EXECUTIVE SUMMARY

Improving Safety and Economics Using Switchgrass on Military Airfields

ESTCP Project RC-201415

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1.0 INTRODUCTION

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. Many airport biologists and managers believe that extant airport grasslands, especially when maintained at about 15-25 centimeters 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. 2013). Furthermore, maintaining large expanses of managed turf grasses has numerous economic and environmental drawbacks, but land-cover alternatives such as switchgrass monocultures (*Panicum virgatum*) outside AOAs could concomitantly reduce these drawbacks and reduce use by wildlife species that are hazardous to aircraft (Blackwell et al. 2009, 2013, DeVault et al. 2012, 2013, Martin et al. 2013, Conkling et al. 2018).

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. 2013; Blackwell et al. 2016). However, grasslands managed for biofuel production, if converted to appropriate cellulosic feedstocks such as switchgrass, 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 megagrams per hectare [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.

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 Federal Aviation Administration (FAA), 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. 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.

2.0 OBJECTIVES

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. Performance objectives established measurable goals for: 1) switchgrass establishment; 2) reduction of hazardous birds (abundance); 3) reduction of hazardous mammals (abundance); 4) reduced relative hazard scores associated with birds and mammals (one Performance Objective each per birds and mammals); 5) reduced maintenance costs; and 6) user acceptance of switchgrass implementation.

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3.0 TECHNOLOGY DESCRIPTION

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. Three military airfields and three civil airports across three latitudinal gradients participated in the demonstration: southern, central, and northern. During the beginning of the demonstration, participating installations identified areas suitable for planting switchgrass which were outside AOAs for most sites, NAS Whiting Field (WHIT) being the exception. However, WHIT did not experience any flight activity throughout the demonstration. We identified two pairs of 8-ha plots per installation (n = 4 plots per installation) with one plot per pair a control and the other a switchgrass monoculture. Participating installations included WHIT, Columbus Air Force Base (CAFB), Dayton International Airport (DAYT), Detroit Metropolitan Airport (DTWA), Gerald R. Ford International Airport (GRFI), and Wright-Patterson Air Force Base (WPAF).

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 guidelines 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 kilograms (kg) per hectare (9 pounds/acre pure live seed [PLS]) and spaced approximately 18 centimeters (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 is primarily their abilities to establish in extreme conditions such as acidic and dry soils, not their 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. Post-planting switchgrass establishment techniques (e.g., additional plant competition control) were developed prior to this demonstration among multiple programs ranging from wildlife conservation to biofuel production across the Midwestern and central United States.

Alternative technologies and methodologies remained consistent throughout the demonstration. Extant airfield grassland management practices surrounding or adjacent to switchgrass demonstration plots 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.

4.0 PERFORMANCE ASSESSMENT

Attempts to establish switchgrass followed our proposed approach of switchgrass planting, establishment, and maintenance. Percent coverage goals were based on past observations of 40%, 60%, and at least 80% switchgrass coverage across the initial 3 years of establishment. However, switchgrass establishment failed to achieve intended coverages at most installations. Late plantings (CAFB and WHIT), excessive moisture (CAFB, DAYT, DTWA) and plant competition (all sites) interacted with establishment attempts throughout the demonstration. For example, during the 2016 herbicide application for a second switchgrass establishment attempt at CAFB, 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. 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.

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). Biologists detected 11,856 birds using sites during 1,212 point counts and detected 24,599 birds in sites during 1,170 line transects. 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.

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. 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 (Figure 1E). 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.

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*), 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. Because coyotes, white-tailed deer and all rabbits (eastern cottontails and unknown rabbits) occurred across all installations, they were included in installation analysis. Cumulative hazard score and species richness were based on top species (i.e., $\geq$ 25 detections) among installations. White-tailed deer and coyote had greater occurrences in controls more often than switchgrass sites during installation-specific analyses. However, years 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). 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).

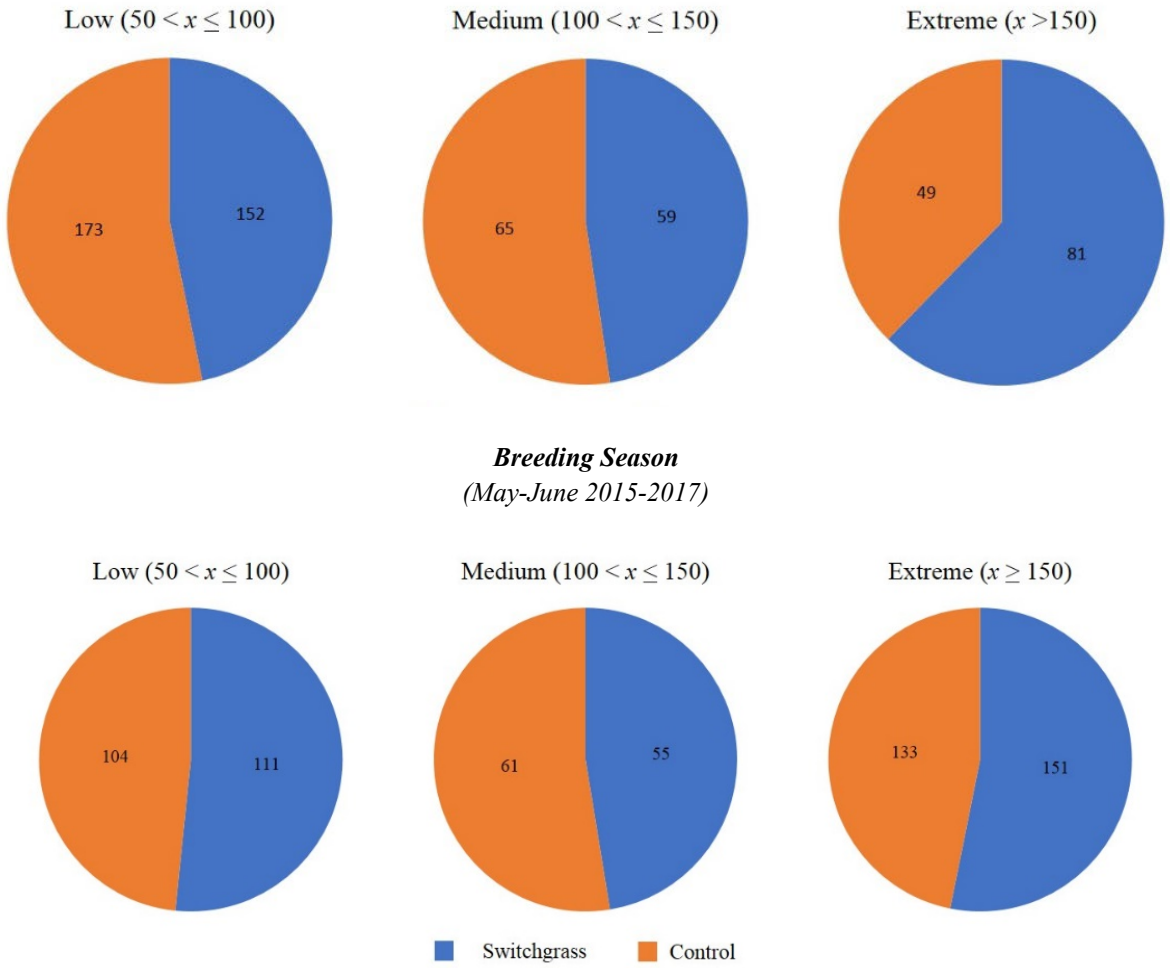

Figure 1. Number of Extreme Observations (Number in Each Slice) Indicated by the Cumulative Hazard Score (CHS) Per Point Count from Morning Point Counts (Breeding Season) or Line Transects (Non-Breeding Season) Between Switchgrass Monocultures and Extant Airfield Grasslands in East Central United States.

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5.0 COST ASSESSMENT

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. 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. 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 from 2025 to 2036 with later years associated with high switchgrass establishment and low mowing costs.

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 centimeter 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.

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6.0 IMPLEMENTATION ISSUES

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 during 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 2). 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.

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.

Figure 2. 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.

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.

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