasslands on 3 airfields and 3 airports in the eastern United States from May 2015 – April 2018. Only mammals with ≥ 25 detections were included in analysis. Installations included Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).

Table 6.3.3. Comparing mammal detections from monthly, 14-day camera trapping surveys between switchgrass monocultures and extant airfield grasslands in east central United States from May 2015-April 2018. Positive responses indicated greater values in controls than switchgrass monocultures.

Site[1]	Year	Species	df	t-stat	*P*-value[2]	95% Confidence Interval		Mean Difference
CAFB	All	*Canis latrans*	63	-1.53	0.132	-2.56	0.34	-1.11
		Odocoileus virginianus	63	2.38	**0.020**	0.66	7.53	4.09
		Sylvilagus spp.	63	-4.55	**≤ 0.001**	-3.98	-1.55	-2.77
		Procyon lotor	63	0.46	0.646	-3.98	-1.55	0.06
		Didelphis virginiana	63	-1.38	0.171	-3.98	-1.55	-0.23
	2015	*Canis latrans*	15	-0.82	0.427	-7.90	3.53	-2.19
		Odocoileus virginianus	15	-1.46	0.165	-9.22	1.72	-3.75
		Sylvilagus spp.	15	-3.88	**≤ 0.001**	-4.17	-1.21	-2.69
		Procyon lotor	15	0.47	0.646	-4.17	-1.21	0.19
		Didelphis virginiana	15	-0.36	0.728	-4.17	-1.21	-0.13
	2016	*Canis latrans*	23	-1.27	0.218	-2.63	0.63	-1.00
		Odocoileus virginianus	23	1.94	0.065	-0.19	5.86	2.83
		Sylvilagus spp.	23	-3.14	**0.005**	-5.05	-1.04	-3.04
		Procyon lotor	23	0.42	0.679	-5.05	-1.04	0.08
		Didelphis virginiana	23	-1.00	0.328	-5.05	-1.04	-0.38
	2017	*Canis latrans*	23	-1.45	0.162	-1.22	0.22	-0.50
		Odocoileus virginianus	23	3.06	**0.006**	3.42	17.74	10.58
		Sylvilagus spp.	23	-2.05	0.052	-5.11	0.03	-2.54
		Procyon lotor	23	-0.27	0.788	-5.11	0.03	-0.04
		Didelphis virginiana	23	-1.70	0.103	-5.11	0.03	-0.17
	2018	*Canis latrans*	7	-0.65	0.537	-2.90	1.65	-0.63
		Odocoileus virginianus	7	1.77	0.120	-1.43	9.93	4.25
		Sylvilagus spp.	7	-1.27	0.243	-5.00	1.50	-1.75
		Procyon lotor	7	0.00	1.000	-5.00	1.50	0.00

		Didelphis virginiana	7	1.76	0.121	-5.00	1.50	2.00
DAYT	All	*Canis latrans*	67	2.40	**0.019**	0.23	2.50	1.37
		Odocoileus virginianus	67	2.41	**0.018**	0.43	4.49	2.46
		Sylvilagus floridanus	67	-4.60	**≤ 0.001**	-4.05	-1.60	-2.82
		Didelphis virginiana	67	-0.95	0.345	-0.91	0.32	-0.29
	2015	*Canis latrans*	13	2.60	0.022	0.50	5.36	2.93
		Odocoileus virginianus	13	1.82	0.091	-1.31	15.45	7.07
		Sylvilagus floridanus	13	-	-	-	-	-
		Didelphis virginiana	13	-1.17	0.263	-0.81	0.24	-0.29
	2016	*Canis latrans*	21	1.56	0.133	-0.59	4.13	1.77
		Odocoileus virginianus	21	0.70	0.490	-1.51	3.06	0.77
		Sylvilagus floridanus	21	-2.48	**0.022**	-3.68	-0.32	-2.00
		Didelphis virginiana	21	-1.63	0.119	-0.83	0.10	-0.36
	2017	*Canis latrans*	23	1.47	0.155	-0.34	2.01	0.83
		Odocoileus virginianus	23	1.55	0.135	-0.68	4.77	2.04
		Sylvilagus floridanus	23	-3.65	**≤ 0.001**	-5.48	-1.52	-3.50
		Didelphis virginiana	23	-1.47	0.156	-2.41	0.41	-1.00
	2018	*Canis latrans*	7	-0.53	0.615	-4.81	3.06	-0.88
		Odocoileus virginianus	7	1.00	0.351	-0.34	0.84	0.25
		Sylvilagus floridanus	7	-2.53	**0.039**	-15.46	-0.54	-8.00
		Didelphis virginiana	7	1.26	0.246	-1.74	5.74	2.00
DTWA	All	*Canis latrans*	47	0.71	0.481	-0.99	2.08	0.54
		Odocoileus virginianus	47	-1.46	0.151	-4.26	0.68	-1.79
		Sylvilagus spp.	47	0.35	0.728	-0.50	0.70	0.10
		Didelphis virginiana	47	0.67	0.508	-0.29	0.59	0.15
	2016	*Canis latrans*	20	0.22	0.827	-2.80	3.47	0.33
		Odocoileus virginianus	20	-2.35	**0.029**	-7.28	-0.43	-3.86
		Sylvilagus spp.	20	-	-	-	-	-
		Didelphis virginiana	20	-0.50	0.623	-0.99	0.61	-0.19
	2017	*Canis latrans*	19	1.16	0.260	-0.92	3.22	1.15
		Odocoileus virginianus	19	0.83	0.415	-1.82	4.22	1.20
		Sylvilagus spp.	19	1.00	0.330	-0.27	0.77	0.25
		Didelphis virginiana	19	1.31	0.206	-0.33	1.43	0.55

	2018	*Canis latrans*	6	-1.55	0.172	-1.47	0.33	-0.57
		Odocoileus virginianus	6	-1.60	0.162	-10.49	2.21	-4.14
		Sylvilagus spp.	6	-	-	-	-	-
		Didelphis virginiana	6	-	-	-	-	-
GRFI	All	*Canis latrans*	41	2.06	**0.045**	0.03	2.54	1.29
		Odocoileus virginianus	41	1.15	0.258	-2.23	8.09	2.93
		Sylvilagus floridanus	41	-4.40	**≤ 0.001**	-5.94	-2.20	-4.07
		Procyon lotor	41	-1.66	0.104	-2.48	0.24	-1.12
		Mephitis mephitis	41	0.00	1.000	-0.51	0.51	0.00
		Didelphis virginiana	41	-1.35	0.183	-1.07	0.21	-0.43
	2016	*Canis latrans*	15	0.41	0.688	-0.79	1.16	0.19
		Odocoileus virginianus	15	-0.37	0.718	-9.77	6.89	-1.44
		Sylvilagus floridanus	15	-3.83	**0.002**	-5.94	-2.20	-7.44
		Procyon lotor	15	0.54	0.595	-2.01	3.39	0.69
		Mephitis mephitis	15	0.30	0.769	-1.15	1.52	0.19
		Didelphis virginiana	15	-1.38	0.188	-0.95	0.20	-0.38
	2017	*Canis latrans*	17	1.66	0.115	-0.48	4.04	1.78
		Odocoileus virginianus	17	1.24	0.232	-3.00	11.56	4.28
		Sylvilagus floridanus	17	-3.21	**0.005**	-4.70	-0.97	-2.83
		Procyon lotor	17	-2.68	**0.016**	-3.77	-0.45	-2.11
		Mephitis mephitis	17	-0.57	0.579	-0.53	0.30	-0.11
		Didelphis virginiana	17	-0.95	0.354	-2.14	0.81	-0.67
	2018	*Canis latrans*	7	1.16	0.283	-2.46	7.21	2.38
		Odocoileus virginianus	7	1.12	0.300	-9.60	26.85	8.63
		Sylvilagus floridanus	7	-1.00	0.351	-0.42	0.17	-0.13
		Procyon lotor	7	-1.72	0.129	-5.93	0.93	-2.50
		Mephitis mephitis	7	-1.00	0.351	-0.42	0.17	-0.13
		Didelphis virginiana	7	0.00	1.000	-0.45	0.45	0.00
WHIT	All	*Canis latrans*	62	-1.70	0.095	-1.42	0.12	-0.65
		Odocoileus virginianus	62	3.84	**≤ 0.001**	4.41	14.00	9.21
		Sylvilagus spp.	62	0.55	0.585	-1.68	2.95	0.63
		Dasypus novemcinctus	62	-0.43	0.666	-0.36	0.23	-0.06
		Mephitis mephitis	62	0.88	0.382	-0.28	0.73	0.22
	2015	*Canis latrans*	13	-1.03	0.324	-4.44	1.58	-1.43

		Odocoileus virginianus	13	2.33	**0.037**	0.42	11.44	5.93
		Sylvilagus spp.	13	-0.62	0.547	-1.28	0.71	-0.29
		Dasypus novemcinctus	13	-1.00	0.336	-0.23	0.08	-0.07
		Mephitis mephitis	13	-1.00	0.336	-0.23	0.08	-0.07
	2016	*Canis latrans*	19	-1.31	0.206	-1.17	0.27	-0.45
		Odocoileus virginianus	19	2.80	**0.011**	1.66	11.54	6.60
		Sylvilagus spp.	19	-0.53	0.602	-6.92	4.12	-1.40
		Dasypus novemcinctus	19	0.57	0.577	-0.40	0.70	0.15
		Mephitis mephitis	19	-1.21	0.242	-1.37	0.37	-0.50
	2017	*Canis latrans*	21	0.00	1.000	-0.91	0.91	0.00
		Odocoileus virginianus	21	2.45	**0.023**	2.12	26.24	14.18
		Sylvilagus spp.	21	2.02	0.056	-0.12	8.58	4.23
		Dasypus novemcinctus	21	-0.84	0.411	-0.79	0.34	-0.23
		Mephitis mephitis	21	1.58	0.129	-0.20	1.47	0.64
	2018	*Canis latrans*	6	-2.20	0.070	-3.62	0.19	-1.71
		Odocoileus virginianus	6	3.86	**0.008**	2.77	12.37	7.57
		Sylvilagus spp.	6	-1.34	0.230	-8.50	2.50	-3.00
		Dasypus novemcinctus	6	-0.21	0.838	-1.78	1.50	-0.14
		Mephitis mephitis	6	1.00	0.356	-2.07	4.92	1.43
WPAF	All	*Canis latrans*	65	-2.09	**0.041**	-1.96	-0.04	-1.00
		Odocoileus virginianus	65	0.21	0.837	-2.37	2.91	0.27
		Sylvilagus floridanus	65	-2.38	**0.020**	-6.32	-0.56	-3.44
		Procyon lotor	65	2.66	**0.010**	0.13	0.90	0.52
		Vulpes vulpes	65	2.18	**0.033**	0.06	1.48	0.77
		Didelphis virginiana	65	0.70	0.486	-0.98	2.04	0.53
		Mephitis mephitis	65	-0.23	0.822	-0.45	0.36	-0.05
		Marmota monax	65	3.78	$\leq$ **0.001**	0.40	1.30	0.85
	2015	*Canis latrans*	15	-1.60	0.129	-4.37	0.62	-1.88
		Odocoileus virginianus	15	0.52	0.609	-5.00	8.25	1.63
		Sylvilagus floridanus	15	-1.00	0.333	-0.98	0.35	-0.31
		Procyon lotor	15	1.29	0.218	-0.37	1.50	0.56
		Vulpes vulpes	15	1.85	0.083	-0.37	5.37	2.50
		Didelphis virginiana	15	1.41	0.179	-1.63	8.00	3.19
		Mephitis mephitis	15	-0.32	0.751	-1.42	1.05	-0.19
		Marmota monax	15	2.44	**0.028**	0.08	1.17	0.63

2016	*Canis latrans*	20	-1.28	0.214	-2.50	0.59	-0.95
	Odocoileus virginianus	20	0.91	0.375	-2.35	5.97	1.81
	Sylvilagus floridanus	20	-1.63	0.119	-12.60	1.56	-5.52
	Procyon lotor	20	0.00	1.000	-0.20	0.20	0.00
	Vulpes vulpes	20	1.44	0.165	-0.19	1.05	0.43
	Didelphis virginiana	20	0.89	0.386	-1.16	2.87	0.86
	Mephitis mephitis	20	-2.50	**0.021**	-1.31	-0.12	-0.71
	Marmota monax	20	2.02	0.057	-0.03	1.55	0.76
2017	*Canis latrans*	21	-0.32	0.756	-1.73	1.27	-0.23
	Odocoileus virginianus	21	-0.31	0.761	-4.58	3.40	-0.59
	Sylvilagus floridanus	21	-1.68	0.107	-10.67	1.13	-4.77
	Procyon lotor	21	1.52	0.143	-0.32	2.04	0.86
	Vulpes vulpes	21	1.00	0.329	-0.05	0.14	0.05
	Didelphis virginiana	21	-1.31	0.206	-4.36	1.00	-1.68
	Mephitis mephitis	21	2.05	0.053	-0.01	1.01	0.50
	Marmota monax	21	2.81	**0.011**	0.21	1.42	0.82
2018	*Canis latrans*	6	-5.28	**0.002**	-2.30	-0.84	-1.57
	Odocoileus virginianus	6	-1.97	0.096	-10.56	1.13	-4.71
	Sylvilagus floridanus	6	-1.00	0.356	-0.49	0.21	-0.14
	Procyon lotor	6	0.97	0.370	-1.31	3.02	0.86
	Vulpes vulpes	6	1.00	0.356	-0.21	0.49	0.14
	Didelphis virginiana	6	0.89	0.407	-0.75	1.61	0.43
	Mephitis mephitis	6	1.00	0.356	-0.83	1.97	0.57
	Marmota monax	6	1.52	0.179	-1.05	4.47	1.71

[1]Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), NAS Whiting Field (WHIT), Wright-Patterson Air Force Base (WPAF).
[2] Significant tests are in **bold** (P-value ≤ 0.05).

Coyotes, white-tailed deer and all rabbits (eastern cottontails and unknown rabbits) occurred across all installations and were therefore included in among installation analysis. Cumulative hazard score and species richness were based on top species (i.e., $\geq$ 25 detections) among installations. Model selection indicated that the only substantial response to switchgrass coverage was by individual species, not species richness, total abundance or cumulative hazard score. All rabbits exhibited the only strong direction response to switchgrass coverage with increasing occurrences as switchgrass coverage increased (Table 6.3.4). Coyotes and white-tailed deer exhibited weak decreases in occurrences as switchgrass coverage increased as indicated by credible intervals being centered around 0 (i.e., “Proportion > 0” ~ 0).

Table 6.3.4. Descriptive statistics of Markov chain Monte Carlo posterior distributions of mammals to increasing switchgrass coverage determined by multivariate and univariate generalized linear mixed models used to investigate mammal community responses to switchgrass monocultures as an alternative land cover on airfields to mitigate mammal strikes with aircraft among 6 airports and airfields from Alabama to Michigan using monthly 14-day camera trapping surveys (May 2015 – April 2018).

					95% Credible Interval	
Species	Mean	SE	Mode	Proportion > 0	Lower	Upper
Coyote	-0.006	0.0001	-0.006	0.045	-0.012	0.001
White-tailed Deer	-0.007	0.0001	-0.007	0.066	-0.016	0.002
Sylvilagus spp.	0.022	0.0003	0.022	0.963	-0.002	0.046

6.3.0 Mammal Frequency of Occurrence Summary and Conclusions

Installation-specific mammal presence and responses varied substantially, but all sites observed site use by coyotes, white-tailed deer, and by at least one species of rabbit. White-tailed deer and coyote had greater occurrences in controls more often than switchgrass sites during installation-specific analyses. However, among years analysis suggesting weak directional responses to switchgrass establishment with a slight decrease in coyote and deer use as switchgrass coverage increased. Rabbits were the main species group exhibiting greater use of switchgrass sites than controls. Overall, mammal responses suggest positive but weak support for establishing switchgrass at airfields and airports but did not meet performance objective success criteria (Performance Objective 3). We used frequency of occurrence and calculated relative hazard scores based on average body weight per species and relative contribution to mammal strike frequency and damage according to the Federal Aviation Administration's Wildlife Strike Database. We compared average mammal hazard scores between switchgrass sites and controls with success indicated by significantly reduced average hazard score in switchgrass sites than control after the first growing season and continued significantly less average hazard score of mammals for every subsequent year. Some installation-specific investigations indicated beneficial outcomes of switchgrass establishment for reducing hazardous mammal use, but among-installation analysis suggested no overall effect (Performance Objective 5).

7.0 COST ASSESSMENT

The following cost elements describe costs and income associated with the establishment of switchgrass monocultures in switchgrass sites, maintenance of control sites (i.e., extant airfield grasslands), and harvesting switchgrass. Local land management contractors were hired for most switchgrass establishment work. Mowing prior to herbicide application on switchgrass sites was performed by airfield personnel or land management contractors. Harvesting switchgrass sites was part of the project's design but only occurred at two sites (DAYT and WPAF) once switchgrass was established (2017). We tracked all costs and any income from haying practices (e.g., haying lease, sale of hay). Life-cycle costs associated with switchgrass sites decreased over time considering main costs occurred during the first 1-2 years during implementation and long-term outlook of minimal maintenance costs for switchgrass haying that may be covered by the harvesters (farmer) or compensated by revenue generated by the sale of hay bales. Established switchgrass stands are also expected to be long-lived.

Life-cycle costs (cumulative costs) associated with extant airfield grasslands were expected to increase over time following trends in gas prices and personnel costs, but tracking annual costs during the demonstration was difficult due to airfield/airport maintenance cost tracking. We tracked all costs and revenue associated with switchgrass technology by installation and land manager. However, some cost elements were combined by land managers (e.g., site preparation and planting, mowing and herbicide application). We did not include these combined costs for single cost elements. We scaled costs per acre and sites to help communicate results to participating installations. All participating land managers remain available for participating installations to contact. Life-cycle costs associated with wildlife monitoring during the demonstration were also recorded and provided to end users but are not the focus of the demonstration's cost assessment.

7.1 COST MODEL

Table 7.1.1. Costs elements for establishing switchgrass monocultures, maintaining control sites, and harvesting switchgrass for a demonstration project investigating switchgrass monocultures as a land cover alternative on military and civil airfields of the eastern United States.

Cost Element		Data Tracked During the Demonstration	Estimated Costs (per acre)
Switchgrass Establishment (switchgrass sites)	Mowing (site preparation)	Installation-specific costs for mowing prior to herbicide application categorized as equipment, mobilization, and labor for switchgrass sites only according to reported costs. Contracted land managers decided on site preparation needs. Some land managers preferred mowing before herbicide application when treating fallow fields that had not been cut during the current growing season. Mowing for site preparation costs was reported in land manager invoices but only occurred at WHIT. Information received was scaled to costs per acre. The costs per acre of all switchgrass establishment practices was our primary metric for evaluating performance objective 4. Details from contractor invoices was transferred to an Access® database after each land management activity, and contractor invoices were filed with other project information by the project manager. Cost estimates of mowing per acre for site preparation were factored into life-cycle costs of converting installation acreage to switchgrass as a one-time application.	$\bar{x}$ = \$80.63 SE = \$3.09 \$76.25-\$85.00 *Contributing Sites* WHIT
	Herbicide applications (site preparation)	Installation-specific costs of materials, equipment, mobilization, and labor in addition to details of tank mixes and application rates were recorded for all herbicide applications during site preparation for switchgrass sites. Most information received was installation-specific. Ohio sites (DAYT and WPAF) combined charges for herbicide and planting ($\bar{x}$ = \$177.5 per acre, SE = \$0) but listed sites under Estimated Costs provided separate invoice lines for herbicide application(s) during site preparation. The costs per acre of all switchgrass establishment practices was our primary metric	$\bar{x}$ = \$85.47 SE = \$8.85 \$51.80-\$115.00 *Contributing Sites* CAFB, DTWA, GRFI, WHIT

		for evaluating performance objective 4. Details from contractor invoices were transferred to an Access® database after each land management activity, and contractor invoices were filed with other project information by the project manager. Details for herbicide applications included the type of chemical(s) used, application rate, total volume applied, chemical costs, equipment costs (per application per acre), and associated labor costs (per application per acre; Table 5.6.1.1). Cost estimates of herbicide application per acre for site preparation were factored into life-cycle costs of converting airfield/airport acreage to switchgrass as a one-time application. W	
	Site bed preparation (site preparation)	Land managers did not recommend or implement any site bed preparation. Initial discussions suggested intensive site bed preparation may be required including but not limited to heavy disking and rolling. However, herbicide applications prior to planting and at WHIT, mowing as well, were the primary site preparation techniques used.	$\bar{x}$ = \$0 SE = \$0
	Switchgrass planting	Installation-specific costs of seed, mobilization, equipment, and labor regarding seed drilling 10.1 kg of switchgrass seed per acre. Switchgrass variety and whenever possible seed source were also recorded. "Cave-n-Rock" was the primary variety. Information received was installation-specific with the exception of replanting the northern site at DAYT, but all costs were scaled to costs per acre. Costs were reported differently among installations and land managers including combined seed and planting costs, seed only, and planting only costs. Hence, the presentation of estimated costs is presented as seed only, planting only, and seed and planting costs. The costs per acre of all switchgrass establishment practices was our primary metric for evaluating performance objective 4. Details from contractor invoices were transferred to an Access® database after each land management activity, and contractor invoices were filed with other project information by the project manager. Switchgrass planting costs per acre factored into life-	*Seed Only* $\bar{x}$ = \$72.26 SE = \$9.15 \$35.00-\$108.00 *Contributing Sites* All sites except WHIT *Planting Only* $\bar{x}$ = \$71.55 SE = \$7.67 \$49.93-\$98.25 *Contributing Sites* CAFB, DTWA, GRFI and

		cycle costs of converting airfield/airport acreage to switchgrass as a one-time cost.	DAYT northern plot replanting *Seed and Planting* $\bar{x}$ = \$110.00 SE = \$0 *Contributing Site* DAYT first planting and WPAF
	Herbicide application (competition control)	Broadleaf herbicides (e.g., 2,4-D) were used after switchgrass planting to decrease plant competition by native and exotic weeds. Ohio installations received the most competition release applications (Table 5.6.1.1). In one case (WPAF), mowing and herbicide application were a combined treatment and invoiced as such. Costs per acre were combined with other switchgrass establishment practices to produce our primary metric for evaluating performance objective 4. Details from contractor invoices was transferred to an Access® database after each land management activity, and contractor invoices were filed with other project information by the project manager. Cost estimates of competition release herbicide application per acre for switchgrass establishment were factored into life-cycle costs of converting installation acreage to switchgrass.	$\bar{x}$ = \$88.25 SE = \$38.54 \$33.75-\$142.75 *Contributing Sites* DAYT, WPAF *Mow and Spray* $\bar{x}$ = \$11.46 SE = \$0 *Contributing Site* WPAF
	Mowing (competition control)	Mowing was also used as an alternative plant competition control technique and implemented in Ohio and Michigan sites, often during late growing season and early dormant season. Costs per acre were combined with other switchgrass establishment practices to produce our primary metric for evaluating performance objective 4. Details from contractor invoices was transferred to an Access® database after each land management activity, and contractor invoices were filed with other project	$\bar{x}$ = \$27.60 SE = \$6.16 \$12.50-\$35.15 *Contributing Sites* DAYT, GRFI, WPAF

		information by the project manager. Cost estimates of competition release herbicide application per acre for switchgrass establishment were factored into life-cycle costs of converting installation acreage to switchgrass.	
Maintenance of Extant Airfield Grassland (control sites)	Mowing	Installation-specific costs of equipment, mobilization, and labor for mowing control sites according to regular maintenance regimes. Limited information was received by installations. The primary response of installations was a lack of specific information pertaining to mowing costs (i.e., costs per acre and effort). Most installations mentioned being unable to relay information pertaining to the number of mowings, personnel time, equipment maintenance, fuel, etc., because of record keeping and budgeting being generalized to airport property maintenance such as grass management within and outside the AOA. Mowing costs associated with switchgrass competition control (see above) could be considered comparable to mowing tall grass fields outside the AOA which for DAYT, GRFI, and WPAF could be assumed to be approximately 1-3 times annually. Therefore, approximate cost estimates could be derived from multiplying switchgrass competition control mowings times the appropriate frequency. Although these costs were not be incurred by the project, they were scaled to costs per acre and compared to switchgrass technology costs over the course of the demonstration to address performance objective 4. Mowing costs per acre were factored into life-cycle costs of maintaining extant airfield grasslands as annual costs.	*One Mow Per Year* $\bar{x}$ = \$27.60 SE = \$6.16 \$12.50-\$35.15 *Two Mowings Per Year* $\bar{x}$ = \$55.20 SE = \$12.33 \$25.00-\$98.08 *Three Mowings Per Year* $\bar{x}$ = \$82.80 SE = \$18.49 \$37.50-\$105.45 *Contributing Sites* DAYT, GRFI, WPAF
	Fertilizing	Installation-specific costs of equipment, materials, mobilization, and labor for fertilizing control sites according to regular maintenance regimes. Participating installations did not apply fertilizer to control sites or other similar grassland areas outside the AOAs during the demonstration. Therefore, fertilizing costs per acre were not factored into life-cycle costs of maintaining extant airfield grasslands as annual costs.	$\bar{x}$ = \$0 SE = \$0

	Herbicide Application	Installation-specific costs of equipment, materials, mobilization, and labor for herbicide applications for competition control on control sites according to regular maintenance regimes. Participating installations did not apply herbicides to control sites or other similar airport grasslands outside the AOA during the demonstration. Therefore, herbicide costs per acre were not factored into life-cycle costs of maintaining extant airfield grasslands as annual costs.	$\bar{x}$ = \$0 SE = \$0
Switchgrass Revenue	Switchgrass Harvest	Difference between installation-specific costs of equipment, mobilization, and labor of harvesting switchgrass and profit from sale of switchgrass hay bales for either quality cattle forage or biomass feedstock for biofuels was the intended metric. However, the primary haying events occurred at DAYT and WPAF in 2017 during which a farmer hayed the southern switchgrass site at DAYT for free and a farmer was contracted to hay and remove bales from both sites at WPAF. The project covered the cost of contracted the WPAF farmer for the southern switchgrass site. For the northern switchgrass site at WPAF, the farmer hayed and removed bales for free. Therefore, switchgrass harvesting revenue per acre was estimated based on minimum available prices per bale. Switchgrass harvesting costs and potential revenue per acre were factored into life-cycle costs of switchgrass implementation beginning at three years post-planting.	*Contracting Farmer to Hay and Remove Bales* $\bar{x}$ = \$175.00 SE = \$0 *Contributing Site* WPAF southern switchgrass site *Estimated Gross Income Based on Harvest Bales (\$30 per bale)* $\bar{x}$ = \$220.90 SE = \$27.38 \$182.19-\$259.62 *Contributing Site* WPAF *Estimated Revenue* $\bar{x}$ = \$45.90 SE = \$27.38 \$7.19-\$84.62

Extant Airfield Revenue	Haying Control sites	Difference between installation-specific costs of equipment, mobilization, and labor of harvesting control sites if not intensively maintained and profit from sale of hay bales. Participating installations did not contract haying operations during the demonstration. Conversations with installation personnel suggested that past management histories of areas outside the AOAs has changed overtime from fallow field management to farmer leases including but not limited to haying operations and row crop. We did not consider mowing by installation personnel to be considered haying. Therefore, extant airfield revenue was not factored into life-cycle revenue of extant airfield grasslands.	$\bar{x}$ = \$0 SE = \$0

7.2 COST DRIVERS

Cost drivers for establishing switchgrass monocultures can vary substantially among site conditions and landowner preferences. Primary cost drivers and variations among installations during this demonstration were soil moisture and plant competition. Soil moisture limited timing of planting and seed germination. For DTWA, soil moisture delayed planting by a year and influence switchgrass establishment thereafter. For CAFB, soil moisture delayed planting until July 2015 and then inhibited use of a seed drill during then and 2016's replanting attempt. Approximately 2 ha of DAYT's southern switchgrass site did not germinate due to excessive soil moisture, and the northern switchgrass site at DAYT had standing water areas that precluded switchgrass establishment in addition to likely attracting observed waterbirds. The southern switchgrass site at GRFI eventually formed a large standing water area from rainwater runoff during 2017-2018. Wetland plants can sometimes be identified during site selection and indicate areas where switchgrass establishment could be difficult. Site location specifications from participating installations limited selection of optimal candidate sites, but all selected sites were similar to other extant airfield grasslands with small patches of wetland plants in most cases. In addition, the temporal period of the demonstration did not allow for us to delay planting until drier conditions occurred at each installation. Greater time flexibility during future switchgrass implementation attempts by participating and other installations could benefit from waiting for optimal planting conditions. In the meantime, these installations should consider additional plant competition control approaches during site preparation.

Switchgrass, similar to other native warm-season grasses, does not compete well with other plants during initial establishment phases. Site preparation approaches used in this demonstration were similar to past work and often succeed in establishing switchgrass. However, even in ideal conditions such as arable land with past management histories of intensive plant competition control, switchgrass has failed to establish. All switchgrass sites experienced some level of plant competition. The minimal plant competition experienced at Ohio sites can be attributed to the diligence of the local land manager. Such diligence in implementing plant competition control measures early and often came at a greater cost to the demonstration's land management expenses. However, the Ohio sites were the only switchgrass sites considered for haying by local farmers. Furthermore, two farmers inquired about haying Ohio sites after the demonstration's field testing period suggesting potential future revenue for the Ohio installations through leasing these areas for haying. Although leasing would likely generate less revenue than haying and selling bales themselves, leasing offers a much easier approach to generating alternative income while not increasing hazardous wildlife.

Future implementation of switchgrass monocultures should consider a few options for plant competition control. Initial burn down approaches using a broad-spectrum herbicide (e.g., glyphosate as active ingredient) will likely continue to be the primary first step. However, burn downs could occur at multiple times throughout the year prior to switchgrass planting. In southern areas similar to CAFB and WHIT, warm- and cool-season plants can compete with switchgrass establishment suggestion both growing and dormant season herbicide applications. Interweaving disking among herbicide applications can also increase plant competition control as annual plant species in the seed bank can be expressed after disking. At CAFB, annual foxtail (*Setaria* app.) was a primary plant competitor that may have been released after the initial burn down attempts in 2015 and early 2016 killed its competitors. During the 2016 herbicide application for the second switchgrass establishment attempt, herbicide drift caused the land manager to return for a second spray of missed strips. During the two weeks between the field spray and spot spray, annual plants such as foxtail germinated but were then controlled by the second application of herbicide to areas not sprayed two weeks prior (Figure 7.2.1). Spraying a herbicide with a soil-binding active ingredient such as glyphosate 1-2 days prior to planting could also have helped with switchgrass establishment during 2016 at CAFB and would not have interfered with switchgrass seed germination when following standard herbicide application rates. Therefore, in areas of potential high plant competition due to turf species or seed bank competitors, multiple herbicide applications, with or without interspersed disking, may be required to effectively reduce plant competition and establish a successful switchgrass stand. Post-planting monitoring and plant competition control can also be beneficial, especially when broadleaf weeds are the primary competitors. Selective herbicides (e.g., 2, 4-D) and mowing can be used in these situations to reduce plant competition and encourage switchgrass establishment as demonstrated at the Ohio sites and GRFI.

Figure 7.2.1. Northern switchgrass site at CAFB during summer 2016. The dark green strip was sprayed approximately two weeks after the rest of the site was sprayed with a broad-spectrum herbicide (e.g., active ingredient glysphosate). The majority of plants in the left half of the

picture with “fuzzy” seed heads are foxtail (Setaria spp.) that likely capitalized on reduced competition from the first spray earlier in the summer but restricted by a slightly later spray.

7.3 COST ANALYSIS AND COMPARISON

Site selection, management intensity, and airfield goals should all be considered when contemplating the implementation of switchgrass monocultures. Candidate switchgrass monoculture sites on airfields and airports should follow most of the recommended site selection criteria of this demonstration (Table 4.0.1). Additional characteristics for ideal sites might include easy access for heavy equipment such as no-till seed drills and tractors with attached elements, few if any excessively wet areas indicated by wetland plants, and a history of intensive plant competition control. Equipment access can be overlooked when considering segments of areas outside the AOA, but easier access can reduce labor costs and remove apprehensions for additional post-planting management such as broadleaf plant control or haying. Although many switchgrass varieties can thrive in moist soil conditions, soil moisture variability can cause noticeable differences in switchgrass germination, not to mention increasing scheduling conflicts between rain events and planting dates. Past intensive plant control is most typical of areas recently farmed or with a farming history in which the seed bank is reduced over multiple years of control applications.

The cost analysis was based on converting extant airport grassland to switchgrass monocultures with intensive pre- and post-planting management as observed at WPAF. Primary assumptions were similar application rates, plant competition control needs based on initial plant communities and invading species, similar land management costs including seed, chemicals, equipment, labor, and fuel, and similar weather conditions of Dayton, OH from May 2015 through October 2017. Cost analysis included all costs associated with WPAF, including contracting a farmer in 2017 for haying the southern switchgrass site. However, potential revenue was assumed to begin in 2018 when farmers contacted WPAF seeking to hay the southern switchgrass site without WPAF, or the demonstration, covering haying costs such as cutting, haying, baling and removing bales. Haying income and mowing (i.e., extant airfield management) scenarios were developed to compare a range of potential cost-benefit ratios. Conservative haying incomes were based on the potential revenue per acre from contracting a farmer to prepare all hay bales and selling bales at $30 per bale ($45.90 per acre maximum). From this starting point, we generated scenarios of 20%, 40%, and 60% hay bale sales of the revenue maximum simulating potential property leasing rates (20%) to low sale rate of hay bales (60%). Mowing costs were based on the contracted switchgrass mowing rate of the land manager which represented the approximate cost of an annual mowing of tall grass areas. As mowing frequencies increase, installation personnel communicated lower costs per mowing considering less personnel time (i.e., labor) due to mowers capable of running at higher gears. Therefore, we simulated increasing mowing frequencies up to 5 mowings per growing season (i.e., approximately monthly for mowing April through September) with 20% cost reductions per mowing beginning with $27.60 per acre for an annual mowing of tall-grass grasslands. For example, two mowings per year would each cost $22.08, or $44.16 per year. For all scenarios, net revenue was calculated sequentially with each year adding the previous year revenue to the current year's revenue. Extant airfield grassland management (Table 7.3.1) and switchgrass monoculture management (Table 7.3.2) revenues were forecasted as the first 3 years of switchgrass establishment, out to 20 total years.

Switchgrass monocultures offered an improvement to existing technology of extant airport grasslands and offered an alternative to leasing property for row crops. Typical airport grassland management outside AOAs involving periodic mowing may be improved by implementing less desirable conditions for wildlife hazardous to aircraft. Despite minimal change in the presence of hazardous wildlife, some switchgrass sites did not begin to transition to monocultures towards the end of the demonstration, a phase during which a greater wildlife response could have been observed. Concomitant to wildlife responses, improvements could also include gradual revenue increases as established switchgrass monocultures provide alternative income via the sale of baled switchgrass hay or leasing airport property to local farmers for haying. Meanwhile, as a safe alternative crop outside AOAs, but on airport property, switchgrass monocultures would likely meet military and FAA recommendations of safe management practices compared to row crops, especially any cereal crops. Switchgrass monocultures are not recommended for short-grass management areas such as within the AOA. Grass height recommendations currently conflict between optimal conditions for visibility within AOAs and switchgrass management. Repeated mowing of switchgrass on similar schedules to short grass management can reduce switchgrass vigilance and allow for invasion of other plant species in the monoculture. Similar conditions often occur in fallow fields mowed approximately monthly in which perennial grasses, forbs, and woody plants, tolerant of frequent mowing or grazing, become well-established and outcompete annual species.

Table 7.3.1. Forecasted costs and revenue from mowing airfield and airport grasslands once to five times per year based on land management costs for mowing switchgrass monoculture sites at Wright-Patterson Air Force Base and a 20% reduction in cost per acre for each additional mow due to shorter grass being easier to cut than tall grass.

	Mowing Frequency Per Year (Cost)					Revenue per Mowing Frequency				
Years	One	Two	Three	Four	Five	One	Two	Three	Four	Five
1 to 3	$ 82.80	$ 132.48	$ 158.98	$ 169.57	$ 169.57	$ (82.80)	$(132.48)	$ (158.98)	$ (169.57)	$ (169.57)
4	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(110.40)	$(176.64)	$ (211.97)	$ (226.10)	$ (226.10)
5	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(138.00)	$(220.80)	$ (264.96)	$ (282.62)	$ (282.62)
6	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(165.60)	$(264.96)	$ (317.95)	$ (339.15)	$ (339.15)
7	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(193.20)	$(309.12)	$ (370.94)	$ (395.67)	$ (395.67)
8	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(220.80)	$(353.28)	$ (423.94)	$ (452.20)	$ (452.20)
9	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(248.40)	$(397.44)	$ (476.93)	$ (508.72)	$ (508.72)
10	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(276.00)	$(441.60)	$ (529.92)	$ (565.25)	$ (565.25)
11	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(303.60)	$(485.76)	$ (582.91)	$ (621.77)	$ (621.77)
12	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(331.20)	$(529.92)	$ (635.90)	$ (678.30)	$ (678.30)
13	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(358.80)	$(574.08)	$ (688.90)	$ (734.82)	$ (734.82)
14	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(386.40)	$(618.24)	$ (741.89)	$ (791.35)	$ (791.35)
15	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(414.00)	$(662.40)	$ (794.88)	$ (847.87)	$ (847.87)
16	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(441.60)	$(706.56)	$ (847.87)	$ (904.40)	$ (904.40)
17	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(469.20)	$(750.72)	$ (900.86)	$ (960.92)	$ (960.92)
18	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(496.80)	$(794.88)	$ (953.86)	$(1,017.45)	$(1,017.45)
19	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(524.40)	$(839.04)	$(1,006.85)	$(1,073.97)	$(1,073.97)
20	$ 27.60	$ 22.08	$ 17.66	$ 14.13	$ 11.30	$(552.00)	$(883.20)	$(1,059.84)	$(1,130.50)	$(1,130.50)

Table 7.3.2. Management costs per acre and forecasted income and revenue from converting airfield and airport grasslands to switchgrass monocultures (management cost) and selling baled switchgrass hay (income) starting 3 years after planting. Income estimates are the sum of total potential income for partial sale of hay bales after accounting for costs associated with contracting a farmer to cut, rake, and bale hay.

Years	Management Cost	Income				Revenue		
		20% Sales	40% Sales	60% Sales		20% Sales	40% Sales	60% Sales
1 to 3	$ 437.61	$ -	$ -	$ -		$(437.61)	$(437.61)	$(437.61)
4	$ -	$ 9.18	$ 18.36	$ 27.54		$(428.43)	$(419.25)	$(410.07)
5	$ -	$ 9.18	$ 18.36	$ 27.54		$(419.25)	$(400.89)	$(382.53)
6	$ -	$ 9.18	$ 18.36	$ 27.54		$(410.07)	$(382.53)	$(354.99)
7	$ -	$ 9.18	$ 18.36	$ 27.54		$(400.89)	$(364.17)	$(327.45)
8	$ -	$ 9.18	$ 18.36	$ 27.54		$(391.71)	$(345.81)	$(299.91)
9	$ -	$ 9.18	$ 18.36	$ 27.54		$(382.53)	$(327.45)	$(272.37)
10	$ -	$ 9.18	$ 18.36	$ 27.54		$(373.35)	$(309.09)	$(244.83)
11	$ -	$ 9.18	$ 18.36	$ 27.54		$(364.17)	$(290.73)	$(217.29)
12	$ -	$ 9.18	$ 18.36	$ 27.54		$(354.99)	$(272.37)	$(189.75)
13	$ -	$ 9.18	$ 18.36	$ 27.54		$(345.81)	$(254.01)	$(162.21)
14	$ -	$ 9.18	$ 18.36	$ 27.54		$(336.63)	$(235.65)	$(134.67)
15	$ -	$ 9.18	$ 18.36	$ 27.54		$(327.45)	$(217.29)	$(107.13)
16	$ -	$ 9.18	$ 18.36	$ 27.54		$(318.27)	$(198.93)	$ (79.59)
17	$ -	$ 9.18	$ 18.36	$ 27.54		$(309.09)	$(180.57)	$ (52.05)
18	$ -	$ 9.18	$ 18.36	$ 27.54		$(299.91)	$(162.21)	$ (24.51)
19	$ -	$ 9.18	$ 18.36	$ 27.54		$(290.73)	$(143.85)	$ 3.03
20	$ -	$ 9.18	$ 18.36	$ 27.54		$(281.55)	$(125.49)	$ 30.57

7.4 COST ASSESSMENT SUMMARY AND CONCLUSIONS

Site preparation and switchgrass planting were initial costs associated with establishing monoculture switchgrass as an alternative land cover on airfields. However, switchgrass does not need to be mowed frequently as does turf grass. Therefore, across all years of study, we expected a net economic benefit from switchgrass sites compared to controls. We calculated annual maintenance costs for all sites each year of study based on available information from participating installations and land managers. We compared switchgrass site costs to controls across all study years and forecasted future cost comparisons. We proposed that successful demonstration of monoculture switchgrass as an alternative land cover for airfields would be partially represented by a 10% net economic gain on switchgrass sites by the end of the study. However, establishment costs were far greater than mowing costs during switchgrass establishment years.

We forecasted cost-benefit scenarios using estimated mowing and haying costs in addition to potential revenue from the sale of switchgrass hay. For all scenarios, net revenue was calculated sequentially with each year adding the previous year revenue to the current year's revenue. Extant airfield grassland management and switchgrass monoculture management revenues were forecasted as the first 3 years of switchgrass establishment, then out to 20 years (Section 7.3). Although the performance objective was not met (Performance Objective 6), forecasted revenues for switchgrass sites at the most expensive (i.e., cost per acre) switchgrass establishment installation were promising. All participating installations were also provided with installation-specific cost forecasts estimating net gains from not mowing beginning 2025 to 2036 with later years associated with high switchgrass establishment and low mowing costs.

8.0 IMPLEMENTATION ISSUES

Regulations for the demonstration were site-specific as mentioned in Site Description (4.0). Herbicide application and other land management records have been provided to airfield personnel for their records and listed in Table 5.6.1.1. Permission to implement land management activities was approved during the initial approval process for each installation, but scheduling land management activities will involve coordination by the project's research associate with airfield personnel and local contractors. Contractors will also need to attain permission to enter airfields but those processes have been identified and explained by airfield personnel for all current sites. Because we will only be observing wildlife, no animal use permits or Institutional Animal Care and Use Committee (IACUC) approval is required.

Wildlife and vegetation surveys and meetings with airfield and airport personnel have helped support monoculture switchgrass as a viable alternative land cover for airfields. However, user acceptance of this new, innovative land cover was the project's ultimate goal. Project personnel met with installation staff throughout the project regarding operations and feedback including presentations during September and October 2018 to share preliminary final results. Although switchgrass establishment failed at multiple locations and switchgrass monocultures were not realized until after the demonstration period (e.g., growing season 2018), discussions during final report presentations revolved around the alternative grassland management approach (i.e., tall grass with infrequent mowings versus frequently mowed short grass). Installations were asked if they would consider continuing to manage for switchgrass/tall-grass on their sites or otherwise leave the switchgrass plots "unmanaged". All installations were asked to provide a letter notifying us of their acceptance of switchgrass/tall grass as an alternative land cover and any additional insights to discussions among airfield/airport personnel regarding management for these areas. Letters were signed by the appropriate staff member(s) (e.g., Chief of USAF BASH Team, Chief of Installation Management Division, Airport Director, Commander, Chief of Wing Safety, etc.) for each installation.

The majority (4 of 6) of participating installations supported maintaining switchgrass plots to differing degrees. Airport personnel for DTWA and GRFI plan to continue maintaining all switchgrass plots. Both installations will likely adopt a high-mow regime as a primary method of maintaining switchgrass coverage with limited additional herbicide applications for broadleaf weed control. The Ohio installations (DAYT and WPAF) will each maintain one switchgrass plot. The southern plot at DAYT will be converted to extant airport grassland likely through a frequent mowing regime due to its proximity to the airport entrance (i.e., aesthetics). At WPAF, the northern switchgrass plot was converted to a new gate construction project towards the end of the demonstration, but WPAF will continue maintaining the southern switchgrass plot as long as support continues from the Installation Commander. Columbus Air Force Base and WHIT experienced switchgrass failure and have both expressed the likelihood of applying periodic mowing to their switchgrass plots and not supporting the future growth and establishment of switchgrass.

9.0 REFERENCES

Barras, S. C., R. Dolbeer, R. B. Chipman, and G. E. Bernhardt. 2000. *Bird and small mammal use of mowed and unmowed vegetation at John F. Kennedy International Airport, 1998- to 1999*. Proceedings of the 19th Vertebrate Pest Conference, University of California, Davis, USA.

Barras, S. C., and T. W. Seamans. 2002. *Habitat management approaches for reducing wildlife use of airfields*. Proceedings of the 20th Vertebrate Pest Conference, University of California, Davis, USA.

Blackwell, B. F., and E. Fernández-Juricic. 2013. *Behavior and physiology in the development and application of visual deterrents at airports*. In: T. L. DeVault, B. F. Blackwell, and J. L. Belant, eds. Wildlife in Airport Environments: Preventing Animal-Aircraft Collisions Through Science-based Management. Johns Hopkins University Press, Baltimore, MD, USA.

Blackwell, B. F., P. Schmidt, and J. A. Martin. 2013a. *Avian surveys methods for use at airports*. In: T. L. DeVault, B. F. Blackwell, and J. L. Belant, eds. Wildlife in Airport Environments: Preventing Animal-Aircraft Collisions Through Science-based Management. Johns Hopkins University Press, Baltimore, MD, USA.

Blackwell, B. F., T. L. DeVault, E. Fernández-Juricic, and R. A. Dolbeer. 2009. *Wildlife collisions with aircraft: a missing component of land-use planning for airports*. Landscape and Urban Planning 93:1-9.

Blackwell, B. F., T. W. Seamans, K. Linnell, L. Kutsch-Bach Brohl, and T. L. DeVault. 2016. *Effects of visual obstruction, prey resources, and satiety on bird use of simulated airport grasslands*. Applied Animal Behaviour Science 185:113–120.

Blackwell, B. F., T. W. Seamans, P. M. Schmidt, T. L. DeVault, J. L. Belant, M. J. Whittingham, J. A. Martin, and E. Fernández-Juricic. 2013b. *A framework for managing airport grasslands and birds amidst conflicting priorities*. Ibis 155:199-203.

Brough, T. E., and C. J. Bridgman. 1980. *An evaluation of long-grass as a bird deterrent on British airfields*. Journal of Applied Ecology 17:243-253.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. *Introduction to Distance Sampling*. Oxford University Press, New York.

Buckley, P. A., and M. G. McCarthy. 1994. *Insects, vegetation, and the control of laughing gulls (Larus atricilla) at Kennedy International Airport, New York City*. Journal of Applied Ecology 31:291-302.

Cerkal R., K. Vejražka, J. Kamler, and J. Dvořák. 2009. *Game browse and its impact on selected grain crops*. Plant, Soil and Environment 55:181-186.

Chamberlain, M. J., J. W. Mangrum, B. D. Leopold, and E. P. Hill. 1999. *A comparison of attractants used for carnivore track surveys*. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 53: 296-304.

Chandler, R. B., J. A. Royle, and D. I. King. 2011. *Inference about density and temporary emigration in unmarked populations*. Ecology 92(7):1429-1435.

Clark, L., and M. L. Avery .2013. *Effectiveness of chemical repellents in managing birds at airports*. In: Wildlife in airport environments: preventing animal-aircraft collisions through science-based management. T. L. DeVault, B. F. Blackwell, and J. L. Belant, eds. Johns Hopkins University Press, Baltimore, MD, USA.

Cleary, E. C., and R. A. Dolbeer. 2005. *Wildlife Hazard Management at Airports, a manual for airport personnel*. Second edition. Federal Aviation Administrations, Office of Airport Safety and Standards, Airport Safety and Compliance Branch, Washington, D. C., USA.

Conkling, T. J., J. L. Belant, T. L. DeVault, and J. A. Martin. 2018. *Impacts of biomass production at civil airports on grassland bird conservation and aviation strike risk*. Ecological Applications 28(5):1168-1181.

Cornell Lab of Ornithology. 2018. *All about birds*. Retrieved August, 2018 from http://www.allaboutbirds.org/ (accessed 08.08.18).

Curtis, P. D., B. Boldgiv, P. M. Mattison, and J. R. Boulanger. 2009. *Estimating deer abundance in suburban areas with infrared-triggered cameras*. Human-Wildlife Conflicts 3(1):116-128.

Daubenmire, R. 1959. *A canopy-coverage method of vegetational analysis*. Northwest Science 50:431.

Deacon, N., and B. Rochard. 2000. *Fifty years of airfield grass management in the UK*. Proceedings of the International Bird Strike Committee 25:1-8.

DeVault, T. L., B. F. Blackwell, T. W. Seamans, M. J. Begier, J. D. Kougher, J. E. Washburn, P. R. Miller, and R. A. Dolbeer. 2018. *Estimating interspecific economic risk of bird strikes with aircraft*. Wildlife Society Bulletin 42(1):94-101.

DeVault, T. L., M. J. Begier, J. L. Belant, B. F. Blackwell, R. A. Dolbeer, J. A. Martin, T. W. Seamans, and B. E. Washburn. 2013. *Rethinking airport land-cover paradigms: agriculture, grass, and wildlife hazards*. Human-Wildlife Interactions 7:10-15.

DeVault, T. L., J. E. Kubel, O. E. Rhodes, Jr., and R. A. Dolbeer. 2009. *Habitat and bird communities at small airports in the midwestern USA*. Proceedings of the Wildlife Damage Management Conference 13:137-145.

DeVault, T. L., J. L. Belant, B. F. Blackwell, J. A. Martin, J. A. Schmidt, L. W. Burger, Jr., and J. W. Patterson, Jr. 2012. *Airports offer unrealized potential for alternative energy production*. Environmental Management 49:517-522.

DeVault, T. L., J. L. Belant, B. F. Blackwell, and T. W. Seamans. 2011. *Interspecific variation in wildlife hazards to aircraft: implications for airport wildlife management*. Wildlife Society Bulletin 35:394-402.

Dolbeer, R. A. 2013. *The history of wildlife strikes and management at airports*. In: Wildlife in airport environments: preventing animal-aircraft collisions through science-based management. T. L. DeVault, B. F. Blackwell, and J. L. Belant, eds. Johns Hopkins University Press, Baltimore, MD, USA.

Dolbeer, R. A., and M. J. Begier. 2012. *Comparison of wildlife strike data among airports to improve aviation safety*. Proceedings of 30th International Bird Strike Conference, Stavanger, Norway.

Dolbeer, R. A., and S. E. Wright. 2009. *Safety management systems: how useful will the FAA National Wildlife Strike Database be?* Human-Wildlife Conflicts 3:167-178.

Dolbeer, R. A., S. E. Wright, and E. C. Cleary. 2000. *Ranking the hazard level of wildlife species to aviation*. Wildlife Society Bulletin 28: 372-378.

Federal Aviation Administration. 2007. *Hazardous wildlife attractants on or near airports*. Advisory Circular 150/5200-33B. U.S. Department of Transportation, Washington D. C., USA.

Federal Aviation Administration. 2011. *Airport planning*. Advisory Circular 150/5300-13. U.S. Department of Transportation, Washington, D.C., USA.AA 2011

Griffin, J. L., P. J. Wangsness, and G. A. Jung. 1980. *Forage quality evaluation of two warm-season range grasses using laboratory and animal measurements*. Agronomy Journal 72:951-956.

Gutzwiller, K. J. 1991. *Estimating winter species richness with unlimited-distance point counts*. Auk 108:853–862.

Hadfield, J. D. 2010. *MCMC methods for multi-response generalized linear mixed models: the MCMC glmm R package*. Journal of Statistical Software 33:1-22.

Iglay, R. B., K. B. Schwarz, J. L. Belant, J. A. Martin, G. Wang, and T. L. DeVault. 2017. *Large mammal use of seminatural grasslands and implications for aviation strike risk*. Journal of Fish and Wildlife Management 9(1):222-227.

Iglay, R. B., T. J. Conkling, T. L. DeVault, J. L. Belant, and J. A. Martin. *In press*. *Forage and biofuel: assessing native warm-season grass production among seed mixes and harvest frequencies within a wildlife conservation framework*. Southeastern Naturalist.

International Civil Aviation Organization. 1991. *Bird control and reduction*. Airport Services Manual, document 9137-AN/898, Part 3. Montreal, Quebec, Canada.

International Civil Aviation Organization. 2002. *Land use and environmental control*. Airport Planning Manual 9184 AN/902, Part 2. Montreal, Quebec, Canada.

Keshwani, D. R., and J. J. Cheng. 2009. *Switchgrass for bioethanol and other value-added applications: a review*. Bioresource Technology 100:1515-1523.

Linhart, S. B., and F. F. Knowlton. 1975. *Determining the relative population abundance of coyotes by scent-station lines*. Wildlife Society Bulletin 3: 119-124.

MacKenzie, D. L., and J. A. Royle. 2005. *Designing occupancy studies: general advice and allocating survey effort*. Journal of Applied Ecology 42(6): 1105-1114.

Martin, J. A., J. L. Belant, T. L. DeVault, B. F. Blackwell, L. W. Burger, Jr., S. K. Riffell, and G. Wang. 2011. *Wildlife risk to aviation: a multi-scale issue requires a multi-scale solution*. Human-Wildlife Interactions 5:198-203.

Martin, J. A., T. J. Conkling, J. L. Belant, K. M. Biondi, B. F. Blackwell, T. L. DeVault, E. Fernández-Juricic, P. M. Schmidt, and T. W. Seamans. 2013. *Wildlife conservation and alternative land uses at airports*. In: Wildlife in airport environments: preventing animal-aircraft collisions through science-based management. T. L. DeVault, B. F. Blackwell, and J. L. Belant, eds. Johns Hopkins University Press, Baltimore, MD, USA.

Pyle, P., and D. F. DeSante. 2013. *Four-letter (English Name) and six-letter (scientific name) alpha codes for 2090 bird species (and 98 non-species taxa) in accordance with the 54th AOU Supplement (2013), sorted by English name*. The Institute for Bird Populations. www.birdpop.org.

R Core Team. 2018. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ralph, C. J., S. Droege, and J. R. Sauer. 1995. *Managing and monitoring birds using point counts: standards and applications*. U.S. Department of Agriculture, Forest Service, General Technical Report PSW-GTR-149.

Robbins, C. S. 1981. *Reappraisal of the winter bird-population study technique*. Studies in Avian Biology 6:52–57.

Rosenstock, S. S., D. R. Anderson, K. M. Giesen, T. Leukering, and M. F. Carter. 2002. *Landbird counting techniques: current practices and an alternative*. Auk 119: 46-53.

Roth, A. M., D. W. Sample, C. A. Ribic, L. Paine, D. J. Undersander, and G. A. Bartelt. 2005. *Grassland bird response to harvesting switchgrass as a biomass energy crop*. Biomass & Energy 28:490-498.

Royle, J. T. 2004. *N-Mixture models for estimating population size from spatially replicated counts*. Biometrics 60(1):108-115.

Schmer, M. R., K. P. Vogel, R. B. Mitchell, K.M. Eskridge, and R. K. Perrin. 2006. *Establishment stand thresholds for switchgrass grown as a bioenergy crop*. Crop Science 46:157-161.

Schmer, M. R., K. P. Vogel, R. B. Mitchell, and R. K. Perrin. 2008. *Net energy of cellulosic ethanol from switchgrass*. Proceedings of the National Academy of Science USA 105:464-469.

Schmidt, J. A., B. E. Washburn, T. L. DeVault, P. M. Schmidt, and T. W. Seamans. 2013. *Do native warm-season grasslands near airports increase bird strike hazards?* American Midland Naturalist 170:144-157.

Schwarz, K. B., J. L. Belant, J. A. Martin, T. L. DeVault, and G. Wang. 2014. *Behavioral traits and airport type affect mammal incidents with U.S. civil aircraft*. Environmental Management 54:908-918.

Scott, J. M., and F. L. Ramsey. 1981. *Length of count period as a possible source of bias in estimating bird densities*. Studies in Avian biology 6: 409-413.

Seamans, T. W., S. C. Barras, G. E. Bernhardt, B. F. Blackwell, and J. D. Cepek. 2007. *Comparison of 2 vegetation-height management practices for wildlife control at airports*. Human-Wildlife Conflicts 1:97-105.

Smith, P. G. R. 1984. *Observer and annual variation in winter bird population studies*. Wilson Bulletin 96:561–574.

Spiegelhalter, D. J., N. G. Best, B. R. Carlin, and A. van der Linde. 2002. *Bayesian measures of model complexity and fit*. Journal of the Royal Statistical Society B. 64:583-639.

Sterner, R. T., D. J. Elias, M. V. Garrison, B. E. Johns, and S. R. Kilburn. 1984. *Birds and airport agriculture in the conterminous United States: a review of literature*. In: Office of Airport Standards, Wildlife Hazards to Aircraft Conference and Training Workshop, DOT/FAA/AAS, Washington, DC, USA.

Strindberg, S., and S. T. Buckland. 2004. *Zigzag survey designs in line transect sampling*. Journal of Agricultural, Biological, and Environmental Statistics 9(4):443-461.

Transport Canada. 2002. *Wildlife control procedures manual*. TP 11500 E. Third edition. Transport Canada, Safety and Security, Aerodome Safety Branch, Ottawa, Ontario, Canada.

VerCauteren, K.C., M. Lavelle, and T. W. Seamans. 2013. *Excluding mammals from airports*. In: Wildlife in airport environments: preventing animal-aircraft collisions through science-based management. T. L. DeVault, B. F. Blackwell, and J. L. Belant, eds. Johns Hopkins University Press, Baltimore, MD, USA.

Washburn, B. E., and T. W. Seamans. 2007. *Wildlife responses to vegetation height management in cool-season grasslands*. Rangeland Ecology and Management 60:319-323.

Washburn, B. E., and T. W. Seamans. 2013. *Turfgrass management to reduce wildlife hazards at airports*. In: Wildlife in airport environments: preventing animal-aircraft collisions through science-based management. T. L. DeVault, B. F. Blackwell, and J. L. Belant, eds. Johns Hopkins University Press, Baltimore, MD, USA.

Wullschleger, S. D., E. B. Davis, M. E. Borsuk, C. A. Gunderson, and L. R. Lynd. 2010. *Biomass production in switchgrass across the United States: database description and determinants of yield*. Agronomy Journal 102:1158-1168.

Zakrajsek, E. J., and J. A. Bissonette. 2005. *Ranking the risk of wildlife species hazardous to military aircraft*. Wildlife Society Bulletin 33:258-264.

APPENDICES

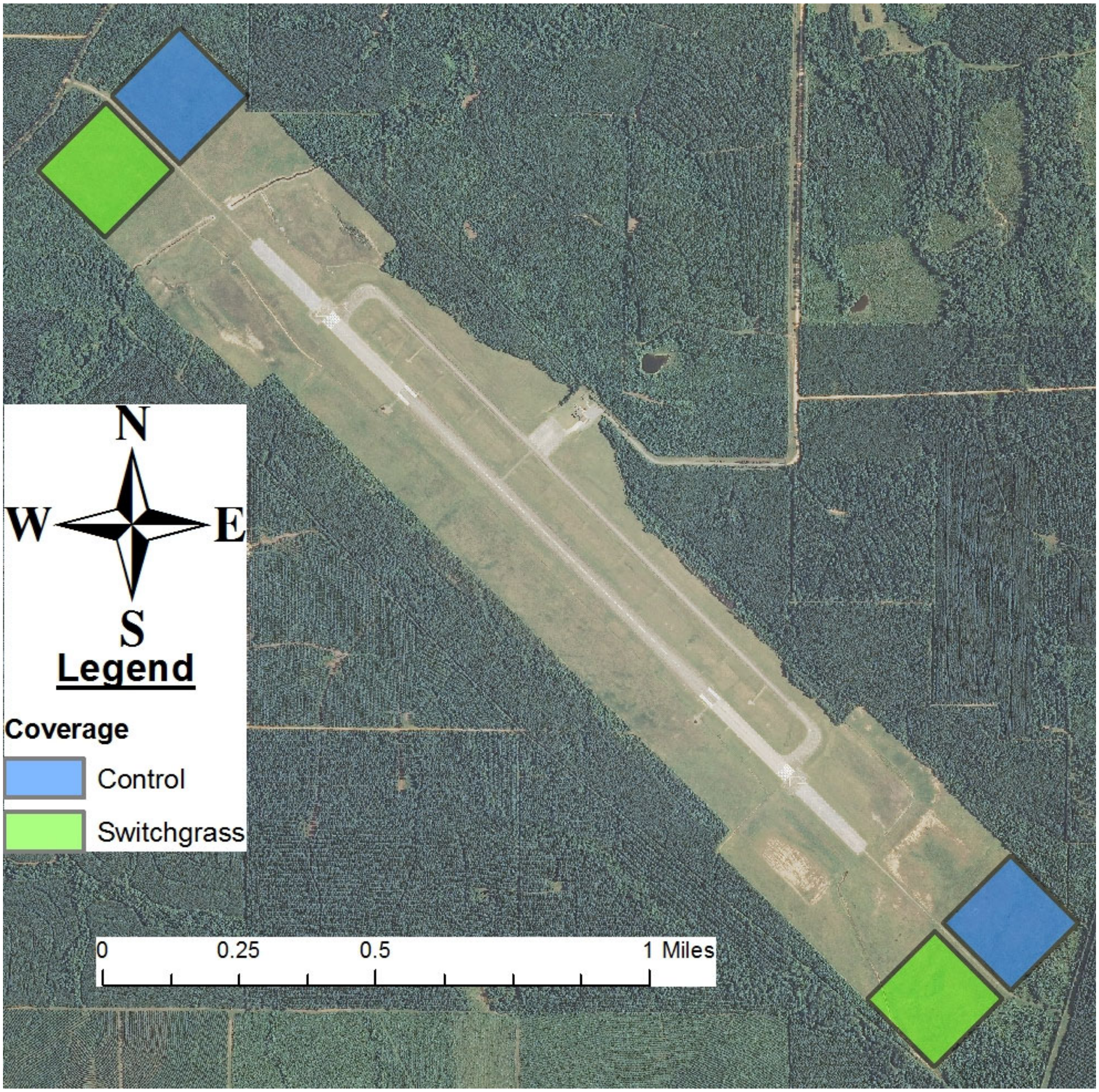
Appendix A: Points of Contact

The following table includes all known points of contact for the project during the time of developing the Demonstration Plan. The information will be updated throughout the project as new sites come online and personnel changes.

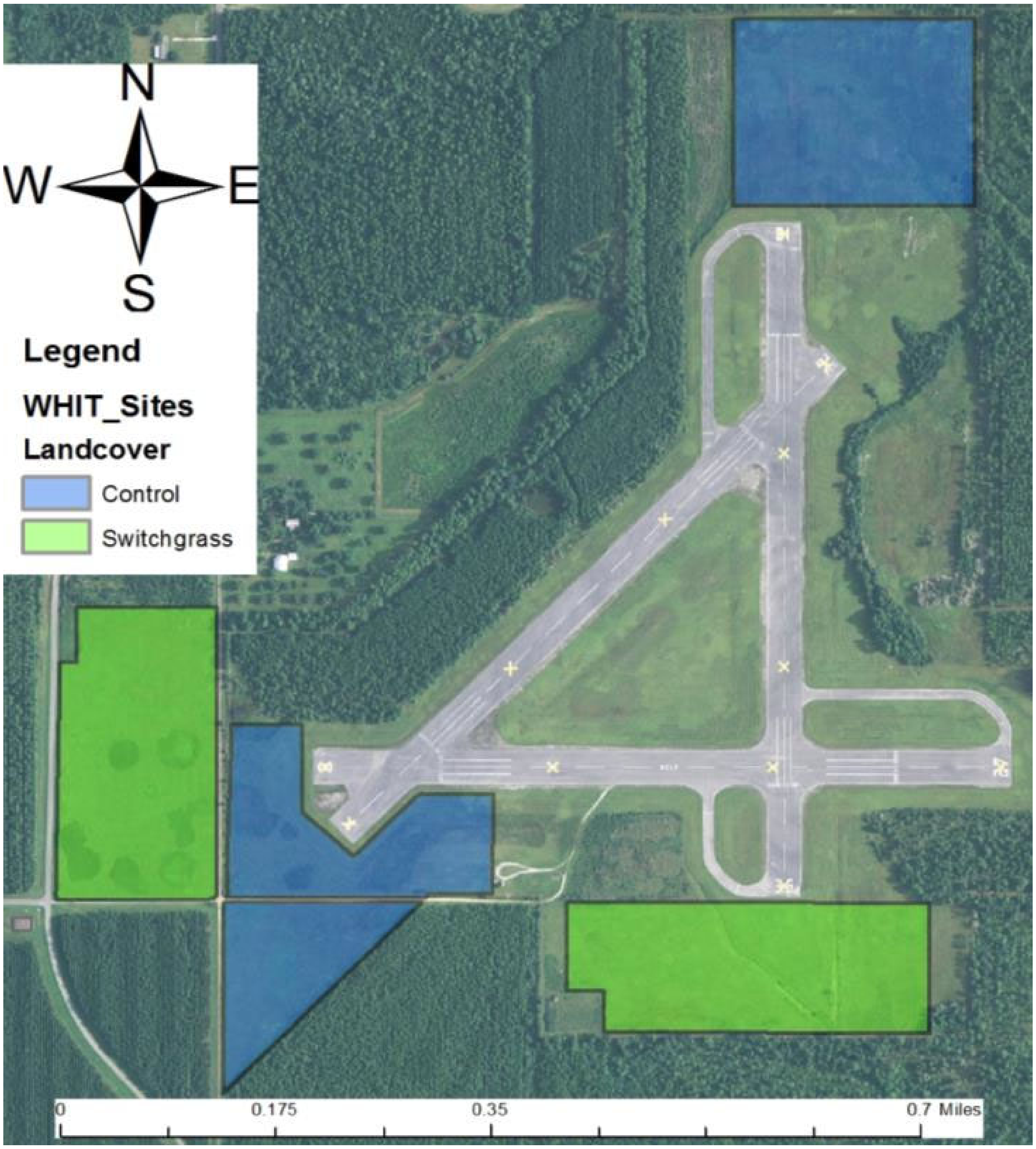
POINT OF CONTACT Name	ORGANIZATION Name Address	Phone Fax E-mail	Role in Project
Travis L. DeVault, Ph.D.	USDA APHIS, WS 6100 Columbus Avenue Sandusky, OH 44870	(419) 625-0242 (419) 625-8465 Travis.L.DeVault@usda.gov	Principal Investigator Overall project supervision and administration; reports.
Jerrold L. Belant, Ph.D.	SUNY ESF Department of Environmental and Forest Biology 252 Illick Hall, 1 Forestry Drive Syracuse, NY 13210	(315) 470-4826 No fax jbelant@esf.edu	Co-principal Investigator Experimental design and supervision of post-doc.
Bradley F. Blackwell, Ph.D.	USDA APHIS, WS 6100 Columbus Avenue Sandusky, OH 44870	(419) 625-0242 (419) 625-8465 Bradley.F.Blackwell@usda.gov	Co-principal Investigator Experimental design and data analysis.
James A. Martin, Ph.D.	University of Georgia Warnell School of Forestry & Natural Resources 180 E Green Street Athens, GA 30602	(706) 543-2344 No fax jmart22@uga.edu	Co-principal Investigator Experimental design and data analysis.
Michael J. Begier, M.S.	USDA APHIS, WS 1400 Independence Avenue SW, Room 1624, South Agriculture Building Washington, D.C. 20250	(202) 799-7098 (202) 690-0053 Mike.Begier@usda.gov	Study site selection and operational field logistics.
Raymond B. Iglay, Ph.D.	Mississippi State University Wildlife, Fisheries, and Aquaculture Box 9690, 775 Stone Blvd Mississippi State, MS 39762	(662) 325-3498 (662) 325-4763 Ray.Iglay@msstate.edu	Project Manager.

Appendix B: Site Maps

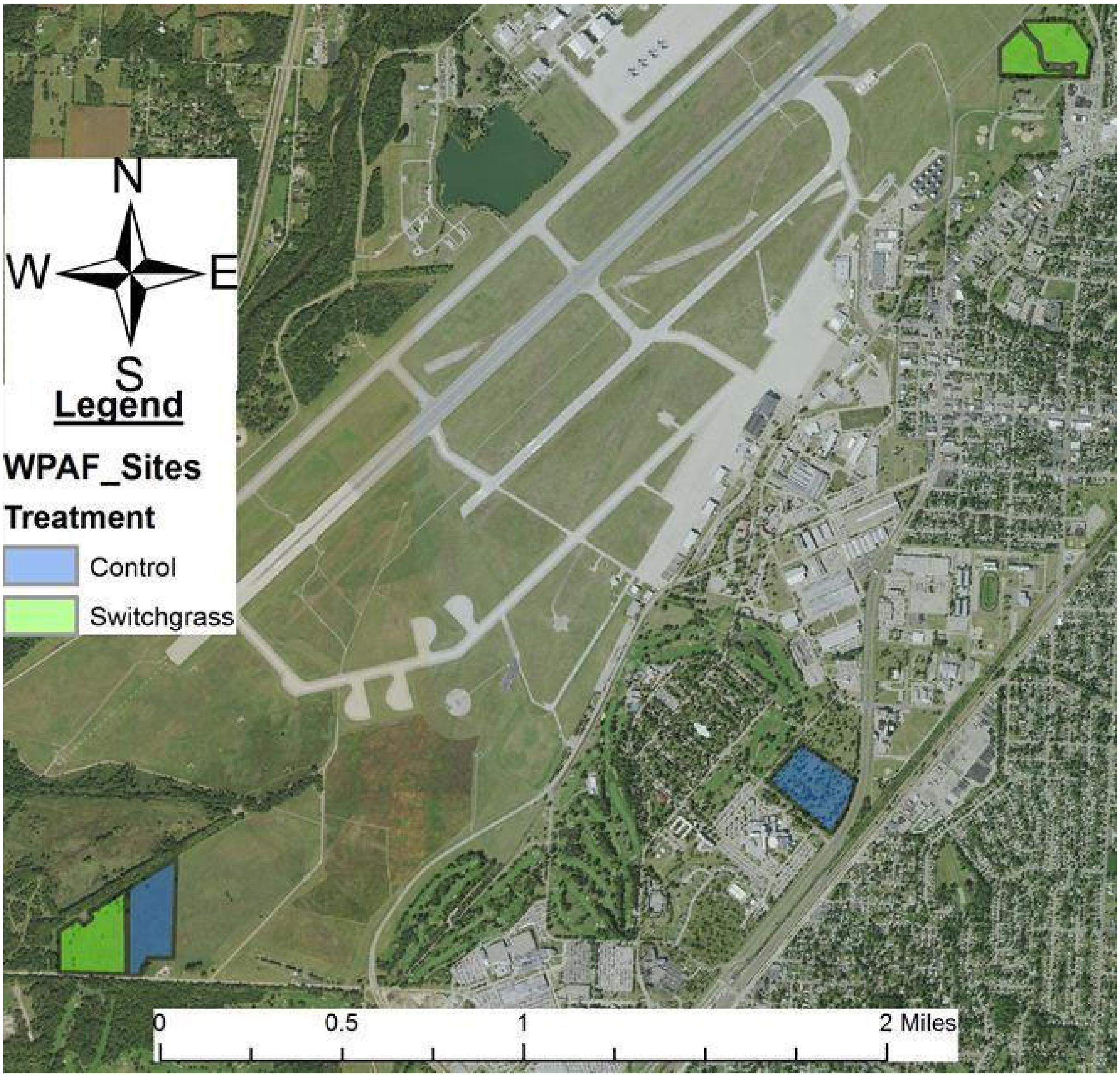
Columbus Air Force Base Auxiliary Field (CAFB) located south of Shuqualak, MS



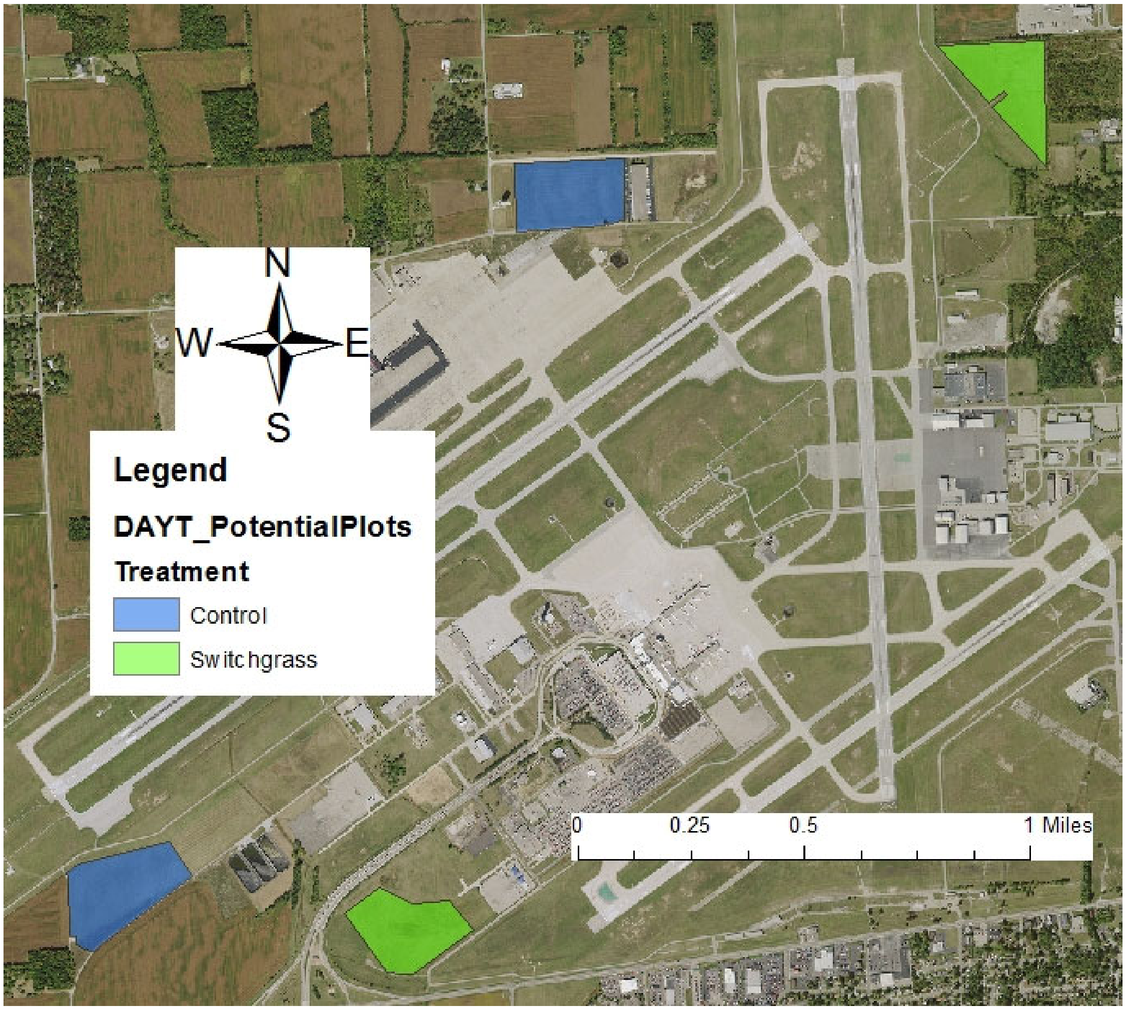
Naval Air Station Whiting Field NOLF Wolf (WHIT) located east of Foley, AL



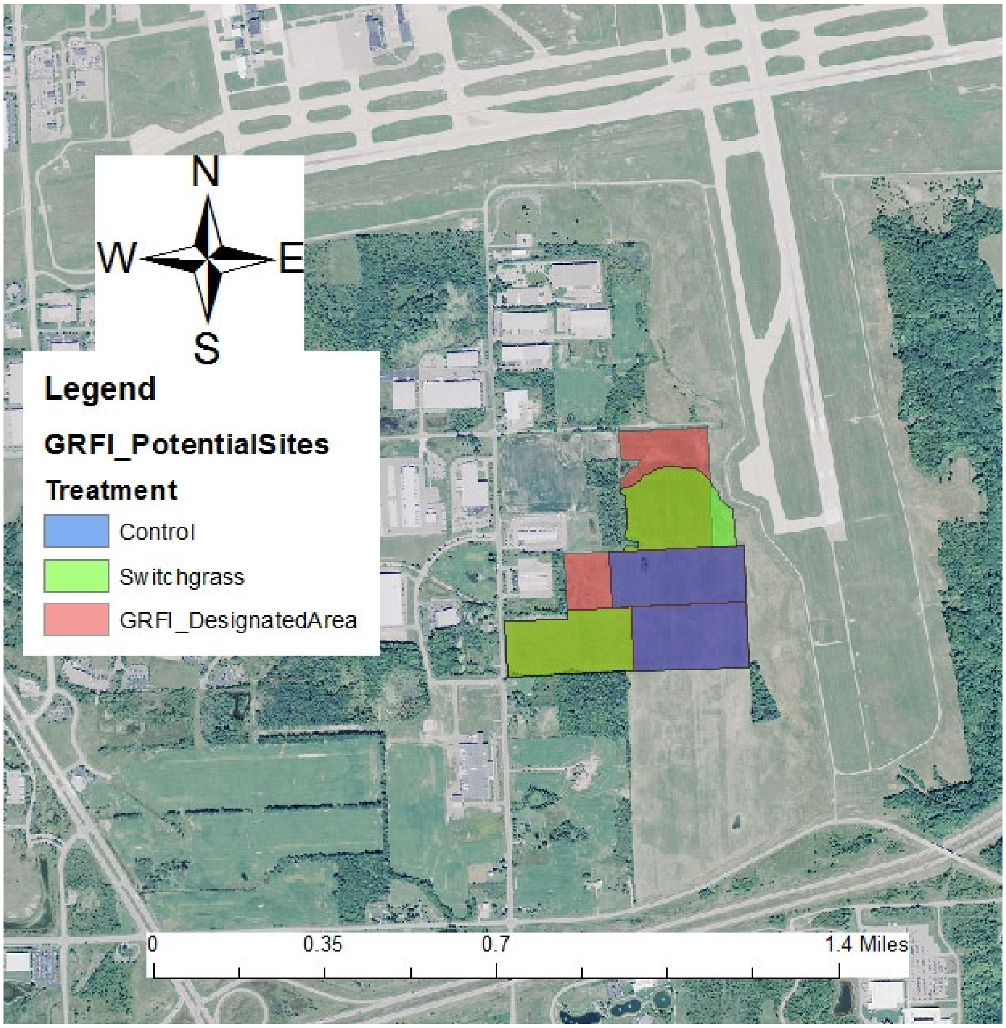
Wright-Patterson Air Force Base (WPAF) located in Dayton, OH



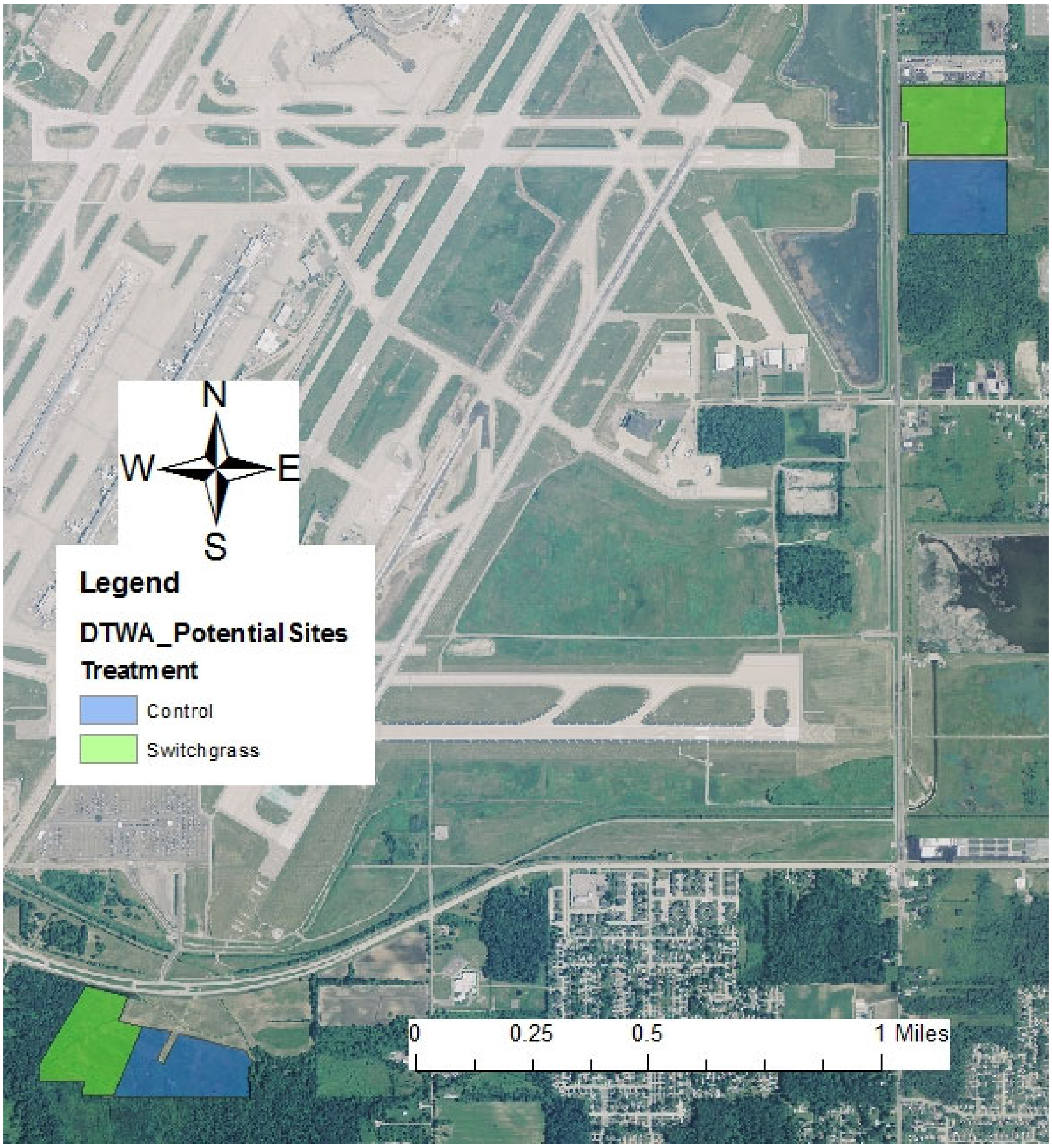
Dayton International Airport (DAYT) located in Dayton, OH



Gerald R. Ford International Airport (GRFI) located in Grand Rapids, MI



Detroit Metropolitan Airport (DTWA) located in Detroit, MI



Appendix C: Sampling Protocol Packet

SWITCHGRASS DEMONSTRATION PROJECT

Improving Safety and Economics Using Switchgrass on Military Airfields – 14 EB-RC5-009

Sampling Overview and Procedures

August 2018

For more information, please contact the project manager.
Raymond Iglay, Ph.D., CWB®
662-325-5933 / ray.iglay@msstate.edu

Switchgrass Demonstration Sites Sampling Protocol Overview

Project Overview

Faunal surveys of switchgrass demonstration plots and extant airfield grasslands will assess whether switchgrass provides a viable alternative land cover for airfields (i.e., equivalent or less hazardous wildlife species). Each site will have two plot pairs [pair = switchgrass demonstration plot and extant airfield grassland (control)]. Birds will be sampled 3 times per month. Mammals will be sampled using one 14-day camera trapping session per month. All plots and sampling points, including camera traps, will be GPS-marked and coordinates provided to biologists by the project manager. Plot pairs are labeled with a 1 or 2. The number one corresponds to the pair with the northern most site [e.g., S1 (northern pair's switchgrass plot), C1 (northern pair's extant airfield grassland)].

General Faunal Sampling Protocol

- Random starting plot and sampling point for each bird sampling event
- Maximum sampling effort for birds equals 3 visits per month, sampling mornings each visit
- Mammal camera trapping should occur mid-month
- All data should be entered in the Access database and submitted to the project manager (Raymond Iglay; ray.iglay@msstate.edu) by the end of the month.
- Biologists may physically mark plot boundaries depending on airfield/airport preferences

Data Entry Overview

- Microsoft® Access promotes consistency among multiple data enterers
- Forms within Access provide user-friendly formats (i.e., similar look to data sheets)
- To enter data:
    - Fill out the appropriate form with all data sheet information
        - For surveys with more than 1 page, you only need to enter the top portion of the data sheet's information once in the Access database
    - After all data for a sampling effort (e.g., a point transect or flush transect)
        - Click "NEXT . . ."
    - Save (CTRL+S) often
    - When finished data entry click "CLOSE FORM" and then "SAVE AND CLOSE DATABASE"

Contact Information Submitting Data

All data can be saved to the project's SharePoint file. You may rename your Microsoft® Access database and save it to your site's SharePoint folder (e.g., "Switchgrass_DataEntry_MasterCAFB.accdb" for Columbus Air Force Base). Once a file is updated, send an e-mail to Ray Iglay at ray.iglay@msstate.edu with subject "*DataFileName* Updated".

Bird Point Transect Surveys

May, June, and July

3 visits per month

1. 5-minute point counts at each bird count sampling point per treatment plot
2. Random sampling order of plots provided by project manager

Bird Point Transect Protocol

1. Arrive at bird count sampling point
2. After arriving at sampling point, allow 2-minutes for birds to settle
    a. Meanwhile, fill out top portion of data sheet (observer, location data, start time, etc.).
3. For each bird (or flock) seen or heard, record the following:
    a. Species: Bird species acronym
    b. DT (Detection type): Aural (A), Visual (V), both (AV)
    c. Sex: Male (M), Female (F)
    d. Min.: Minute intervals of 0-1 (1), 1-2 (2), 2-3 (3), 3-4(4), 4-5 (5)
    e. Dir.: Compass direction (e.g., N, NW, SSW) of detection from observer
    f. Dist.: Distance (m) to the bird or center of flock's location in reference to you.
    g. In Plot?: Whether the bird or center of the flock are in the plot (Yes or No)
    h. Altitude: Ground Level (1), > 0 to 50m (2), 51 to 100m (3), >100m (4)
    i. Behavior: Searching (S), Head-down Foraging (HDF), Head-up Foraging (HUF), Flying Over Plot/Airfield (T), Using Airspace (FLY), Left the Plot (LP), Flew into Plot (A)
    j. Flock?: Is the observation of a flock (Yes or No)
    k. #" Number of birds in the flock, enter "1" for single bird observations.
    l. Notes: Please record any ancillary observations.
4. Avoid double counting. Keep track of birds flushing from one area of the plot to another as best you can to avoid counting the same individuals twice or more.
5. Please enter data as soon as possible. The same day is best, within a week is great.
    a. Please use alpha codes (Pyle and DeSante 2014) for any new bird species encountered and acknowledge the new species in the Notes section of your data sheet.

Bird Flush Transect Surveys

August through April
3 visits per month

1. Slow walked line transect beginning in random corner and zigzagging across plot
    a. GPS-marked points along plot borders will be provided to use as bearing points
    b. Points will be sequentially-labeled representing sampling order
2. Random sampling order of plots provided by project manager

Bird Flush Transect Protocol

1. Arrive at starting point
2. Fill out top portion of data sheet (observer, location data, start time, etc.).
3. Begin slow walk (1-2 mph), scanning for birds
4. For each bird (or flock) seen or heard, record the following:
    a. Species: Bird species acronym
    b. DT (Detection Type): Aural (A), Visual (V), both (AV)
    c. Sex: Male (M), Female (F)
    d. Dir.: Compass direction (e.g., N, NW, SSW) of detection from observer
    e. Dist.: Distance (m) to the bird or center of flock's location in reference to you.
    f. In Plot?: Whether the bird or center of the flock are in the plot (Yes or No)
    g. Altitude: Ground Level (1), > 0 to 50m (2), 51 to 100m (3), >100m (4)
    h. Behavior: Searching (S), Head-down Foraging (HDF), Head-up Foraging (HUF), Flying Over Plot/Airfield (T), Using Airspace (FLY), Left the Plot (LP), Flew into Plot (A)
    i. Flock? Is this a flock or not (Yes or No)
    j. #: Number of birds in flock, enter "1" is single bird.
    k. GPS_Label: GPS-mark location on line using GPS unit and enter point label here
    l. Notes: Please record any ancillary observations.
5. Avoid double counting. Keep track of birds flushing from one area of the plot to another as best you can to avoid counting the same individuals twice or more.
6. Please enter data as soon as possible. The same day is best, within a week is great.
    a. Please use alpha codes (Pyle and DeSante 2014) for any new bird species encountered and acknowledge the new species in the Notes section of your data sheet.

Mammal Camera Trap Surveys

One 14-day Trapping Period Every Month

1. Mammal camera trap points are GPS-marked
    a. Two camera trap stations per plot
    b. At each stations:
        i. A camera ~12" above the ground on a wooden stake
        ii. A lure placed on the ground, 5m in front of the camera
2. Trapping period begins at midnight on the day the cameras are placed and activated
3. Trapping period ends at midnight on the 14th day. Pick-up cameras on the 15th day
    a. For example, cameras placed on May 4th will be picked-up on May 19th
4. Place a fresh (new) Fatty Acid Scent Tablet on the ground on the first day
5. If in a public access area, please ground anchor cameras to deter theft
6. To reduce false triggers by swaying vegetation, please kill vegetation within an 8-m radius of the camera lens (about 26 ft.), essentially created a half moon of dead vegetation in front and to the sides of the camera
    a. Any herbicide with glyphosate as the primary active ingredient (e.g., Round-up® or Ranger Pro)
    b. Either premixed or self-mixing is acceptable. Just need to kill the vegetation
        i. Herbicide mixed with water and a non-ionic surfactant with 1.5-2.0% glyphosate should work fine
        ii. E.g., Ranger Pro and Roundup Pro have 41% glyphosate.
            1. For a 2% solution, I would need 10.24 ounces of glyphosate for 4 gallons of solution
            2. At 41% concentrate, I would need 14.4 ounces of herbicide
            3. In the sprayer add about 2 gallons of water, the surfactant and herbicide, then fill the sprayer with water to the 4-gallon mark
    c. Spray all vegetation within the radius and try to avoid wind drift
    d. The primary vegetation of concern is any plant within about 15 ft. of the camera lens.

Camera Settings

Camera set-up explained in "Reconyx Game Camera Set-up"

Camera Anchors

Instructional PowerPoint available for making additional anchors.

1. Drive 36” Green Steel U-post into ground to approximately the first pre-drilled hole above the “U”.
2. Mount camera using supplied ¼” carriage bolt to 3rd hole (3rd hole from bottom or top of U-bar). The hole should be approximately 12” (1 foot) above ground level.
3. Drive earth anchor into ground near U-post (within 1 ft) making sure that no more than 2 inches are above ground. We do not want mowers to get tangled with 3/32” cable.
4. Connect camera cable’s loop to earth anchor loop with lock.
5. Perform Walk Test (see page 8) to ensure camera will not trigger for much, if any movement more than 6 feet beyond the lure station.
    a. You can change the camera’s angle by adjusting the carriage bolt and/or leaning the U-post slightly. Due to the height of the camera mount, it does not take much of an angle to limit the trigger area to our desired area.
6. Arm camera and return to pick up 14 days later and possibly check beforehand.

Picture Transfer

1. Transfer pictures from SD card to computer
2. Create a new folder for each trapping period and plot’s pictures
    a. Filename: ***SiteAcronym_CameraNumber_PlotAcronym_StartDate_EndDate***
    b. Example Filename: CAFB_CAM1_S2_07072015_07222015
3. Upload folder to Site’s SharePoint Folder and e-mail Ray Iglay at ray.iglay@msstate.edu with Subject “*AirfieldAcronym* Pictures Updated”

Reconyx Game Camera Set-up

Supplies

1. Reconyx game camera (n = 8/site)
2. 12 charged, rechargeable AA NiMH batteries per camera (n = 96/site)
3. 4 GB, SD Card (n = 8/site)
4. SD Card USB Port Reader (n=1/site)
5. 12-bay battery chargers (n = 2/site)

Case Overview

1. Open case using right-side latch
2. 2, 6-battery bays on right
3. Controls, backlit screen, and SD card insert on left

Getting Started

1. Insert an SD card
    a. Insert SD card with label facing you and card's notch in the bottom right corner as shown in picture
2. Switch Camera "On"
    a. First time set-up includes setting date and time
    b. Use left/right arrow buttons to decrease or increase date and time
        i. Need to increase time past 12 noon or decrease below midnight to change AM/PM
    c. Set "Temperature" to "Fahrenheit)
    d. Set "Battery Type" to "NiMH"
    e. When "Finished" appears with "Ok" selected, press "Ok" button
3. Camera will read the SD card and then display date, time, memory left on SD card, and available battery life

Set-up Camera

1. Scroll right (">" arrow button) to "Change Setup"
    a. Press "OK" button
2. Select "Advanced" in "Quickset" menu
    a. Press "OK" button
3. In "Advanced Setup"
    a. Scroll to "Trigger" and press "Ok" button
    b. Using left and right toggle buttons choose the following settings pressing "Ok" after each selection
        i. Motion Sensor: "On"
        ii. Sensitivity: "High"
        iii. Pics per Trigger: "3"
        iv. Picture Interval: "Wait 1 Sec"
        v. Quiet Period: "No Delay"
        vi. Finishing: "Ok"
4. The camera menu will return to "Change Setup"
5. Now your camera is set-up

Walk Test

1. The Walktest option in the camera's menu can be used to test the trigger range.
    a. The motion sensor set to "High" sensitivity can trigger on heated objects, such as mammals, up to 100 feet away.
    b. To avoid false triggers, cameras can be angled down, but it's best to make sure cameras will trigger on objects around the lure.
2. Conducting a Walktest to set the camera trigger range for 8 m in front of it
    a. Select "Walktest" in the menu, close the case, and mount the camera
    b. A red light flashing on the front of the camera indicates a motion was detected
    c. Mark the 8 m radius around the camera
    d. Adjust the camera angle until the camera only triggers when you cross the camera's viewing area from ≤ 8 m
    e. Open the case and select your next desired option (e.g., Arming Camera) or turn off for storage.

Arming Camera

1. Once your camera is set-up, it will not work until armed.
2. Arm the camera by scrolling through the main menu until you reach "Arm Carmera"
    a. Press "Ok" Button
    b. Camera will count down 10 seconds to arm. You can cancel at any time
    c. A red light will flash on the front of the camera while arming but stop once armed.
3. To disarm the camera either:
    a. Press "Ok" button twice
        i. One press shows the number of pictures, SD card memory, and battery life
        ii. Second press returns you to the main menu
    b. Turn camera power switch "Off"

Other Camera Features

1. Erase Card
    a. Formats your SD card (i.e., erases all of the pictures on your card)
    b. Using your computer to format the SD card is preferred over using the camera
2. Check Status
    a. Reports number of pictures, memory used on SD card, and remaining battery life
3. Camera Info
    a. Displays camera information including serial number.

Supplies to Consider

Plot Markers

Suggestion: Patio steps or wooden stakes and fluorescent orange spray paint

Please ensure that any markers are allowed by the airfield.

Bird Surveys

Binoculars, GPS units, Clip Board, Pencil(s), Data Sheets

Mammal Surveys (Distributed to biologists by U.S.D.A. - N. W. R. C.)

- Cameras
- AA Batteries (12 required per camera)
- SD card (8 GB) and card reader for computer
- 18” garden stakes from Lowes should suffice for cameras (~$8 per 25)
- Lures
    - 1 bottle of U. S. D. A. Fatty Acid Scent Tablets
- Glyphosate herbicide (e.g., Round-up® or Ranger Pro) to kill vegetation in front of cameras

Species Lists, Acronyms, and Data Codes

Bird Species*							
Acronym	**Common Name**	**Acronym**	**Common Name**	**Acronym**	**Common Name**	**Acronym**	**Common Name**
ABDU	American Black Duck	CONI	Common Nighthawk	INBU	Indigo Bunting	RWBL	Red-winged Blackbird
AMBI	American Bittern	CORA	Common Raven	KILL	Killdeer	SAVS	Savannah Sparrow
AMCO	American Coot	COTE	Common Tern	LAGU	Laughing Gull	SEOW	Short-eared Owl
AMCR	American Crow	COYE	Common Yellowthroat	LASP	Lark Sparrow	SEPL	Semipalmated Plover
AMGO	American Goldfinch	DCCO	Double-crested Cormorant	LCSP	Leconte's Sparrow	SESA	Semipalmated Sandpiper
AMKE	American Kestrel	DEJU	Dark-eyed Junco	LESA	Least Sandpiper	SEWR	Sedge Wren
AMPI	American Pipit	DICK	Dickcissel	LESC	Lesser Scaup	SNBU	Snow Bunting
AMRO	American Robin	DOVE	Unknown dove sp.	LETE	Least Tern	SNEG	Snowy Egret
AMWI	American Wigeon	DOWO	Downy Woodpecker	LISP	Lincoln's Sparrow	SNGO	Snow Goose
AMWO	American Woodcock	DUN	Dunlin	LOSH	Loggerhead Shrike	SNOW	Snowy Owl
AWPE	American White Pelican	EABL	Eastern Bluebird	MAKE	American Kestrel	SORA	Sora
BAEA	Bald Eagle	EAKI	Eastern Kingbird	MALL	Mallard	SOSP	Song Sparrow
BANO	Barn Owl	EAME	Eastern Meadowlark	MERL	Merlin	SSHA	Sharp-shinned Hawk
BANS	Bank Swallow	EAPH	Eastern Phoebe	MODO	Mourning Dove	SWKT	Swallow-tailed Kite
BAOW	Barred Owl	EASO	Eastern Screech Owl	NFLK	Northern Flicker	SWSP	Swamp Sparrow
BARS	Barn Swallow	EATO	Eastern Towhee	NOBO	Northern Bobwhite	SWTH	Swainson’s Thrush
BEKI	Belted Kingfisher	EAWP	Eastern Wood-Peewee	NOCA	Northern Cardinal	TRES	Tree Swallow
BBPL	Black-bellied Plover	EUCD	Eurasian Collared-Dove	NOGO	Northern Goshawk	TUSW	Tundra Swan
BCNH	Black-crowned Night Heron	EUST	European Starling	NOHA	Northern Harrier	TUTI	Tufted Titmouse
BGGN	Blue-gray gnatcatcher	FALC	Unknown Falcon	NOMO	Northern Mockingbird	TUVU	Turkey Vulture
BHCO	Brown-headed Cowbird	FICR	Fish Crow	NONE	No Birds detected	UNBK	Unknown blackbird
BLGR	Blue Grosbeak	FISP	Field Sparrow	NOPI	Northern Pintail	UNDU	Unknown duck
BLHE	Blue Heron	FOTE	Forster’s Tern	NSHO	Northern Shoveler	UNHA	Unknown hawk
BLJA	Blue Jay	GADW	Gadwall	OROR	Orchard Oriole	UNKN	Unknown species
BLVU	Black Vulture	GBBG	Great Black-backed Gull	OSPR	Osprey	UNLG	Unknown *Larus* Gull
BOBO	Bobolink	GBHE	Great Blue Heron	PRAW	Prairie Warbler	UNSP	Unknown Sparrow
BRAN	Brant	GCFY	Great Crested Flycatcher	PRWA	Prairie Warbler	UNSW	Unknown Swallow
BRPE	Brown Pelican	GHOW	Great Horned Owl	PUFI	Purple Finch	UPSA	Upland Sandpiper

BRTH	Brown Thrasher	GOEA	Golden Eagle	PUMA	Purple Martin	VESP	Vesper Sparrow
BWTE	Blue-winged Teal	GRAK	Grackle species	RBGR	Rose-breasted Grosbeak	WARB	Unknown Warbler
CACH	Carolina Chickadee	GREG	Great Egret	RBGU	Ring-billed Gull	WESA	Western Sandpiper
CAEG	Cattle Egret	GRHE	Green Heron	RBWO	Red-bellied Woodpecker	WEVI	White-eyed Vireo
CAGO	Canada Goose	GRSP	Grasshopper Sparrow	REDH	Redhead	WHIM	Whimbrel
CANV	Canvasback	GRYE	Greater Yellowlegs	REVI	Red-eyed Vireo	WISN	Wilson's Snipe
CARW	Carolina Wren	GWTE	Green-winged Teal	RHWO	Red Headed Woodpecker	WITU	Wild Turkey
CEDW	Cedar Waxwing	HERG	Herring Gull	RLHA	Rough-legged Hawk	WIWR	Winter Wren
CHSP	Chipping Sparrow	HETH	Hermit Thrush	RNDU	Ring-necked Duck	WODU	Wood Duck
CHSW	Chimney Swift	HOFI	House Finch	RNEP	Ring-necked Pheasant	WOTH	Wood Thrush
CLSW	Cliff Swallow	HOLA	Horned Lark	ROPI	Rock Pigeon	WTSP	White-throated Sparrow
COGD	Common Ground-Dove	HOSP	House Sparrow	RSHA	Red-shouldered Hawk	YBCH	Yellow-breasted Chat
COGR	Common Grackle	HOWR	House Wren	RTHA	Red-tailed Hawk	YBCU	Yellow-billed Cuckoo
COHA	Cooper's Hawk	HUGO	Hudsonian Godwit	RTHU	Ruby-throated Hummingbird	YCNH	Yellow-crowned Night Heron
COME	Common Merganser						

*Please use alpha codes (Pyle and DeSante 2014) for any new bird species encountered and acknowledge the new species in the Notes section of your data sheet. The above list includes species observed on a previous switchgrass study near West Point, MS, and species of reported strikes (Dolbeer et al. 2013).

If a new species is observed, please create a 4-letter code and acknowledge the addition in the Notes section of the first occurrence and choose “NEW” for Species in the data entry form.

Mammal Species	
Acronym	**Common Name**
BOCA	Bobcat
COYO	Coyote
DODO	Domestic Dog
ECRA	Eastern Cottontail Rabbit
GRAFO	Gray Fox
NBAR	Nine-banded Armadillo
NORA	Northern Raccoon
REFO	Red Fox
SPSK	Spotted Skunk
STSK	Striped Skunk
VIPO	Virginia Possum
WIHO	Wild Hog
WTDE	White-tailed Deer
WOCH	Woodchuck

General Data Codes for Bird Sampling

Detection Type (DT)	**Altitude**	**Behavior during Transect**	**Wind**	
	Ground Level (1)	Searching or Foraging (F or S)	**mph**	**Description**
Aural (A)	>0m to 50m (2)	Head Down/Up Foraging (HDF, HUF)	< 1	Calm; smoke rises vertically
Visual (V)	51 to 100m (3)	Flyover (T)	1-3	Smoke drift shows wind direction
Both (AV)	> 100m (4)	Using Airspace (FLY)	4-7	Wind felt on face; leaves rustle
		Left the Plot (LP)	8-12	Leaves, small twigs in constant motion (3)
		Flew into Plot (A)	13-18	Raises dust, loose paper; moves small branches (4)

Unidentifiable birds can be represented by the following Hazard Groups when conducting *Initial Hazard Surveys* from the edge of a plot.

Hazard (Species) Group
Blackbirds/ starlings (BBST)
Doves/Pigeons/ Quail (DPQU)
Gulls (GULL)
Raptors (RAPT)
Sparrows (SPAR)
Waterfowl (FOWL)

Unknown Bird (sizes: ?SIZE, SM, ME, LG)

Literature Cited

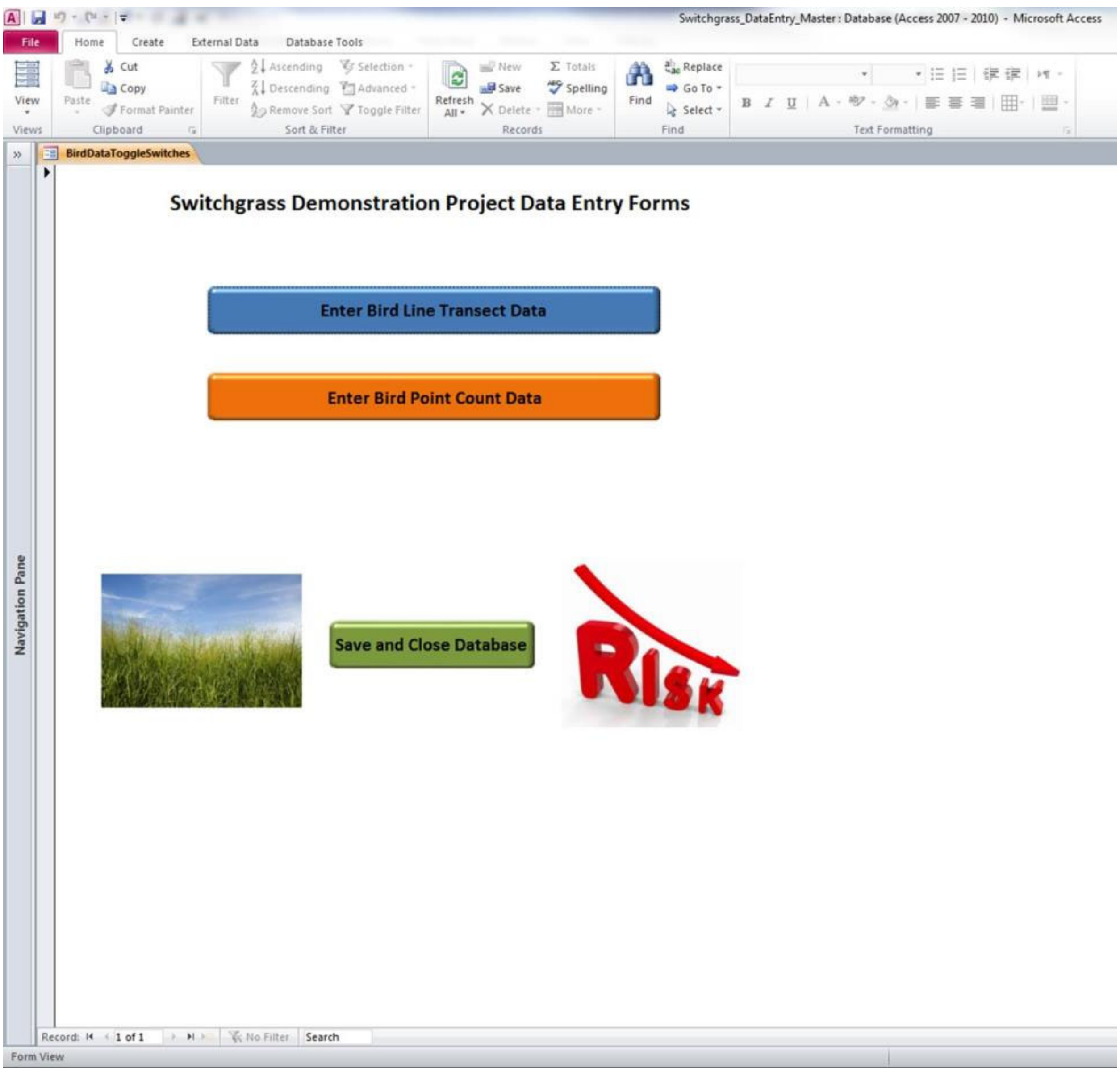
Dolbeer, R. A., S. E. Wright, J. Weller, and M. J. Begier. 2013. Wildlife strikes to civil aircraft in the United States 1990-2012. Federal Aviation Administration National Wildlife Strike Database Serial Report Number 19. Washington D. C., U.S. A.

Pyle, P., and D. DeSante. 2014. List of North American birds and alpha codes according to American Ornithologists' Union taxonomy through the 54th AOU Supplement [Downloaded June 10, 2014]. Available from http://www.birdpop.org/alphacodes.htm.

Appendix D: Access® Data Entry Database

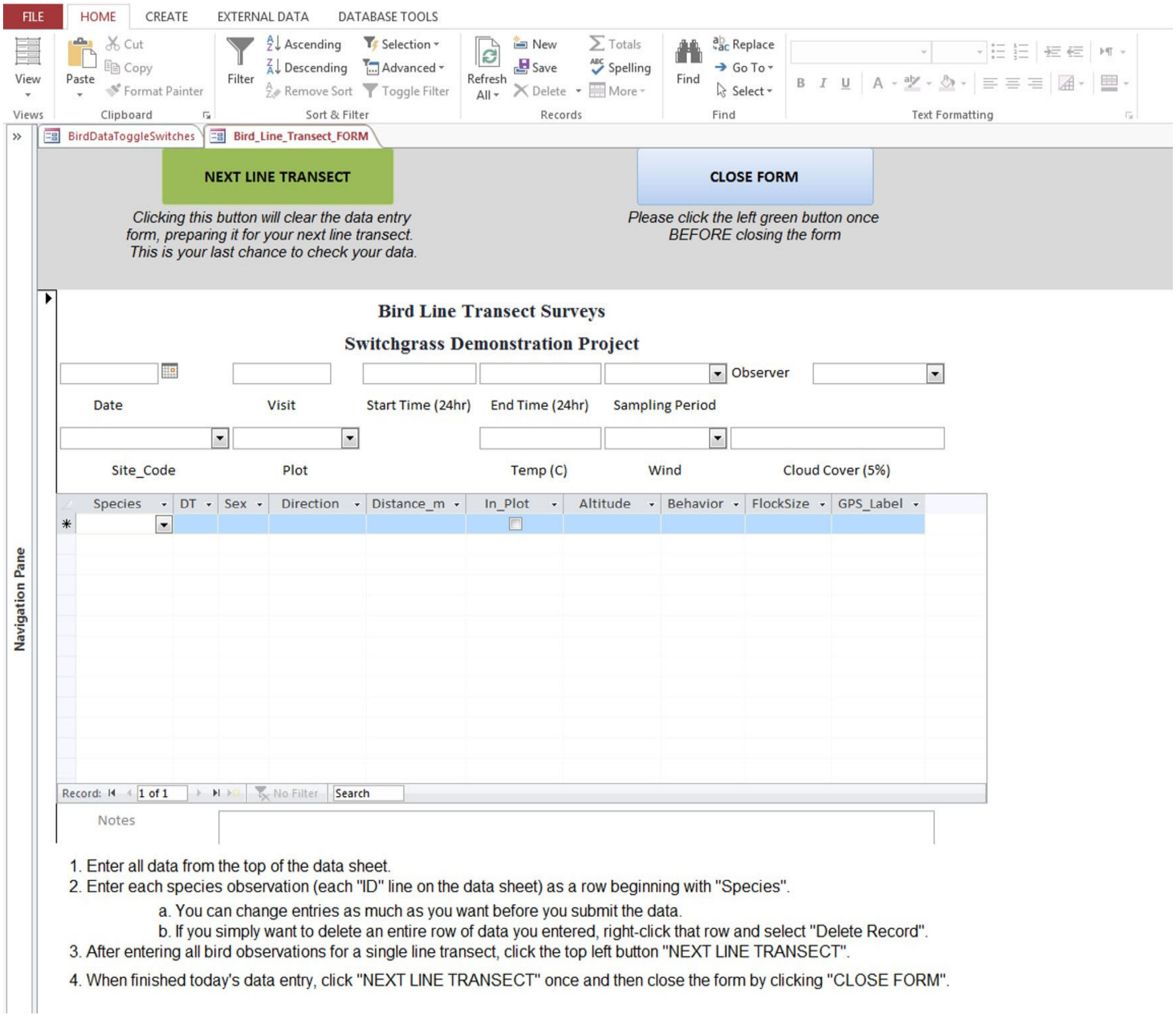
A Microsoft Access® data base was developed to assist with data organization among a minimum of 6 field observers. Although the data base includes background information for data analysis such as species lists and site descriptions, users other than the project manager will see the following front page views.

Initial screen after opening data base



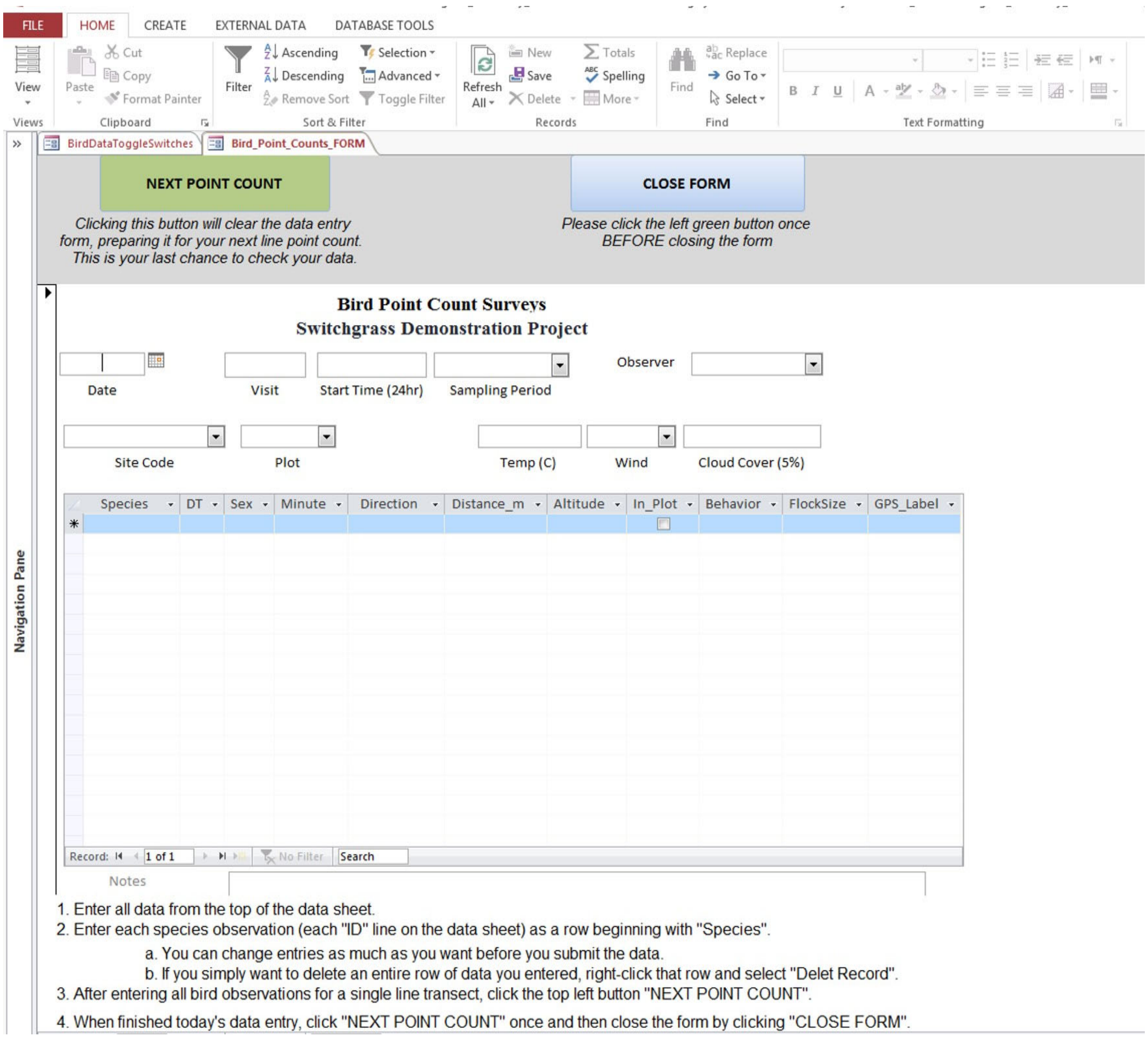
Bird Line Transect Data Entry Form

This form appears after a user clicks “Enter Bird Line Transect Data”.



Bird Point Count Data Entry Form

This form appears after a user clicks "Enter Bird Point Count Data".



Appendix E: Additional Sampling Protocol

Calibration of Equipment

The only equipment requiring calibrations were game cameras, herbicide applicators, and seed drills. A demonstration video was produced regarding game camera set-up to ensure consistent use among biologists and installations. Professional land managers were contracted for all herbicide application and switchgrass planting for treatment installation and each calibrated their equipment appropriately. Local herbicide application by biologists to maintain camera trapping areas did not require equipment calibration.

Quality Assurance Sampling

Concomitant sampling protocols for professional airport biologists, simple faunal survey techniques, and a standardized data entry platform ensured quality assurance sampling. Oversight by the project manager in addition to organizational aspects of a project database, data entry by airport biologists and standardized data sheets further supported quality data sampling. Sites were visited by the project manager annually throughout the project's duration to meet with biologists and installation staff and monitor switchgrass establishment. All field data was entered by airport biologists or the project manager in the project's database. Updated databases were uploaded to a shared cloud file, and field data sheets mailed to the project manager for any additional accuracy checks regarding quality assurance evaluation.

Sample Documentation

The sample documentation program had three components: 1) bird count field data, 2) a Microsoft Access® database, and 3) digital files. Bird count field data sheets provided ample space for all required bird sampling information (Appendix B). Data sheets were developed and modified based on our experience and interactions with participating airport biologists. The Microsoft Access® database complemented the standardized data sheets with a consistent data entry platform for participating airport biologists to enter their data (Appendix C). Participating airport biologists entered their data, with the exception of WHIT, and sent their updated database file electronically to the project manager for final data checks and data compilation. In addition, some participating biologists mailed their field data sheets to the project manager for additional quality assurance evaluations during which the project manager randomly compared field data sheets with entered data. We used a properly arranged Microsoft Access® database to help reduce data entry errors by limiting data entry options to specific entries such as American Ornithological Union's bird species acronym lists and a user platform that limits data entry personnel views to data entry forms, not actual database tables. In addition, biologists used installation- or state-specific databases allowing for further isolation of data entry errors to minor databases. Final data compilation combined exported data from these databases in Program R. Other digital files in addition to the field data sheets were camera trapping pictures and GPS-marked points for line transects. These files were also submitted to the project manager via the shared cloud folder with a copy kept on airport biologist computers.

Appendix F: Support Letters by Participating Installations

Columbus Air Force Base (CAFB) Support Letter

Raymond B. Iglay, Ph.D. 20 Nov 2018
Center for Resolving Human-Wildlife Conflicts
Department of Wildlife, Fisheries & Aquaculture
Mississippi State University
Office: 217 Thompson Hall
Mississippi State, MS 39762

RE: CAFB Intentions for southern switchgrass plot, Area A

CAFB intends to maintain the southern switchgrass plot by mowing, due to failure in stand establishment. This management practice will reduce manpower and equipment burdens and decrease potential BASH hazards.

CAFB intends to maintain the southern switchgrass plot by periodic mowing. Occasionally, herbicides may be used to control broadleaf competition. Future management considerations are driven by military mission requirements, therefore the overall disposition of the southern switchgrass plot could change as dictated by the Installation Commander.

CAFB sincerely appreciates being given the opportunity to participate in the DOD ESTCP project.

Gary Wright
Gary L. Wright
Airfield Manager
Columbus AFB

Dayton International Airport (DAYT) Support Letter

INTERNATIONAL AIRPORT

Easy to and through.

November 15, 2018

Raymond B. Iglay, Ph.D., CWB
Department of Wildlife, Fisheries & Agriculture
Mississippi State University
775 Stone Blvd., a211 Thompson Hall
Mississippi State, MS 39762

Dear Dr. Iglay,

At the Dayton International Airport, we embrace Sustainability and Wildlife Hazard Mitigation for the Airline industry. We appreciate the honor of being involved in this most important research and see it as influencing how the Federal Aviation Administration and the Department of Defense promote the future management of the airfield and surrounding turf grasses.

We understand that the protection of the environment and Wildlife Hazard Mitigation are not mutually exclusive. At the Dayton International Airport, we have developed our Planes to Prairies program, where airport land associated with the Runway Protection Zones (RPZ) are being converted to dense, native tallgrass prairies. These prairies are thought to attract small, sometimes threatened grassland species while deterring larger, more hazardous birds.

Your project has provided a great opportunity for us to partner with you and evaluate our program in unity with yours. With our program continuing, we'll maintain the switchgrass demonstration plot within the RPZ, however, with the proximity of the other demonstration plot to the entrance of the Airport, we will allow it to naturally turn back to multi-cultural grasses and lawn.

Thank you for giving us this opportunity. It is a pleasure working with you.

Sincerely,

Mike Cross
Acting Planning and Engineering Manager
Dayton International Airport

Owned and Operated by the City of Dayton
3600 Terminal Drive - Suite 300 - Vandalia, Ohio 45377-1095
(937) 454-8200 / 1-877-FLYDAYT Telephone * (937) 454-8284 Fax * www.flydayton.com

Detroit Metropolitan Airport (DTWA) Support Letter

DETROIT METRO • WILLOW RUN
WAYNE COUNTY AIRPORT AUTHORITY

11050 Rogell Drive #602
Detroit, MI 48242
ph: 734 247-3316
fax: 734 247 3337
www.metroairport.com

To: Raymond B. Iglay
Assistant Research Professor
Mississippi State University

From: Matt LaFleur
Senior Airfield Operations Manager

Date: 11/19/18

Subject: Switchgrass Demonstration Project

Wayne County Detroit Metropolitan Airport intends to continue the management of the switchgrass plantings as part of the switchgrass demonstration project started in 2015 under the guidance Mississippi State University and the United States Department of Agriculture.

The results of the project appear to support the objectives of the airports, Wildlife Hazard Management Plan and the reduction of wildlife species that may pose a hazard to aviation interests. The airport will continue to maintain the plots and collect data that would support the objectives of the airports Wildlife Hazard Management Plan.

With your continued support and guidance, the airport looks forward to continued research in alternative grass management techniques at commercial service airports.

Please contact me if you have any questions.

Cc File

Gerald R. Ford International Airport (GRFI) Support Letter

GERALD R. FORD International Airport

December 11, 2018

Dr. Raymond Iglay, CWB
Mississippi State University
Department of Wildlife, Fisheries & Agriculture
Box 9680
Mississippi State, MS 39762

Beginning in 2015, The Gerald R. Ford International Airport Authority participated in a research effort by the Mississippi State University involving the planting of switchgrass to determine its effects on various wildlife species. The effort was led by Dr. Travis DeVault of the USDA WS National Wildlife Research Center and Dr. Raymond B. Iglay, CWB with MSU's Department of Wildlife, Fisheries & Agriculture along with their colleagues and support from the Department of Defense. As part of this effort, multiple switchgrass plots were developed outside of the Air Operations Area at GRR by the efforts of the research team. The team subsequently assumed sole responsibility for monitoring the grass and observing its influence on wildlife at GRR.

The research team continued their research efforts on the switchgrass plots in a very transparent fashion, informing the Authority when and where they would be on site to evaluate the plantings with no assistance required by the Authority. Additionally, the switchgrass plots reduced the need for the Authority to maintain these areas. Specifically, the need to maintain these plots through mowing efforts was significantly diminished or eliminated depending on the progression of the switchgrass.

With the switchgrass research project completed, the Authority has initially elected to retain the switchgrass plots as it appears that it will reduce the maintenance needs (mowing) of these plots as they will only require annual mowing during the late switchgrass growing season. This, coupled with the potential benefit of the switchgrass being an effective wildlife deterrent, has resulted in an initially favorable view by the Authority on this effort.

Mr. Iglay facilitated this research effort in a very effective and professional way, remaining sensitive to the airport's needs and concerns throughout the effort. We would not hesitate in considering further accommodations to future research efforts.

Respectfully,

Bruce Applebach, A.A.E.
Airport Operations Manager
Gerald R. Ford International Airport Authority

Gerald R. Ford International Airport Authority
5500 44th Street SE Grand Rapids, MI 49512-4055 ph 616.233.6000 fx 616.233.6025
flyford.org

NAS Whiting Field (WHIT) Support Letter

15 January 2019

Good Morning Dr. Iglay,

My name is Dr. Leann Bair, the Airfield Manager for all 14 airfields in the NAS Whiting Field complex. I would like to thank you for the opportunity for Navy Outlying Landing Field (NOLF) Wolf to participate in your switchgrass demonstration project. However due to the inability of the switchgrass to take root and grow in the designated areas of the airfield, I am unable to provide a decision in support of the benefits of switchgrass due to lack of primary data. I am also unable to provide any discussion points for management or establishment of switchgrass as the sandy soil at NOLF Wolf did not allow the grass to populate.

I wish you the best of luck in your future endeavors.

VR,
Leann

Dr Leann Bair
Airfield Manager
NAS Whiting Field
(O) 850-665-6133
(C) 850-602-1590

Wright-Patterson Air Force Base (WPAF) Support Letter

DEPARTMENT OF THE AIR FORCE
88TH CIVIL ENGINEER GROUP (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE OHIO

20 Nov 2018

Raymond B. Iglay, Ph.D.
Center for Resolving Human-Wildlife Conflicts
Department of Wildlife, Fisheries & Aquaculture
Mississippi State University
Office: 217 Thompson Hall
Mississippi State, MS 39762

RE: WPAFB Intentions for southern switchgrass plot, Area A

WPAFB intends to maintain the southern switchgrass plot as is, in order to reduce manpower and equipment burdens, decrease potential BASH hazards and increase potential revenue opportunities.

WPAFB intends to maintain the southern switchgrass plot by periodic, annual mowing and/or baling and possibly prescribed fire. Occasionally, herbicides may be used to control broadleaf competition. Future management considerations are driven by military mission requirements, therefore the overall disposition of the southern switchgrass plot could change as dictated by the Installation Commander.

WPAFB sincerely appreciates being given the opportunity to participate in the DOD ESTCP project.

Darryn M. Warner
Natural Resources Program Manager
88 CEG/CEIEA