Contents

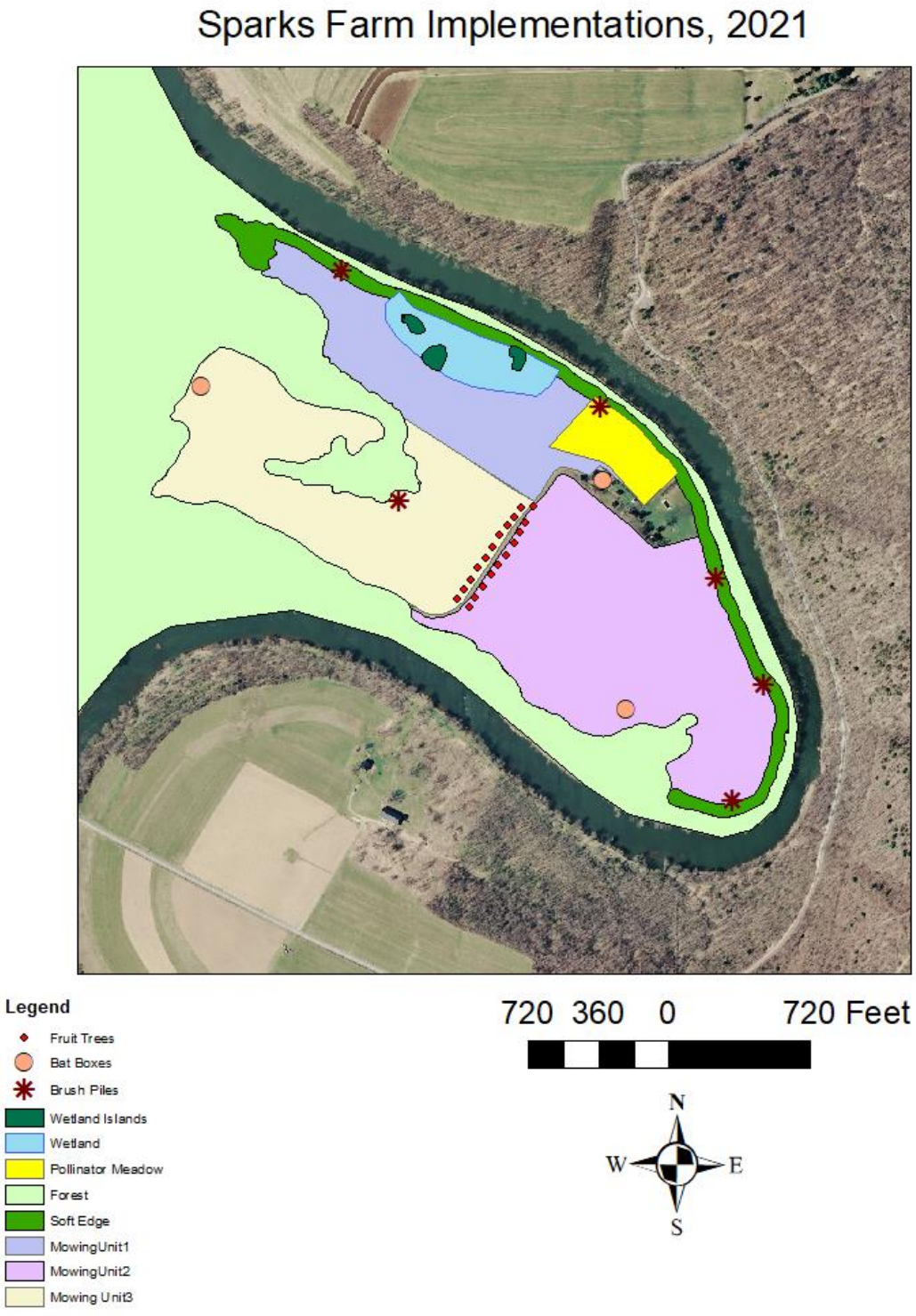
SUMMARY/INTRODUCTION

Sparks Farm is a 447-acre property owned by Juniata College in Bedford County, Pennsylvania with the intention to be used as an educational facility and an actively managed wildlife reserve. The focus of the Farm's management centers around four primary species groups: pollinators, grassland birds, wetland birds, and mammals. The management of Sparks Farm will prioritize a variety of species by taking into account the Farm's diverse habitat and wide potential for wildlife improvement. This plan works to blend effective habitat management techniques with aesthetics to showcase how wildlife management efforts can be implemented in an artful and creative manner.

LANDOWNER GOALS

The landowner's overall goals are to provide a natural area that works to create improved wildlife habitat across the property, including that for Species of Greatest Conservation Need, while still offering ample opportunities for outdoor education, recreation, and relaxation. It is imperative that the management strategies are visibly available to the public for the offered educational opportunities, however, the majority of the implementations need space away from human activity to be an effective part of a wildlife management plan.

LANDSCAPE CONTEXT



MANAGEMENT PLAN FOR SPARKS FARM

Pollinator Management Plan

INTRODUCTION

Most plant species rely on pollination in order to reproduce, and there are many pollinators responsible for this task. Flowers have evolved to attract a variety of insect, mammal, and bird species that utilize their nectar while spreading the plants' genetic material. Since pollination plays a key role in plant success, protecting pollinators is essential to promoting biodiversity and the health of ecosystems everywhere (Kenney, 2017). At Sparks Farm there are several pollinator species of interest that should be targeted for habitat management. Optimal techniques for said management include installing pollinator boxes, planting fruit trees, scheduling mowing times, planting a pollinator meadow, and incorporating flowering and pithy plant species in existing fields.

SPECIES OF INTEREST

Baltimore Checkerspot Butterfly (*Euphydryas phaeton*)

The Baltimore Checkerspot butterfly (*Euphydryas phaeton*) is a wetland species that is considered imperiled (S2) and at risk of extirpation in Maryland. A population of checkerspots has been located at Sparks farm. Threats to the species include loss of wetland habitat, loss of vegetation needed for reproduction and feeding due to deer browsing, and the spread of invasives (*Rare, Threatened and Endangered Animal Fact Sheets Baltimore Checkerspot (Euphydryas Phaeton Drury)*, 2021). This species feeds almost exclusively on white turtlehead flowers (*Chelone glabra*) when in the larval stage, once matured they feed on various species such as common milkweed (*Asclepias syriaca*), dogbane *(Apocynum* spp.), and arrowwood viburnum (*Viburnum recognitum*). Protection of the white turtlehead flower is vital to maintaining the population of Checkerspots at Sparks farm (see pre & post monitoring). While the turtlehead provides essential breeding and nectaring habitat for Checkerspots, they are mostly pollinated by bumblebees (*Wetland Butterflies - Species at Risk in Pennsylvania*, 2021). White turtlehead plants grow in swampy areas, where the soil is consistently moist ("White Turtlehead (Chelone Glabra)," 2021). It is more of a wetland species and desires partial sun, it will be beside some taller vegetation in order to fulfill this need. See wetland bird plant chart for information regarding the price and purpose of including the plant.

Monarch Butterfly (*Danaus plexippus*)

Danaus plexippus populations have been drastically declining due to habitat loss and fragmentation (*Monarch Butterfly*, 2021). Their diet as a larva is very specific, feeding almost exclusively on milkweeds. Once they turn into adults, Monarchs will feed on the nectar of many blooming species (*Monarch Butterflies- Eastern United States*, 2021). On the Sparks farm property there is established milkweed throughout the fields that are providing essential host plants for the species and quality nectar for other pollinating species. Improving the amount of milkweed and various nectar species can aid in their migration, as well as aid in the populations of other species.

Bumble Bees (*Bombus* spp.*)*

Bumble bees (*Bombus* spp.*)* are some of the most common and widespread social bees in Pennsylvania. They are important pollinators and are typically generalists when it comes to preferences of flowering species (Cameron et al., 2011). There are two species of bumble bee that are of particular interest: the common eastern bumble bee (*Bombus impatiens*), the most prolific species in Pennsylvania, and the rusty patched bumble bee (*Bombus affinis*), which is endangered in the United States (Anton & Grozinger, 2021). Many North American bumble bee species have declined in abundance as well as distribution ranges (Cameron et al., 2011). Because bumble bees are essential pollinators, reductions in their numbers have exceptional ecological consequences. As with most pollinator species, habitat loss or degradation is one of the main causes of population drops. To boost the numbers of bumble bees and other generalist pollinators at Sparks Farm, diverse wildflower mixes will be dispersed on the property (see Pollinator Meadow) and mowing times will be managed to optimize the growth of beneficial flowering species (see Mowing Schedule). Bumble bees need a cavity in which to build their nest, so techniques should be applied to increase available nesting cavities.

Mason Bees (*Osmia* spp.)

Native solitary nesting bees such as mason bees would also benefit from an increase of flowering species. Mason bees (*Osmia* spp.) are exceptionally efficient pollinators and are one of the few native bees managed for agriculture in Pennsylvania (Moisset & Wojcik, 2021). There are over 100 species of *Osmia* in North America, all of which are known for visiting flowering trees (Moisset & Wojcik, 2021). There are already several species of fruit and nut trees at Sparks Farm, and more native mast-producing trees should be added (see Fruit Trees). In addition to increasing flowering meadow and tree species, mason bees would also benefit from pollinator boxes and pithy plant stems. As one of the many native solitary wood-nesting species, mason bees require hollow tunnels in which to build their nests, which can take the form of pithy twigs or man-made cavities (Vaughan & Black, 2008). Both should be implemented at Sparks Farm.

Solitary nesting bees such as bumble and mason bees utilize a variety of nesting substrates, using materials such as hollow twigs, dead wood, and paper-based tubes (Brokaw & Isaacs, 2017). These materials can all be incorporated into man-made pollinator boxes, which can be as simple as several tubes secured into a bundle or one piece of untreated lumber with holes drilled into the surface. Designs can also be more complex, using a multilayered structure with numerous types of nesting materials. Creating a variety of cavity sizes may also attract different types of pollinators based on their body sizes (Brokaw & Isaacs, 2017). These boxes should be ideally placed 4 to 5 feet above the ground within range of flowering plants, put out in early spring and left outside until late October (Brokaw & Isaacs, 2017). Once the bee habitat has been created and established, they must be kept clean to prevent the spread of diseases amongst nesting bees (see Management Plan). One pollinator box is currently being stored at Sparks Farm. A survey of pollinator habitat should be completed to determine the optimal abundance and distribution of boxes near and inside the pollinator meadow. Pollinator boxes should be placed near edges of the pollinator meadow, so they can be easily maintained. It would be ideal to have at least one pollinator box along each of the sides of the meadow, but additional boxes could be added if resources allow.

Example Pollinator Box at Sparks Farm

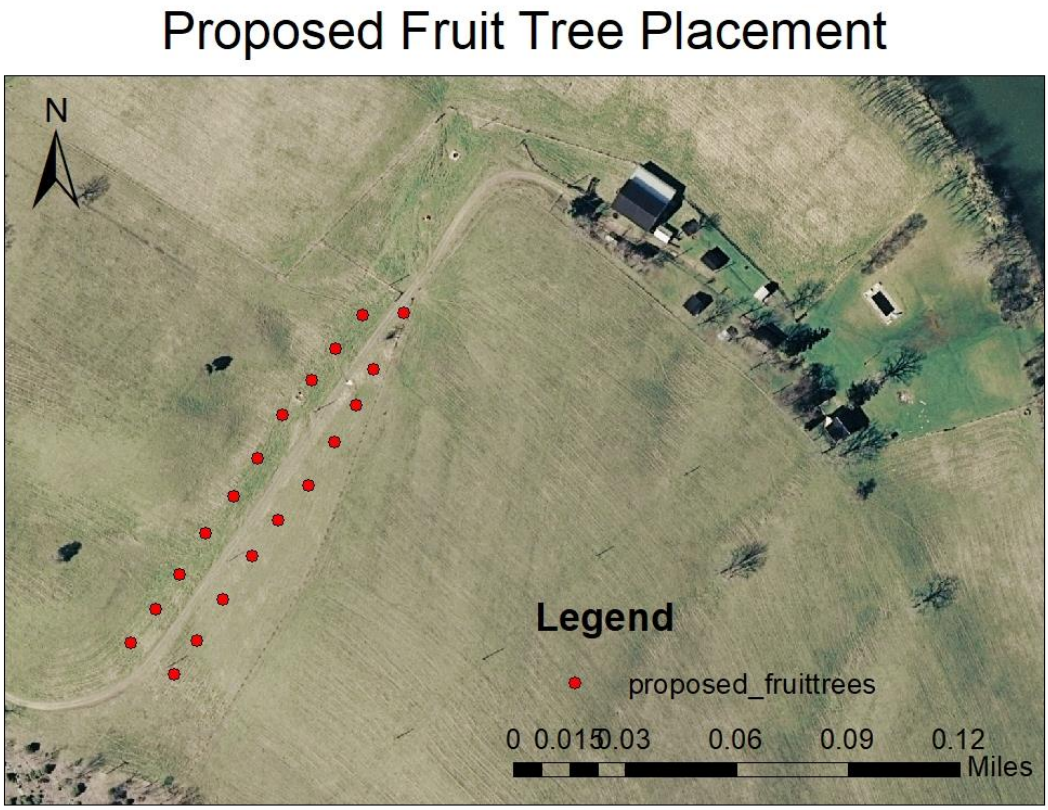
In addition, many native species of grasses as well as herbaceous and woody plants have pithy stems that these bees can utilize. Grasses with pithy stems such as Indiana grass and little bluestem can easily be incorporated into the fields (*Nesting Resources*, 2021). Many herbaceous plants have pithy or hollow stems including goldenrod, butterfly weed, Joe-pye-weed and wild bergamot (*Nesting Resources*, 2021). These plants can be incorporated into the fields, edge habitat, and the pollinator meadow. Sumac (*Rhus* spp.) and black elderberry (*Sambucus canadensis)* are woody plants with pithy stems that can be included in the development of a soft edge along the river (*Nesting Resources*, 2021).

MANAGEMENT OBJECTIVES

Implementation 1: Fruit Trees

Fruit trees would provide both aesthetic value and resources for wildlife. Planting fruit trees would attract pollinating birds and insects that utilize their nectar, edible foliage, and larvae can use them as a host plant (see "Proposed Fruit Tree Placement" map below).

Fruit Trees	**Benefits**
Serviceberry (Amelanchier alnifolia)	Serviceberry offers fruit, nectar and edible foliage for wildlife such as hummingbirds, caterpillars/butterflies, and other beneficial insects. Butterflies such as spring azures make use of the nectar and the plant serves as a host to swallowtail larvae (Brenner, 2010). The foliage is also food for 124 different caterpillar species (Parnum, 2019). This tree prefers a sunny location but can also tolerate some shade (Brenner, 2010).
Sweet crabapple (*Malus coronaria*)	Mason bees love crabapples and it attracts large numbers of other native bees (Matsumoto et al., 2009).
Cockspur hawthorn (*Crataegus crus-galli*)	Hawthorns act as a larval host to native moths, attracting bees, butterflies, and other pollinating insects (*Crataegus Crus-Galli (Cockspur Hawthorn)*, 2019).
Pawpaw (*Asimina triloba*)	Pawpaw trees evolved to attract beetles and flies, but is also a host to Zebra Swallowtail (*Eurytides marcellus*) larvae ("Pawpaw Tree - A National Treasure," 2017).



Implementation 2: Mowing Schedule to benefit pollinators

In order to maintain grassland habitat, fields must be mowed to prevent them from reverting to forest. However, pollinators benefit from unmowed vegetation, so infrequent mowing is desirable (Stoner, 2017). Unmowed areas allow plants to mature and produce seeds. Unmowed plants provide flowers for nectar and hollow stems for cavity nesting pollinators (Stoner, 2017). To accomplish this, the fields at Sparks farm should be mowed based on a fractional schedule (page 29).

Implementation 3: Creating a Pollinator Meadow

Pollinator meadows composed of native perennials and grasses provide food and shelter for a variety of species. They also help with filtering stormwater, storing carbon, recycling nutrients, and building soil. A well-established pollinator meadow can be aesthetically pleasing and requires minimal maintenance.

A designated area located between the barn and the river should be converted into a pollinator meadow containing a high percentage of herbaceous plants (see “Xerces Society Seed Mixes” table below) . This area is relatively flat and open with plenty of available sunlight making it ideal for establishing a pollinator meadow (see “Proposed Pollinator Meadow” map below). Bees, butterflies, and other pollinators benefit greatly from the flowers and stems of flowering herbaceous plants such as Goldenrod (*Solidago nemoralis*), Joe-pye-weed (*Eutrochium purpureum)*, and New England Aster (*Symphyotrichum novae-angliae*). The flowers of these plants provide pollinators with nectar, and the stems provide nesting and overwintering habitat for cavity-nesting pollinators.

Proposed Pollinator Meadow

Planting Techniques

Seeds should be planted in the early fall because perennial seeds need cold temperatures and moisture before they germinate. Winter precipitation helps the seeds settle into the soil, and this avoids grasses being favored by a spring planting to maintain wildflower dominance. To plant the seeds, broadcast planting is a low-tech and low-cost method where seeds are spread onto bare soil. To spread the seed mix evenly, combine with an equal amount of damp sawdust to give a visual representation of the seed distribution.

Seed Mix

Pennsylvania Pollinator Mix Breakdown ("Xerces Society Seed Mixes - Ernst Conservation Seed," 2021).

	Botanical Name	Common Name	Price/lb
21.90 %	*Schizachyrium scoparium, Fort Indiantown Gap-PA Ecotype*	Little Bluestem, Fort Indiantown Gap-PA Ecotype	19.20
21.80 %	*Elymus virginicus, Madison-NY Ecotype*	Virginia Wildrye, Madison-NY Ecotype	9.60
10.00 %	*Echinacea purpurea*	Purple Coneflower	46.21
8.00 %	*Chamaecrista fasciculata, PA Ecotype*	Partridge Pea, PA Ecotype	7.67
8.00 %	*Coreopsis lanceolata*	Lanceleaf Coreopsis	32.56
6.00 %	*Heliopsis helianthoides, PA Ecotype*	Oxeye Sunflower, PA Ecotype	38.71
3.00 %	*Zizia aurea, PA Ecotype*	Golden Alexanders, PA Ecotype	327.63
2.50 %	*Verbena hastata, PA Ecotype*	Blue Vervain, PA Ecotype	39.94
2.20 %	*Penstemon digitalis, PA Ecotype*	Tall White Beardtongue, PA Ecotype	198.53
2.00 %	*Asclepias incarnata, PA Ecotype*	Swamp Milkweed, PA Ecotype	200.83
2.00 %	*Monarda fistulosa, Fort Indiantown Gap-PA Ecotype*	Wild Bergamot, Fort Indiantown Gap-PA Ecotype	179.80
1.80 %	*Vernonia noveboracensis, PA Ecotype*	New York Ironweed, PA Ecotype	322.62
1.60 %	*Liatris spicata, PA Ecotype*	Marsh Blazing Star, PA Ecotype	433.55
1.30 %	*Aster lateriflorus*	Calico Aster	677.09
1.30 %	*Pycnanthemum tenuifolium*	Narrowleaf Mountainmint	186.16
1.20 %	*Aster laevis, NY Ecotype*	Smooth Blue Aster, NY Ecotype	375.74
1.00 %	*Agastache foeniculum*	Anise (Lavender) Hyssop	220.30
1.00 %	*Geum canadense, PA Ecotype*	White Avens, PA Ecotype	207.10
1.00 %	*Lespedeza capitata, RI Ecotype*	Roundhead Lespedeza, RI Ecotype	136.61
0.70 %	*Oenothera fruticosa var. fruticosa*	Sundrops	462.24
0.50 %	*Asclepias syriaca, PA Ecotype*	Common Milkweed, PA Ecotype	176.10
0.50 %	*Eupatorium fistulosum, PA Ecotype*	Joe Pye Weed, PA Ecotype	354.57
0.40 %	*Solidago nemoralis, PA Ecotype*	Gray Goldenrod, PA Ecotype	405.16
0.30 %	*Solidago juncea, PA Ecotype*	Early Goldenrod, PA Ecotype	381.99
100.00 %		**Mix Price/lb PLS:**	**$82.04**

Site Preparation

Preparing the area first starts with preventing competition from weeds, and it is best to avoid herbicide use. The site should be plowed and disked in the fall to expose cool season grass roots to freezing winter temperatures which buries the seeds.

Plant Selection

It is essential to select a mix of plants with a diversity of color, shape, and size/height to support a diversity of pollinators. Plants with different blooming schedules should be selected so that there are always at least three different species of flowers blooming at any time throughout the growing season to ensure a steady pollen source. Grasses can be mixed into the wildflowers (no more than 25% grass) as hosts for butterfly larvae and nesting areas for bees and other insects that overwinter. To calculate the amount of seed needed, there should be around 4.5 lbs - 6.7 lbs of seed per acre. Local ecotype seeds are best to use as they ensure the plants are well adapted to the area's weather and soil types.

Ongoing Management

The ongoing management of a pollinator meadow is minimal. There is no need to water a pollinator meadow unless there are drought conditions, and fertilizing is also not necessary; however, it is important to manage weeds the first two years a meadow is establishing itself. Weeds should be mowed during the first year after they have gone to flower in November. Some of these annual weeds to look out for are Mile-a-minute (*Polygonum perfoliatum*) and Shattercane (*Sorghum bicolor*). In the second year, biennial weed species, such as Bull thistle (*Cirsium vulgare*) (*Visual Guide to Pennsylvania's Noxious Weeds*, 2008), will also need to be mowed in November, but by the third growing season the wildflowers should be well established with thick enough root systems to keep weeds out. At this point, all that is needed is the occasional removal of tree saplings or shrubs that may try to grow in the field but hand cutting. Once the field is mature you should avoid mowing more than ⅓ of it at a time. If gaps appear, they can be reseeded by hand as needed. It is important not to use pesticide or herbicide as they can be very destructive to pollinator habitats (Lee-Mäder et al., 2013).

PRE AND POST MONITORING

Pre and Post-monitoring techniques will be necessary to keep track of pollinator species utilizing Sparks farm before and after alterations have been made. A preliminary species survey should be done before the overhauling of the land into what is wanted, and afterwards at least yearly, and after major cuts or other operations that may disturb pollinators. This will set up future and past records for caretakers and researchers to look back on and determine the effect the changes have had on the population of pollinators.

Managers of Sparks farm can incorporate these post-monitoring techniques into educational programs for visitors or conduct these techniques themselves or in cooperation with research groups. It is important to quantify the effects of the changes made to Sparks farm. While none of these monitoring techniques are absolutely necessary, they will ensure a source of information for future managers and researchers on the property to provide a view into the present and the past. Different post-monitoring techniques that can be employed on Sparks farm include but are not limited to: Citizen sciences, insect visitation transects, floral observation plots, and pan trapping.

Citizen Science

Citizen science would be citizens informally recording any pollinator sighted on the farm. These sightings can be reported on apps such as iNaturalist. It would be desirable to host student groups at Sparks farm to find and record pollinator observations on iNaturalist or some other citizen science platform, whether it is through club outings or future classes. Citizen science can be an

especially valuable source of information for any insects or pollinators that are of concern that have been sighted by visitors to Sparks farm.

Insect Visitation Transects

Insect visitation transects are conducted on 200 meters of linear route at a slow pace for 12 to 15 minutes (O'Connor et al., 2019). During this time researchers identify and count all insects seen visiting flowers within 1 meter of the transect line (O'Connor et al., 2019). Netting and collecting specimens for identification is allowed. This technique should be employed in the field units at Sparks farm before the fields are replanted and annually in following years after replanting.

Floral Observation Plots

Floral observation plots are conducted within plots of 50 x 50 cm^2 and observed for a set amount of time. When an insect visits a flower within the observation plot, the flower and insect species are recorded. The dense concentration of flowering plants in the pollinator meadow would likely make this observation technique ideal in this area. To assess the pollinator meadow using this technique, multiple observation plots should be established at random locations within the pollinator meadow.

Pan Trapping

Surveying insect species by pan trapping requires less time and effort than the techniques above. It involves a bowl filled with water and unscented detergent to break surface tension (O'Connor et al., 2019). Bowls are placed on wooden stakes at the average height of flowers and after a set period of days, the trapped insect specimens are collected and identified (O'Connor et al., 2019). This is a low-effort, cost-effective method to survey large areas for pollinator species. This technique should be employed in the fields and the pollinator meadow. Additionally, this technique could also be used to survey for pollinators in the forest as well.

Grassland Bird Management Plan

INTRODUCTION

The Role of Grasslands

Grasslands share two unique characteristics with wetlands: they are crucial for biodiversity, and they have severely declined in the twentieth century. Grasslands have been identified as a high priority for restoration, reclamation, and management by Pennsylvania's State Wildlife

Action Plan (*2015 - 2025 Pennsylvania Wildlife Action Plan*, 2015). Scientists conducting global studies have concluded that temperate grasslands are in dire decline with the ratio of converted grassland to protected land ten to one, five times higher than the tropical rainforest (Hoekstra et al., 2005). Grasslands are plant communities dominated by herbaceous plants that do not have standing water or fully saturated soil for more than a few days per year and are mowed no more than once a year (Latham & Thorne, 2007). There is no widely accepted quantitative definition of grasslands, but they can be summarized as being dominated by grasses (>50% cover), have few to no trees (<5% cover), consisting of monocotyledons, plants with narrow leaves growing from the base, and are comparatively resistant to intensive grazing (Devine, 2016). Grasslands are driven by the scarcity of water and can be found with variable proportions of sedges, rushes, legumes, and other native herbaceous plants (Gibson & Newman, 2019).

Grasslands provide a variety of ecosystem services such as carbon sequestration, holding about 20% of global soil carbon stocks (Conant et al., 2001). Because herbaceous vegetation dominates grasslands, unlike forests, carbon storage in roots accounts for 60-80% of the biomass in the ecosystem (Ramankutty et al., 2008). Additionally, grasslands promote genetic diversity, weather amelioration, and serve as critical wildlife habitat for bird species (Sala & Paruelo, 1997). Grassland birds are defined as “any species that has become adapted to and reliant on some variety of grassland habitat for part or all of its lifecycle” (Vickery et al., 1994). Grasslands are among the most threatened ecosystems according to the International Union for the Conservation of Nature with the most significant threat being human land use (Henwood, 1998). Grasslands, as outlined in the Pennsylvania State Wildlife Action Plan, are among the most vulnerable ecosystems in the state due to their high conversion rate into croplands. Pennsylvania’s breeding bird fauna includes 15 species that are referred to as grassland-obligate or grassland-interior species, that is, to nest and successfully rear young they need access to large grasslands (Latham & Thorne, 2007).

Grasslands in Decline

Before European settlement grasslands in temperate northeastern North America were the result of natural disturbances such as fire, wind, disease, beaver (*Castor canadensis*) activity, flooding, and insect damage. These are now commonly the result of human disturbances, farming, and habitat management practices (Askins et al., 2007). Historically, fire represented an important disturbance mechanism leading to today’s fire-adapted grass species such as Oaks (*Quercus spp.*) and Bluestems (*Andropogon spp.).* The Pre-Columbian Northeast was heavily forested with large openings resulting from periodic burnings by Native Americans (Norment, 2002). After the extirpation of Native Americans, beavers filled the role left behind creating large “beaver meadows" especially in floodplains resulting in wet meadows suitable for grassland species, such as Bobolinks (*Dolichonyx oryzivorus*) and Grasshopper Sparrows (*Ammodramus savannarum*) (Askins, 1999). Windthrow events from hurricanes and tree disease from infestations also created favorable conditions for grasslands (Runkle, 1990). Yet the grasslands of the Northeast have changed drastically over the last 400 years, in tandem with land-use practices. Population declines of grassland birds in the twentieth century resulting from

forest succession, human development (Vickery & Dunwiddie, 1997), fire suppression (P. Vickery et al., 2005), and agricultural intensification, all reducing grassland habitats (Askins, 1993).

During the past decades grassland birds have shown “steeper, more consistent, and more geographically widespread declines than any other behavioral or ecological guild of North American birds” (Knopf, 1994). A recent 2019 study reveals that since 1970, bird populations in the United States and Canada have declined by 29%, or almost 3 billion birds, with grassland birds hardest hit, with a 53% reduction in population. The report revealed continuing declines in threatened and endangered species but for the first-time revealed losses among common backyard birds (Rosenberg et al., 2019). Grassland bird population suffering the most from habitat fragmentation, nest parasitism, pesticides, and invasions of woody vegetation (Peterjohn & Sauer, 1999). An overwhelming cause of the regional decline due to agricultural intensification. As grasslands are converted to farmlands, grassland birds now depend largely on agriculturally managed fields and pastures. This intensification is often a shift towards monocultures with fewer native plant species (Matson et al., 1997), and a focus on field production towards fiber for hay or silage (Rahmig et al., 2009). These shifts tend to degrade grassland bird habitat by increased use of pesticide, removal of natural field edges, spring plowing, land drainage, harvesting, mowing, and pastoral farming (Traba & Morales, 2019).

Why Warm Season Over Cool Season Grasses

Native grassland in North America can be divided into two categories: cool season and warm season grasses each with their own benefits and drawbacks (Table 1.). Cool-season grasses produce most growth during the spring and late fall when the soil and air temperatures are cooler. In temperate climates they generally go dormant or nearly so in midsummer, requiring a minimum air temperature for active shoot growth at 40-42^{o}F (4-5^{o}C) (Dickerson et al., 1997). Conversely, warm season grasses produce most biomass during the hot summer months from July through September. Growth for these species does not begin until air temperatures reach 60-65^{o}F (15-18^{o}C) and soil temperatures reach 50^{o}F (10^{o}C) (Dickerson et al., 1997; Johnson, 1976), best growth occurs when air temperatures average 85^{o}F (29^{o}C) (Dickerson et al., 1997; Moorman et al., 2017). Warm season grasses survive and adapt better than cool season species (Jacobs, 1999), especially under conditions of high-water stress (Barnes, 1985), high temperatures (Bokhari et al., 1975), high oxygen concentrations, low carbon dioxide concentrations (Bazzaz & Fajer, 1992), and high irradiance (Thompson & Harper, 1988), all characteristics of Sparks Farm. Cool season and warm season legumes are often mixed in grassland fields to fix nitrogen to reduce soil mineral depletion (Ashworth et al., n.d.; Dickerson et al., 1997). Legumes also maintain their forage quality, while grasses decrease in forage value when they go to seed head (*Extending the Grazing Season with Plant Diversity*, 2019). Regardless of the type of grass or legume, perennial plants should be favored over annuals because they reduce the need for

replanting, require less maintenance, and grow in a variety of soils (Clary, 2012; Corbin & D'Antonio, 2004).

Table 1. A summary of the benefits and drawbacks of warm-season and cool-season grasses (*Comparing Warm-Season and Cool-Season Grasses*, 2004)

Topic	Summary of the Benefits and Drawbacks of Warm-Season vs. Cool-Season Grasses	
	Warm-Season Grasses	Cool-Season Grasses
Erosion Control and Water Quality	Provide long-term benefits for erosion control and sediment trapping. Produce more overall biomass for nutrient uptake than cool-season grasses. Provide nutrient uptake during the summer when cool-seasons are dormant.	Provide short-term and long-term benefits for erosion control and sediment trapping. Provide nutrient uptake earlier in the spring and later in the fall than warm-season grasses.
Wildlife Habitat	Provide excellent nesting and feeding habitat. Bunch grasses provide openings for feeding, while maintaining overhead protection from predators. Stiff-stemmed grasses are more likely to remain standing for good winter protection. Plantings are more likely to remain diverse, supporting a balanced mix of plant species and insect populations.	Due to earlier "green-up," they provide a better source of food (green foliage and insects) in early spring than warm-season grasses. Tend to mat down more quickly than most warm season grasses as they age. This degrades the quality for nesting, feeding, and overhead protection. May harbor more agricultural insect pests in the summer, especially if plant diversity has declined.
Establishment	Usually need a specialized seed drill to plant these grasses. Seed may be more expensive	Plant with a conventional grass drill or cultipacker-seeder. Can sometimes be planted with a grain drill.

	and less readily available than cool-season grasses. Usually do not need much lime or any fertilizer. Tolerate poor soil conditions (i.e., nutrient-poor and/or low pH) better than cool-season grasses. Seeds are slow to germinate. Seedlings usually need 2 to 3 years to establish. Weed competition is often a problem during establishment, especially on the better soils. Seedlings and established stands are very drought tolerant. Good for sites with low moisture-holding capacity (e.g., sand hills, rocky slopes).	Relatively inexpensive, readily available seeds. Have higher nutrient requirements than warm season grasses. Less tolerant of poor soil conditions. Seeds germinate fairly quickly. Seedlings are usually well-established 1 to 2 years after planting. Rapid seedling growth results in less weed competition during establishment. Higher seedling mortality and thinning of established stands on dry sites or during drought periods, unless supplemental water is applied.
Maintenance	Maintained by using prescribed burning or light strip disking on a 3 to 4-year rotation. Grasses are long-lived and usually do not need reseeding. Can be hayed or grazed with careful management. Selective herbicides may be used for weed control	Maintained by mowing on a 2 to 3-year rotation, and by overseeding with legumes every 3 to 4 yrs. As stands mature, grasses may thin out and need to be reseeded. Can be hayed or grazed with careful management. Selective herbicides may be used for weed control.
Other Issues	Most species grow very tall (5 to 8 feet), and depending on where they are planted, can "block the view." This may be a benefit or a drawback, depending on what is nearby.	Tend to be low-growing (3 feet tall or less).

Geographic Considerations

Because of Pennsylvania's geographic location, lack of native grasslands, heavy agricultural, and livestock industry most birds use "grassland surrogate" sites dominant in cool season grasses such as Orchardgrass (*Dactylis glomerata*), Reed Canarygrass (*Phalaris arundinacea*), Bromegrasses (*Bromus spp.*), Fescues (*Festuca spp.*), and Timothy. Instead of their preferred perennial warm season grasses like Big Bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and Switchgrass (*Panicum virgatum*) (Dickerson et al., 1997; Norment, 2002). These species are preferred over the annual warm season grasses like Sorghum-Sudangrass (*Sorghum* × *drummondii*), or Pearl Millet (*Pennisetum glaucum*) because they do not need yearly planting. Warm season legumes such as Trefoils (*Lotus spp.*) should also be prioritized over cool season legumes like Clovers (*Trifolium spp.*) and Alfalfas (*Medicago spp.*) for nitrogen fixation. Plus, cereal crops like Canadian Wild Rye (*Elymus canadensis*) are especially beneficial in retaining soil moisture, reducing erosion, and providing cover and forage for birds (*Canada Wild Rye*, 2021). Warm season grasses are best adapted to sites with deep, moist, fertile soils, but will grow well in droughty sites (Dickerson et al., 1997). Furthermore, elevation, soil type, and aspect can affect a grass species establishment. For instance, big bluestem does best at lower elevations in silt or sandy loam and on a south facing slope (*Big Bluestem*, 2016). Whereas cool season Perennial Ryegrass (*Lolium perenne*) prefers lower elevations in clay loam on northern slopes (*Perennial Ryegrass*, 2008). Pennsylvania's geography favors cool season grasses making the establishment of mixed warm and cool season grasslands one of the hardest land management activities.

Warm season grasses perform best in temperatures warmer than the best temperatures for cool season grasses (*Warm-Season Grasses and Wildlife*, 2007). This creates significant challenges in the establishment year and the following spring with competition between the two grass types. The three primary concerns are the climate, microclimates of grasslands, and climate-soil interactions. Specifically, the length of the growing season, the warmth received by the plant in the growing season, and frost heaving during the fall and spring (Dickerson et al., 1997). The length of the growing season and amount of heat a plant receives can affect a plant's growing degree days, the number of days that exceeds a specific plant's minimum temperature requirements (Patton, 2021). Either factor can limit seed germination and seedling growth with different species requiring different amounts of each. It is estimated that warm season grasses need a minimum 140 growing degree days for success. However, successful planting can be accomplished within 100 days in well drained fertile soils (Dickerson et al., 1997; *Seed and Seedling Biology*, 2012).

In the Northeast, the introduced dominant cool season grasses, though abundant, have low adaptability to the poor soil quality allowing warm season grasses like indiangrass, bluestems

(*Andropogon spp.*), and Deertongue (*Dichanthelium clandestinum*) to flourish (Gherbin et al., 2007). Additionally, sites in the Northeast are prone to frost heaving, occurring after planting, commonly in the spring, when marginally developed plants are ripped out of the ground by the ice crystals that alternately form and thaw along the roots. To counter this problem, it is best to plant a large enough quantity of grasses that the effects of heaving are minimized. As a rule of thumb, plants with 10 or more stems are much less vulnerable than those with fewer stems (Biswell & Schultz, 1953; Dickerson et al., 1997).

Summer Slump

Using a blend of warm and cool season grasses in Pennsylvania is ideal because it provides continuous cover and forage crops of grassland birds and avoids the "summer slump" (Fig. 1) that many perennial cool season grasslands suffer (*Extending the Grazing Season with Plant Diversity*, 2019). A phenomenon first recognized by farmers, when temperatures exceed 80^{o}F there is a severe decline in cool season grass growth that forces a farmer to harvest early or purchase feed to supplement insufficient forage material (*No-Till Annuals to Beat the Summer Slump on a Dairy Farm*, 2018). By integrating warm season grasses into cool season fields, it helps avoid this phenomenon (Fig. 2). The same logic applies when managing grasslands for bird diversity, the inclusion of perennial warm season grasses help avoids the cool season grass "summer slump" by providing continuous forage and nesting material throughout the summer.

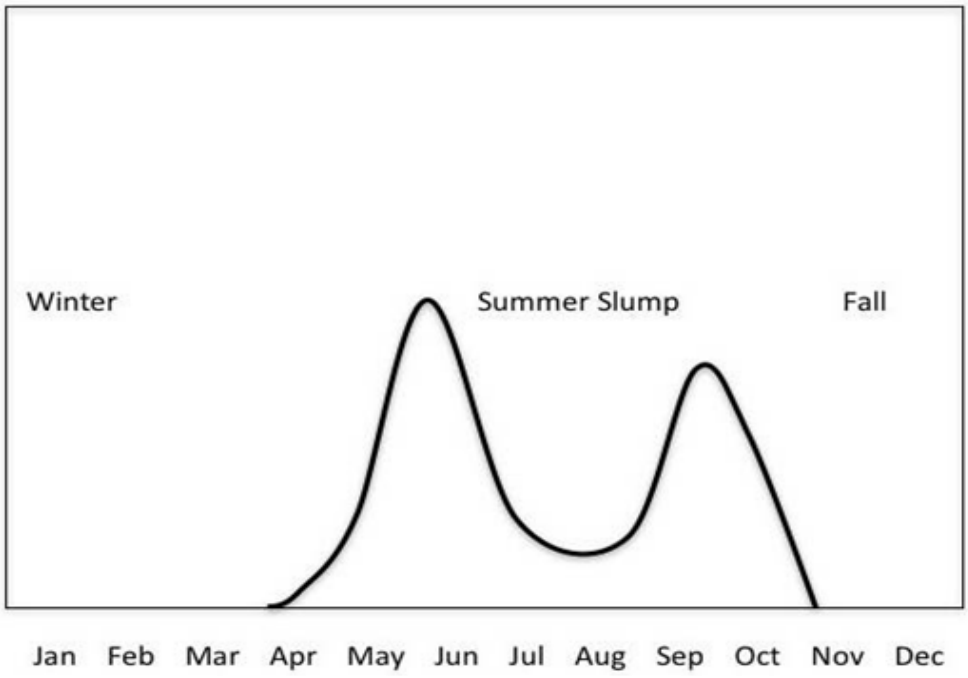


Figure 1: Cool-season grass productivity often peaks first in mid-May and then later in September. Because of grazing and mowing grasses pastures and fields often lose their productivity in mid-Summer leading to foraging stress.

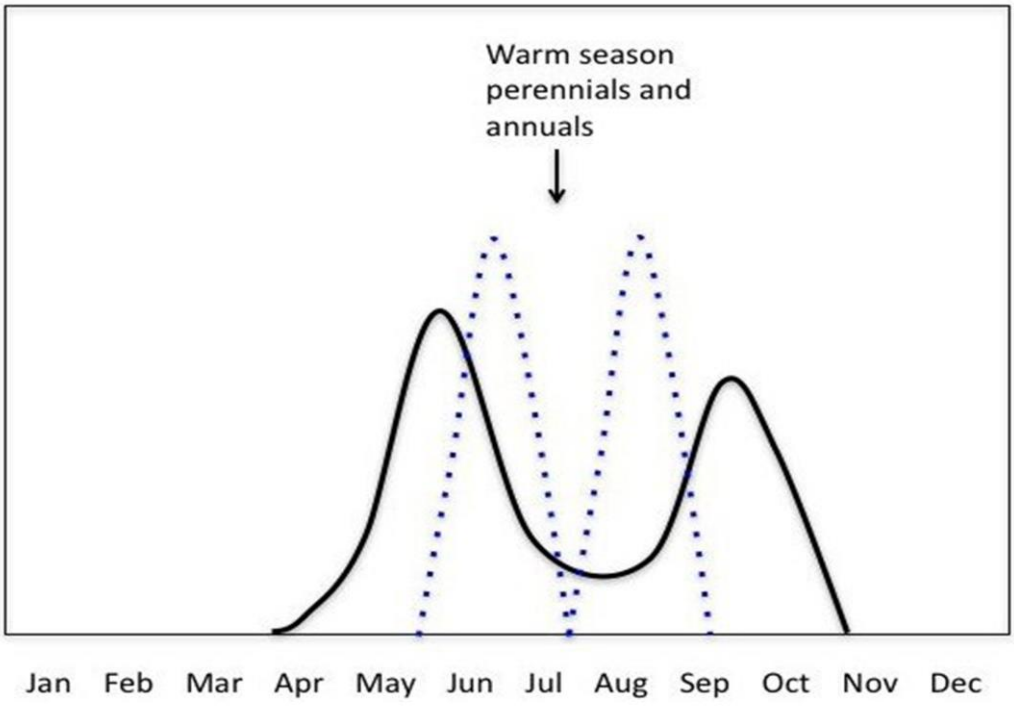


Figure 2: The inclusion of warm season annual and perennial grasses can help alleviate the summer "slump" and provide continuous forage material for wildlife. Unfortunately, there will still be a period in late July where the productivity of the warm season grasses decline.

Grasses for Sparks Farm

Survey's from Sparks Farm indicate there is approximately 85 acres of potential grassland habitat. Sparks Farm's previous land-use history consisted of a robust dairy farm operation from the late 1970s - 1990s (Robert Yelonosky, pers. comm. 2021) when Juniata College acquired the property. Since the College's acquisition the old pastures have been used for hay production with no other management than the annual cutting of the field in the late summer. The current composition of the fields is dominant in the cool-season Timothy grass (*Phleum pratense*), a common grass species found in northeast pastures (*Warm-Season Grasses and Wildlife*, 2007). We recommended a mixture of warm-season and cool-season grasses and legumes (for nitrogen fixation) be introduced into the fields.

General Grassland Bird Requirements

While all grassland birds have different nesting and foraging requirements generalizations can be made. Fortunately, many bird species do not need native vegetation to accomplish breeding (Latham & Thorne, 2007) with the decline of native grasslands, agricultural landscapes, pastures, and crop fields now serve as "grassland surrogates" sites. But agricultural practices of harvesting and mowing these sites leaves a high likelihood of destroying nests and killing adults (Bollinger & Gavin, 2004). Although these impacts are unavoidable, they can be minimized during field operations. Additionally, some species are area sensitive, requiring large blocks of unbroken continuous grassland habitat (Brennan & Kuvlesky, 2005; Latham & Thorne, 2007). Some species prefer woody vegetation scattered throughout an area (Cody, 1981) where others may prefer to be adjacent to wetlands or riparian zones (Murkin et al., 1997). Estimates for the minimum size of a grassland will vary with bird species, one trend is clear, large contiguous grasslands provide the greatest potential. The interspersion of various types of grass species and herbaceous plants can help maximize habitat quality (Askins et al., 2007). Before any grassland manipulation occurs the requirements for individual species must be understood.

SPECIES OF INTEREST

Meadowlark (*Sturnella magna*)

Appearance: The eastern meadowlark is a medium size bird, with dense black and brown mottling on its body, with a large, vibrant patch of yellow on its breast and belly, with a pronounced, dark black V-shaped bib. It is a prominent, well known grassland nesting bird, and its range extends from southern Canada to the northern areas of South America, and most of the eastern continental U.S. This species breeding season is quite large, spanning from late March to August (Lanyon, 1956). The female can produce up to two clutches in a season and incubates

eggs for 12-16 days. The hatchlings fledge in an additional 10-12 days afterwards. These birds are short distance and resident migrators, spending their winters in the Southern states.

Threats: A pressing threat to the eastern meadowlark is brood parasitism by native brown-headed cowbirds. Females have been reported abandoning nests that have fallen victim to parasitism. Habitat fragmentation is another harmful factor only further harms the species and presents greater opportunities for the opportunistic cowbirds to invade (Hull, 2000). The biggest threat to this species is loss of habitat, as prairielands that once hosted eastern meadowlarks are on the decline. Pastures under the management of family farms with varying vegetation are being replaced with large farming operations and monolithic crop rotations. Early and intense grazing, mowing equipment, and the use of pesticides can negatively affect the populations as well. The most beneficial solution can be attributed to the creation of suitable habitat that is devoid of these threats (Jaster et al., 2020).

Management Implications: Keys to management for the eastern meadowlark are providing large areas of contiguous grassland of intermediate height with significant grass cover and moderate forb density. Eastern Meadowlarks prefer moderately tall grasslands with abundant litter cover, high proportion of grass, moderate to high forb density, and low coverage of woody vegetation (Hull, 2000). They have been reported utilizing fields developed under the CRP management programs, pastures, haylands, and reclaimed surface mines. They are generalists in terms of grassland types but generally remain absent from woody and shrubland. Meadowlarks require larger tracts of grassland to establish territories used for display, breeding, and rearing of young, and prefer not to nest in small grassland areas. One study in Wisconsin suggested an average of 2.3-3.8 ha of land required per territory (Wiens, 1969). Area required to host Eastern Meadowlarks was estimated to be of at least 5ha or about 12 acres (Herkert, 1991). With this information Sparks farm at about 40 acres of area to be dedicated to grasslands could benefit and support a population of eastern meadowlarks.

Grasshopper Sparrow (*Ammodramus savannarum*)

Appearance: The grasshopper sparrow is a small sparrow with a length of 4.3-4.5 in (10.8-11.5 cm) and a wingspan of 7.9 in (20 cm), weighing in around 0.5-0.7 oz (14-20 g) (Vickery, 2020). In profile, the grasshopper sparrow is rather flat headed and short tailed. Their plumage is lightly marked and buffy tan in color, with clean, unstreaked underparts that contrasts with the brown, grey, and orange colors of their wings and backs (Vickery, 2020). They are typically found close to the ground, but during breeding season the males will perch at the top of grasses or on fences to sing (Vickery, 2020). The breeding season in Pennsylvania starts late April around 90 days (Gyekis et al., 2019; Vickery, 2020). Grasshopper sparrows lay about 4-5 eggs at a time (Kaufman, 2014b). Incubation lasts 11-12 days and young leave the nest around 9 days after hatching, before they are able to fly well (Kaufman, 2014b).

Requirements: Grasshopper sparrows are a grassland associated species. They are found in grasslands, hayfields, prairies, and lightly grazed open pastures (Kaufman, 2014b). Suitable habitat is dry, with fairly tall grasses, weeds, and occasional shrubs (Kaufman, 2014b). Nests are placed on the ground at the base of thick grasses, weeds, or shrubs, often in a slight depression so that the rim of the nest is level with the ground (Kaufman, 2014b). Surrounding vegetation is often woven into the cup nest for extra cover (Kaufman, 2014b). Their diet consists primarily of insects and seeds. Insects are fed upon in the summer and include grasshoppers, beetles, caterpillars, ants. Other invertebrates consumed consist of spiders, snails, centipedes, and earthworms. Seeds are more often consumed during the winter months, consist mainly of grasses and waste grain (Kaufman, 2014b). Foraging is a solitary behavior that occurs on the ground within grasses of suitable height.

Threats: The grasshopper sparrow faces habitat loss, degradation, and fragmentation due to intensive agriculture practices and urbanization (Kaufman, 2014b; Vickery, 2020). Changes in climate have also introduced spring heat waves that threaten nestlings and drought that destroys their food and water sources and leaves their habitat vulnerable to wildfires (Kaufman, 2014b). Between 1966 and 2015, the species has seen a steep 72% decline in population (Vickery, 2020). They are currently classed as a species of Least Concern by the IUCN Red List (BirdLife International, 2018).

Management Implications: Maintaining open grasslands is essential for the grasshopper sparrow. This can be done in a variety of ways, including controlled burns every 4-5 years, limited grazing, and mowing schedules (*Making a Good Home for Grasshopper Sparrows*, 2015). These procedures should be done outside the months of late April through early August as to prevent nest destruction and hatchling mortality. To ensure that the open grassland is suitable for grasshopper sparrow use, native bunch grasses along with scattered forbes and shrubs should be planted, and thatch buildup should be minimized (*Making a Good Home for Grasshopper Sparrows*, 2015). Ground disturbance should also be avoided to discourage the growth of non-native weeds (*Making a Good Home for Grasshopper Sparrows*, 2015).

Bobolink (*Dolichonyx oryzivorus*)

Appearance: The bobolink is a small neotropical migrant with a length of 5.9-8.3 in (15-21 cm) and a wingspan of 10.6 in (27 cm), weighing in around 1.0-2.0 oz (29-56 g) (Renfrew et al., 2020). In profile they have flat heads, short tails, and a sharply pointed bill (Renfrew et al., 2020). Breeding males have colorful plumage that is mostly black with a white back and rump and a rich buffy nape (Renfrew et al., 2020). Females and non-breeding males have warm buffy brown plumage that is streaked with dark brown on the back and flanks, and bold brown stripes on the crown (Renfrew et al., 2020). Usually, bobolinks stay hidden in tall grasses, but during mating season the males perform display flights and song over nesting territory (Renfrew et al., 2020). Bobolinks once a year lay around 5-6 eggs at a time that are grey to reddish brown and

heavily blotched with brown and lavender (Kaufman, 2014a). Incubation lasts 11-13 days and the young leave the nest 8-13 days after hatching, generally before they are able to fly (Kaufman, 2014a).

Requirements: Bobolinks are a grassland associated species. They are found in hayfields, meadows, and freshwater marshes (Kaufman, 2014a). Suitable habitat is damp with fairly tall grasses, dense weeds, and scattered low bushes (Kaufman, 2014a). Nests are placed on usually damp soil at the base of dense grasses, weeds, or larger non woody plants (Kaufman, 2014a; Renfrew et al., 2020). The nest is open and woven of course grasses and stems and lined with fine grasses (Kaufman, 2014a). Their diet consists of insects and seeds. They feed primarily on insects in the summer such as beetles, caterpillars, wasps, ants, and other invertebrates such as spiders and millipedes (Kaufman, 2014a). During winter they feed heavily on the seeds of weeds and grasses, and grain (Kaufman, 2014a). Foraging occurs on the ground and within the grasses and weeds (Kaufman, 2014a).

Threats: The bobolink faces habitat loss, degradation, and fragmentation due to land use changes, in addition to extermination as an agricultural pest, hunting as a food source, poaching for the pet trade, and hatchling mortality during crop harvest (Renfrew). Climate change also threatens to change the location of and restrict the size of their breeding grounds, and creates greater weather risks during migration (Kaufman, 2014a). Between 1966 and 2015, the bobolink suffered a 65% decrease in population (Renfrew et al., 2020). They are currently classed as a species of Least Concern by the IUCN Red List (BirdLife International, 2016).

Management Implications: Maintaining grasslands is essential for the bobolink. This can be done in a variety of ways, including controlled burns and carefully timed mowing schedules. These procedures should be done outside the bobolink's breeding season to allow nestlings enough time to fledge. It is also recommended to keep cattle out of bobolink territory during this time to prevent hatchling and nest mortality (Kaufman, 2014a). To ensure that the open grassland is suitable for bobolink use, warm season grasses should be planted and allowed to grow tall, and thatch should be retained (Hall, 2021).

Dickcissels (*Spiza americana*)

Appearance: Dickcissels are a small bird of about six inches with a wingspan of nine to eleven inches. Males are characterized by its greyish body, chestnut-colored wings, a vibrant yellow chest, black bib, and yellow streak above the eye (*Dickcissel*, 2014). Females are generally duller and most closely resembles a house sparrow, with the exception that the females are bulkier and may present a dull yellow eye streak. The dickcissel is an obligate grassland species and can be found nesting in the summer as far north as Saskatchewan and as far south as Texas (*Dickcissel*, 2014). This species is a neotropical migrant and will spend winters in the southern hemisphere, a majority of its population residing in Central Venezuela. Dickcissels return to northern breeding

grounds around April to early May. Eggs are generally laid in clutches of four and incubated for 12 days. Offspring usually fledge and leave the nest in just about a week (*Dickcissel*, 2014).

Threats: The bird is currently under threat from a few different sources of pressure. Dickcissel nests are often parasitized by native brown headed cowbirds. They are nomadic nesters that often don't return to the same nesting grounds consecutive years in a row, this may help deter parasitism due to the erratic patterning of their nesting (*Dickcissel*, 2014). Dickcissels are nocturnal migrators and do so in flocks, this makes them particularly vulnerable during this time of population convergence. The most impactful threat to this species is ongoing development, loss of crucial grassland habitat, and the lack of large disturbance events that created grassland biomes in the past (*Dickcissel*, 2014).

Management Implications: This bird species inhabits large grassy fields and has been recorded to take advantage of reclaimed strip mines and hay fields (*Dickcissel*, 2014). They show fondness of alfalfa fields during the beginning and end of their breeding season. A study in Northern Kansas concluded that Dickcissel abundance was significantly associated with field-level vegetation characteristics, though nesting success was positively correlated with the food sources found in ground cover (Hughes et al., 1999). The species actively seek out fields surrounded by woody vegetation (Zimmerman, 1966). These woody edge habitats are important for this species to provide perches for song projection and extra vertical cover. Management practices should consider field vegetation composition, ground cover, and woody edges when selecting habitat to benefit Dickcissels (Hughes et al., 1999). Efforts to identify and monitor annual nesting sites can aid in the conservation of this species and uses of federal grants such as the Department of Environmental Protection's Conservation Reservation Program (CRP) can be utilized to provide helpful habitat to this bird. Fortunately, this species does not seem to be sensitive to field sizes and has been found nesting in small patches of appropriate habitat (*Dickcissel*, 2014). Making this bird a perfect candidate for management at Sparks Farm.

MANAGEMENT OBJECTIVES

Implementation 1: Integration of Warm Season Grasses

Planting Techniques/Considerations

Because it is recommended that warm season grasses be planted in early spring at roughly the same time as cool season grasses (Dickerson et al., 1997) it leads to problems of competition between the two types of grasses (*Comparing Warm-Season and Cool-Season Grasses*, 2004). In the northeast where cool season grasses and weedy vegetation is dominant, careful maintenance of the grassland is needed. For planting at Sparks Farm a flowchart has been created to aid in planting (Fig. 3) Special attention should be used when adding nitrogen fertilizers with grasslands only to be applied to the mid-summer in grasslands of very low fertility and low

populations of weeds or cool season grasses (Dickerson et al., 1997). A secondary application of nitrogen is most desirable in the second growing season of a grassland. If any fertilizer is applied in the first year it should contain high levels of phosphorus to stimulate root development (Latham & Thorne, 2007). Sparks Farm because of the dominant Timothy grass should not receive any fertilizer in its first year and only receive the soil enhancements in the second growing season. Stands of warm season grasses are slower to develop and the success of seeding is difficult to assess in the first year.

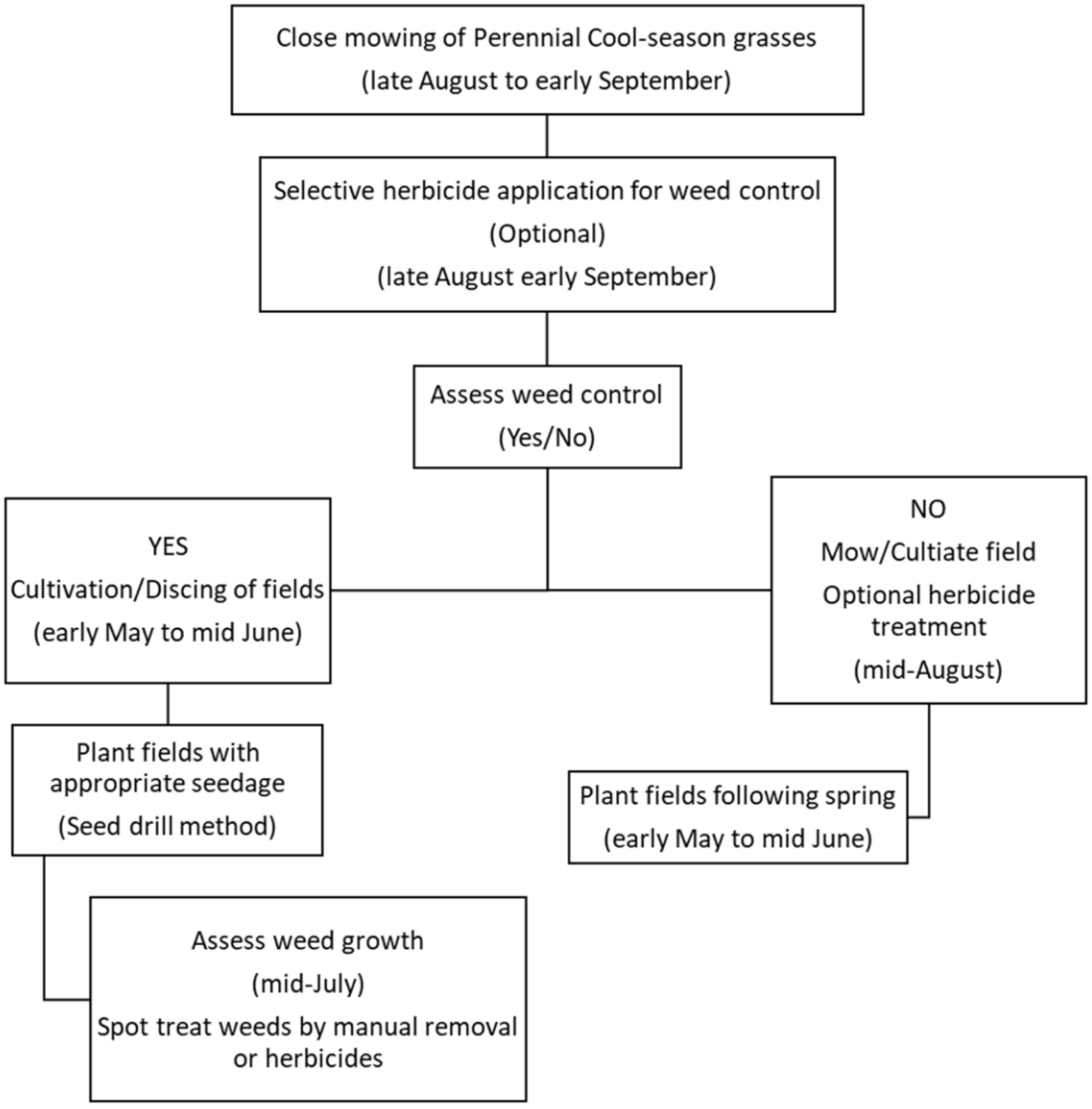


Figure 3. A flowchart of the planting year activities for Sparkes Farm

Seed Mixture

The seed mixture for planting at Sparks Farm should focus on providing adequate cover and food for grassland birds and maintaining soil health. Because of these dual objectives two proposed grass seed mixtures have been created. In proposal 1 (Table 2) the field would be dominant (60%) covered in perennial ryegrass followed by the big four warm season grasses, little bluestem (20%), big bluestem (10%), switchgrass (5%), and indiangrass (5%). The perennial warm grasses combined with the cool season grain provides immediate cover and acts as a companion crop. The ryegrass will mature quickly during the cool wet season and go dormant in the hot dry periods of summer, allowing the native warm season grasses to develop into long-term cover. Option 2 (Table 3) still prioritizes grassland birds but also focuses on maintaining soil health by integrating legumes into the mix. In this planting there will be an equal mix of white clover and perennial ryegrass (30%) followed by big bluestem and switchgrass (15% each), and then birdsfoot trefoil and partridge pea (5% each). The ryegrass provides the immediate forage material in early spring, the warm season grasses for cover and nesting, and the clover, trefoil, and pea to add nitrogen back into the soil. The nitrogen fixation processes of the legumes are invaluable because it reduces the need of nitrogen as fertilizer. Maintaining proper nitrogen levels are especially important in the field to ensure that the soil is not depleted by the continuous growth of the warm season grasses making the planting of legumes indispensable in the long-term management of Sparks Farm's grasslands.

Table 2. Option 1: Proposed Seed mixture for Sparks Farm with a focus on the Big Four warm-season grasses used for grassland bird cover, forage, and nesting and the estimated cost at a seed rate of 15 lbs./acre.

% Of Mix	# Acres	Species	Cost/lbs	Seed Rate Cost at 15 lbs./acre	Estimated Total
60%	51	Perennial Ryegrass (*Lolium perenne*)	$ 7.90	$118.50	$6,043.50
20%	17	Little Bluestem (*Schizachyrium scoparium*)	$ 22.00	$330.00	$5,610.00
10%	8.5	Big Bluestem (*Andropogon gerardii*)	$ 22.00	$330.00	$2,805.00
5%	4.25	Switchgrass (*Panicum virgatum*)	$ 19.00	$285.00	$1,211.25
5%	4.25	Indiangrass (*Sorghastrum nutans*)	$ 17.90	$268.50	$1,141.13
				Total	$16,810.88

Table 3. Option 2: Proposed Seed mixture for Sparks Farm with a focus on soil health and nesting/forage for grassland birds and the estimated cost at a seed rate of 15 lbs./acre.

% Of Mix	# Acres	Species	Cost/lbs.	Seed Rate Cost at 15 lbs./acre	Avg Cost for Sparkes
30%	25.5	White Clover (*Trifolium repens*)	$ 13.90	$208.50	$5,316.75
30%	25.5	Perennial Ryegrass (*Lolium perenne*)	$ 7.90	$118.50	$3,021.75
15%	12.75	Big Bluestem (*Andropogon gerardii*)	$ 22.00	$330.00	$4,207.50
15%	12.75	Switchgrass (*Panicum virgatum*)	$ 19.00	$285.00	$3,633.75
5%	4.25	Birdsfoot Trefoil (*Lotus corniculatus*)	$ 9.80	$147.00	$624.75
5%	4.25	Partridge Pea (*Chamaecrista fasciculata*)	$ 13.00	$195.00	$828.75
				Total	$17,633.25

Preplanting Preparations

Before planting of the warm season grasses the Sparks Farm field should be mowed to remove the dominant timothy grass and any other weeds present in the field. In cases like Sparks Farm where heavy growth of cool season grasses is prominent it can be difficult to establish warm season grasses without tilling or plowing necessitating constant supervision to ensure warm season grass establishment. Discing of the field to break up the top layer of soil and use of a seed drill to broadcast the seed mix should be used. Because Sparks Farm's sloping fields there is a high erosion risk if traditional plowing or tilling is used. The inclusion and careful application of herbicide treatments is often used to remove stubborn invasive plants and should not be discounted if used on a spot treatment basis.

Planting Year Activities

Seeding Date: All grasses at Sparks Farm should be seeded when the soil moisture and temperature are optimal for germination. For several warm season grass a temperature of 50^{o}F (10^{o}C) is needed before they will germinate (Vickery & Dunwiddie, 1997). The seeding time for Sparks Farm should occur between mid-spring and early summer (Table 4.), later planting may cause problems like frost heaving and seed loss due to wildlife. Dormant seeding of warm season grasses is not recommended because of early competition of weeds in the spring. The exact time of seeding is difficult to assess because of yearly variation in weather patterns with seeding dates extending three to four weeks past recommended times (Fay & Schultz, 2009).

Table 4. General dates when to start planting cool and warm-season grasses.

Cool-Season Grasses	Warm-Season Grasses
Spring (April-May)	Late Spring (mid May-late June)
Late Summer (July-August)	Late Summer is NOT recommended
Late fall as a dormant planting (end of October or later)	Late fall/dormant is NOT optimum

Seedbed: Proper seedbed moisture is essential, a simple rule for checking seedbed moisture is if the soil can be readily formed into a ball in the palm of the hand yet breaks easily when dropped. A firm seedbed is essential for proper seeding depth, too loose the seeds will be placed too deep for germination. Warm season grasses should be placed at ¼ to ½ inch depth in fine to medium textured soils (*Five Keys to Successful Grass Seeding*, 2010). Another rule of thumb for planting is the seed should be occasionally visible on the soil surface after seeding. Any attempt to plant deeper than 1 inch can significantly reduce their establishment. Seeds that require light will be hindered and seeds that require high nutrient levels will also be hindered. Weeds will be the largest challenge at Sparks Farm and at time of seeding the number of actively growing weeds should be minimized.

Seed Placement: Because a seed drill is being employed there is no need for cultipacking the field that would result from plowing or tilling. Careful alignment of the seed drill is necessary to ensure uniform dispersal and planting depth. Often different grass seeds are shaped differently, some are awned while others are sharply pointed; the use of specialized seed agitators should also be considered to remove any chaff for better dispersal.

Seed Quality & Rate: The seeding rates for native warm grasses usually vary from 10-15 pounds of Pure Live Seeds (PLS) per acre. Pure live seed is the measure used to describe the percentage of a quantity of seed that will germinate. The purity of a seed mix is a percentage of seed weight of the total viable seeds of a specific species and does not include inert seeds, weed seeds, chaff, and other crops seeds that may have been mixed in during packaging (*Pure Live Seed*, 2018). In the northeast the seeding rate should be 15-20 PLS per acre to account for the harsher weather and soil conditions (Dickerson et al., 1997). The PLS will vary with seed mix and can be found on the packaging information for each seed mix or grass species.

Post-Planting Weed Control

Chemical, mechanical, prescribed burnings, shredding, disking, and grazing are all practiced today to manage undesired invasive, woody, or weedy plant growth from reestablishing (Alldredge et al., 2013). We highly recommend adopting either a controlled burn cycle or

mechanical mowing schedule to maintain the Sparks grassland setting.

Prescribed Fire: Unlike wildfires, prescribed fires are controlled and follow a set guideline of management goals and desired outcomes. Utilizing the fire as a tool to suppress the growth of woody vegetation prevents the process of succession from occurring, repeatedly resetting the grasslands vegetation composition. The benefits of a burn can be expressed in many ways, stimulating germination of forbs and grasses in the seedbank, offering improved nutrient cycling, and removal of excessive litter and debris to provide more bare ground for wildlife (Alldredge et al., 2013). A burn cycle for Pennsylvania is recommended every 2-3 seasons and must be conducted during optimal weather conditions and before the arrival of nesting bird populations or after they have migrated south again. This means the preferred time to conduct a burn is during the months of March, April, or November (Alldredge et al., 2013). A burn must be completed following all of Pennsylvania's regulations and safety protocols. We recommend consulting a private firm or the Pennsylvania Game Commission to carry out safe and effective burns. Prescribed fires are more intensive, challenging to carry out and more costly than a mowing regime, though this method is more effective and desired in its management benefits. As Sparks is meant to be a property dedicated to the use of future and past Juniata students, a controlled fire may be considered as an educational opportunity for those students enrolled in a fire ecology course offered at Juniata.

Rotational Mowing: Rotational mowing can prevent the natural process of succession, reduce bird mortality, and help control for undesired weeds and pest plants from entering the fields (Alldredge et al., 2013). A mowing schedule for weed management should follow the outlined mowing practices described in the below rotational cutting section. This method is more cost effective than prescribed burns and is most recommended for the Sparks farm property due to its small size and the presence of mowing equipment already belonging to the property owner.

Implementation 2: Soil Enhancement

The soil in the fields at Sparks Farm is composed of four different soil series: Birdsboro, Calvin-Channery, Albrights, and Allegheny, as defined by (Knight, 1998) each with their own unique characteristics. In general the soil is a silt loam with an intermixed clay layer and differing runoff, permeability, water capacity, and erosion characteristics based on the specific location in the field. For instance, the lowermost fields, near the river, the soil is well-drained, with high permeability and water storage capacity, and low runoff potential. The uppermost fields, near the memorial garden, have moderate permeability and water capacity with little risk of erosion. Whereas, the sections of the field on the slopes have high runoff and erosion potential, and low permeability and water capacity. Regardless of the soil series, all the soil at Sparks Farm is highly capable of supporting cultivated crops and pastureland. These types of soils are all receptive to a variety of planting practices.

In the determination of which warm season grasses would grow best in the soil present at Sparks Farm a simple soil analysis was conducted by the Agricultural Analytical Service Laboratory at the Pennsylvania State University to determine pH, phosphorus (ppm), Potassium (ppm), Magnesium (ppm), and other soil recommendations. The average pH of Sparks Farm soil is 5.96, phosphorus 18.71 ppm, potassium 72.00 ppm, and magnesium 84.57 ppm. Overall, the result revealed the soil at Sparks Farm was below optimum levels for warm season grasses and soil enhancements of lime, phosphorus, and potassium should occur at the time of planting. The inclusion of any nitrogen based fertilizer should only be added after the first growing year to help control weed growth. From the results a target pH of 7 should be set for approximately 36 lbs. /acres of lime (calcium carbonate) be added to the soil to supply the necessary calcium and magnesium levels. The nitrogen levels of the soil also need frequent replenishment which can be achieved by the addition of native legumes such as clovers and trefoils into the field.

Implementation 3: Rotational Cutting

One of the unique challenges of managing grasslands is combating the effects of succession. If there are not occasional disturbances to grassland, often in the form of mowing, cultivating, or burning the grassland will be replaced by woody vegetation and woodland bird species. The current mowing schedule of Sparks Farm occurs during the bird's primary nesting season for hay production and the entire grassland is cut. To maximize the benefit to birds and reduce mortality by mowing, cutting should be done between August 20th and mid-September. The fields at Sparks farm should be divided into 3 units (Fig. 4), with one unit mowed each year. Mowing after August 20th prevents the disruption of grassland bird nests and allows the immature young time to leave the fields. If grasses are mowed in June and July there is a high chance of destroying nests and killing immature birds. Mowing in mid-September removes woody vegetation and releases nutrients in the soil before they can be stored in the roots. Mowing one third of the field and rotating which third allows the unmowed units to produce seeds, control invasive plants, and release built of nutrients into the soil. Native warm season grasses should be cut at a minimum height of 10 inches and allow regrowth of 10-12 inches before the first killing frost. Mowing below this height may kill the plant because grass species store most of their energy reserves at their bases. Additionally, mowing should begin in the center of the field and move outwards to allow animals to escape the field as opposed to mowing from the outside-in. Rotational mowing of only one-third of Sparks Farm a year will provide the best chance to reduce bird mortality and allow the establishment of warm season grasses.

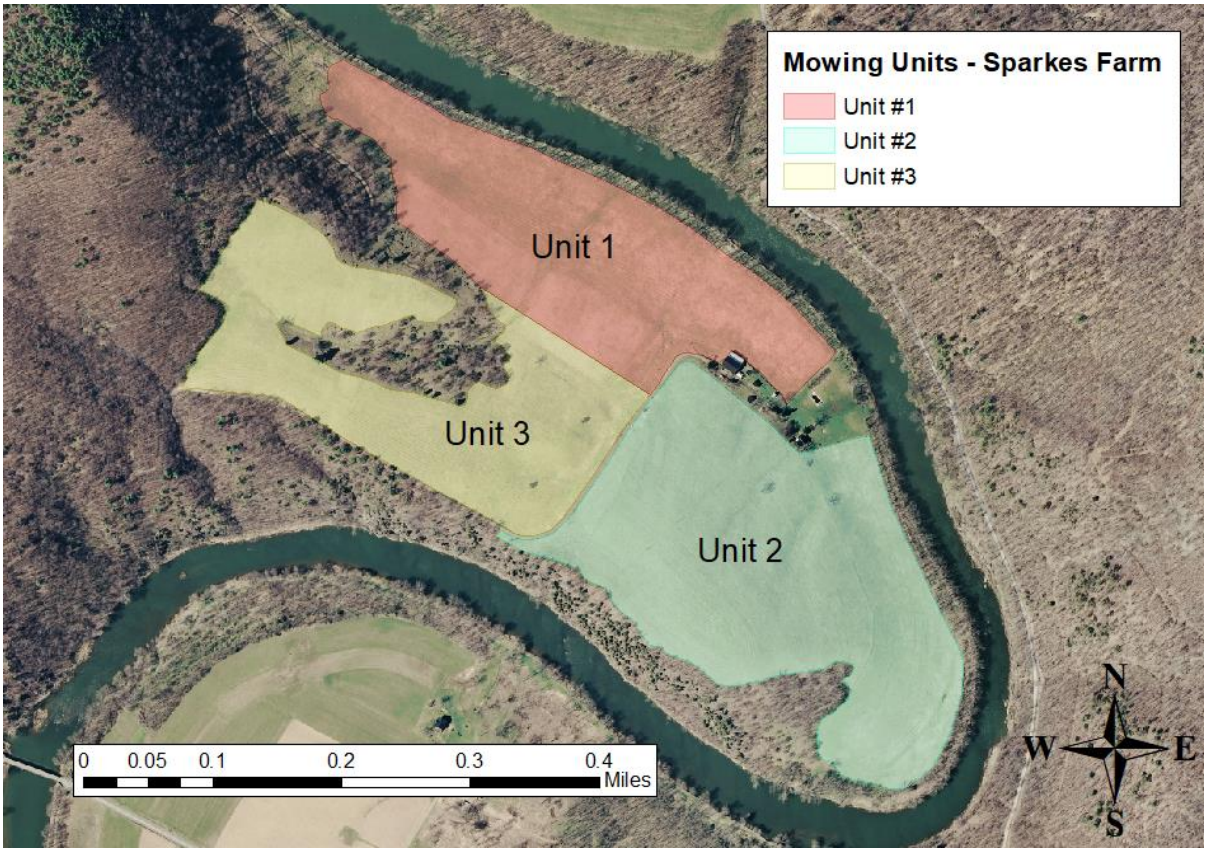


Figure 4: The proposed rotational mowing units for Sparks Farm with each unit mowed once every three years.

POST MONITORING

Management plan success will be monitored and measured through a combination of scientific surveys and naturalistic observations. The success of the plan will be determined by the presence of both the vegetation planted and the birds observed in the field.

To assess the success of the warm season grasses, we recommend randomly sampling the fields for their presence and abundance during the summer of the second year after their planting to allow for the proper establishment time (*Establishing Native Grasses*, 2011). This will be achieved by generating the sample locations through a random number generator, then sampling those locations in the field and counting the desired vegetation species. If the target species are present in a sufficient amount, then the plantings can be ruled as a success.

To assess for the target bird species, a combination of acoustical monitoring and visual observations will be implemented. The acoustical equipment and surveying will consist of setting up Song Meter SM4 bioacoustics recorders (Wildlife Acoustics, Maynard, MA) throughout the fields and actively recording bird songs from 5:00 - 8:00 a.m. when birds are most active. Recordings will then be classified, grouped, and manually identified using

Kaleidoscope Pro 5 (Version 5.4.6., Wildlife Acoustics, Maynard, MA). A species will be considered present and actively using Sparks Farm fields if its recording is present for seven continuous days during between May and July, most birds breeding season. Visitors will be encouraged to report their sigiting to the land manager and/or add entries to citizen science platforms such as eBird and iNaturalist. If the target species are determined to be present and are utilizing the managed grassland habitat for nesting and or migration purposes once the warm season grasses are established, then the management for these species can be ruled as a success.

Wetland Bird Management Plant

INTRODUCTION

Why Wetlands Are Important

Wetlands operate as a natural sponge that traps and slowly releases surface water, rain, snowmelt, groundwater, and floodwater (US EPA, 2015). The holding capacity of wetlands helps control floods and prevents water logging of surrounding crops and grasslands. Similarly to water control, the wetland helps prevent erosion and will create a sturdy holding area for a source of water. Not only do wetlands hold and control water levels, they are great carbon sinks, holding up to 30% of land carbon (US EPA, 2015). This helps with the carbon emissions and pollutants that the world is dealing with on a global scale today. Since the wetlands act as a natural buffer and barrier, they can trap the pollutants that travel through, holding them and eventually breaking them down, such as bad algae and bacteria. This process would aid in the filtration of the Juniata River that is nearby, helping promote the overall water quality. Overall, the production of a wetland can provide a variety of benefits to the ecosystem around it, and the biodiversity that inhabits it.

Wetlands provide a source of habitat for not only local, but migrating species of animals, (particularly birds). Wetlands are homes, or habitats for a wide variety of plants, insects, amphibians, reptiles, mammals, and in our case specifically, birds. Since wetlands are one of the most productive ecosystems in the world, they form a refuge for almost every trophic level, which is necessary for the survival of the different diversities (*Why Are Wetlands Important?*, n.d.). As far as migration, a wetland is a great roosting and feeding spot for traveling birds, such as waterfowl, songbirds, etc. For migratory species, due to the impacts of climate change, they are specifically vulnerable at the time of migration. With this being said, a wetland provides a source of refuge in a time of mating, egg-laying, nesting, etc. More than one-third of the United States' threatened and endangered species live only in wetlands, and nearly half use wetlands at some point in their lives (*Why Are Wetlands Important?*, n.d.). Therefore, the creation of wetland

at Sparks Farm would not only create an aesthetic view, but a large ecological refuge for a variety of wildlife species.

SPECIES OF INTEREST

Wood Duck *(Aix sponsa)*

About - Wood ducks are a small to medium sized bird native to the United States. Adult wood ducks average about 19 inches in length with a wingspan of about 28-38 inches. Due to its vibrant color schemes, this species is considered one of the most beautiful and recognizable birds in the United States. The males (drake), have red eyes and red bills with a yellow patch base. The head and crest of the duck appears iridescent purplish-green with white stripes across the cheek. The sides of drake wood ducks are yellow with black and white stripes and the wings are brown with blue markings. The female wood duck (hen) has a greyish-brown head and body with blue markings on the wing. The hen wood duck also has a crest on the head with a white ring around the eyes and white feather patches around the chin and back of the head. The belly of both female and male wood ducks is white (*Wood Duck | National Wildlife Federation*, n.d.). This species can be found inhabiting inland swamps, slow-moving creeks and rivers, marshes, ponds, and wetlands. Typically favor open marshes within generally forested regions and areas containing overhanging tree limbs and shrubs which provide cover, food, and protection. Generally surface feeders, submerging head and neck for food within reach under the surface, occasionally up-ending or butt-up feeding for resources further under the water's surface. Wood ducks are rarely seen feeding on land. Their diet at a young age consists of small fish, invertebrates, crustaceans, and various insects. As they age, their diet expands to more plant-based material like fallen seeds from trees and shrubs, and aquatic plants and their seeds. Acorns serve as a large portion of the adult wood duck's diet (*Wood Duck | Audubon Field Guide*, n.d.). Wood ducks pair up in late winter and begin to breed in early spring. Breeding pairs that choose natural nesting sites favor cavities in trees 10'-65' above ground or water. Sites can be directly over the water's surface, or up to a half-mile away from the water's edge. Legal protection and provision of nesting boxes increase reproductive success. Placement of nesting boxes may be lower than natural sites and do best over open water to decrease the rate of nest predation. Nests may contain anywhere from 6 – 40 eggs in a clutch.

Status and Threats – Wood duck populations suffered in the late 19th and early 20th century, extinction for this species seemed imminent. Causes of decline consist of habitat loss, deforestation, and hunting pressure. Northern bottom-land timber harvesting caused a multitude of problems for the species for these regions served as their winter breeding, nesting, and feeding grounds. Loss of cavity bearing trees that provide nesting sites and loss of hardwood/mast bearing trees that provided food majorly attributed to the decline in population. Hunting pressure prior to 1918 was thought to be one of the largest contributing factors to the start of the decline.

In the 19th century, wood ducks were the most popular species of waterfowl to hunt due to their wide-spread range and colors. The migratory bird treaty act prohibited the hunting of wood ducks nationwide and from this, biologists saw the first increase in numbers. Hunting seasons were reopened in 1941 once populations were seen as stable. The destruction of wetland and marsh habitats are still a pressing threat to this species today, for they serve as great habitat for resident populations and stops for migratory populations. Wood duck populations are no longer threatened, and are becoming increasingly healthy due to hunting laws and restrictions, as well as conservation strategies (*Status of the Wood Duck*, n.d.).

Mallard Duck *(Anas platyrhynchos)*

About – The mallard is a relatively medium-large sized duck, averaging 20-25 inches in length and about 33–39-inch wingspan for adults. Male (drake) mallards have a mostly brown body and chest with a black and white rear. The dark green and purple iridescent head matched with a bright yellow bill and white neck band makes this duck easily recognizable. Females on the other hand have rather drab colored bodies and heads, mostly brown with patches of black. The bill of the female is a dull orange color with scattered black patches. The wings and feet of both female and male mallards are similar, brown with iridescent blue easily seen in flight and the feet are bright orangish-red (*Mallard Identification, All About Birds, Cornell Lab of Ornithology*, n.d.). This species can be found inhabiting marshes, ponds, swamps, rivers, creeks, and wetlands. May also be found in any type of aquatic area or habitat. Mallards typically favor more shallow water with high amounts of aquatic vegetation. This species is considered "dabbling" or "puddle" ducks due to, feeding on the water's surface, submerging head and neck, up-ending or butt-up feeding for resources below the water's surface. Occasionally mallards will feed on land around the edges of water or in grain fields. Their diet mostly consists of plant material including seeds, stems, roots, shoots, from a variety of plant species (grasses, sedges, smart weeds, pond weeds). Also feeds on insect species, small invertebrates and vertebrates, and crustaceans. Like most waterfowl species, mallard pairs form late fall and winter and begin breeding early spring. The female will choose her nesting site generally on the ground within dense vegetation or wood debris. Nesting locations are most commonly found within a few feet of the water's edge but can be up to a mile away from any water. Clutch sizes consist of 7-10 eggs but, sometimes can be found with 10-15 eggs (*Mallard | Audubon Field Guide*, n.d.).

Status and Threats – The mallard is considered to be the most abundant and plentiful duck species in North America. It serves as an indicator species in terms of habitat quantity and quality. Furthermore, the mallard population serves as an indicator for the health of waterfowl as a whole. This species is not threatened in terms of numbers and is considered stable throughout its current range despite being the most hunted species of waterfowl in the United States; however, certain populations are declining, have been permanently damaged, and or experience fluctuations quite regularly (Duck, n.d.). In the north-eastern part of the United States, mallard populations have been declining about 1% a year since the estimated 900,000 birds in 2017.

Threats contributing to the decline of this species have not fully been tested but have been hypothesized consisting of habitat loss, disease, hybridization, and winter food shortages. Millions of captive reared mallards were released in the 19th century to supplement wild populations. This, along with the natural habit of mallards and other species of ducks congregating in industrialized areas like city parks has spiked the spread of disease (Avian influenza). Hybridization presents a problem to the "old world mallard" due to farm raised and captive raised mallards breeding with wild individuals. The loss or degradation of breeding and non-breeding habitat either from drought or human imposed factors, is thought to be one of the largest contributing factors to the decline. In addition to this loss of resources, harsh winters have caused food shortages across the north-eastern flyways (*Understanding Waterfowl*, n.d.).

Belted Kingfisher *(Megaceryle alcyon)*

About – The belted kingfisher is a small sized bird with a large, crested head and bill relative to its size. The stocky body and wings of the bird are a bluish-grey color with a white belly and neck collar. Females of this species have a chestnut-colored belly band wrapping around to the flanks. Adult belted kingfishers average 11-14 inches in length including their square-tipped tail and a 19–23-inch wingspan (*Belted Kingfisher Identification, All About Birds, Cornell Lab of Ornithology*, n.d.). This species can be found inhabiting streams, rivers, lakes, estuaries, wetlands, and marshes across most of Alaska, Canada, and North America. Belted kingfishers typically favor habitat with clear water for optimal fishing. During breeding seasons, the species is limited to areas containing suitable dirt banks for nesting holes and bodies of water that don't freeze during winter months (*Belted Kingfisher*, 2014). The diet of this species mostly consists of small fish species, generally 4"-5" long. Also have been known to predate on tadpoles, frogs, crayfish, aquatic insects, lizards, and occasionally small mammals and birds (*Belted Kingfisher - Facts, Diet, Habitat & Pictures on Animalia.Bio*, n.d.). Typically breeding in late winter and early spring, the belted kingfisher requires steep, sanded or densely soiled banks along water's edge in order to create burrows for nesting. Two toes of the bird are fused together for easy digging. Generally the clutch size consists of 6-7 eggs (*Belted Kingfisher*, n.d.).

Status and Threats – The belted kingfisher is not threatened and considered to be a familiar and widespread bird across most of its range. Although, according to the North American Breeding Bird Survey, from 1966-2014 this species population experienced a 1.6% decline per year. (A cumulative decline of about 53%) Currently the hunting of this species has been banned by migratory bird laws but, in the past belted kingfishers were killed and trapped near trout streams, hatcheries, and various fisheries due to the diet of this bird. Biologists do not account for this to be the start of their decline; however, conservation for this species is not common for the same reasons (*Belted Kingfisher Life History, All About Birds, Cornell Lab of Ornithology*, n.d.). Other threats to this species include pollution from eating fish, loss of habitat and suitable nesting grounds. In addition, this species has a low tolerance for human disturbance but has also benefited from man made sand/gravel pits (*Belted Kingfisher*, n.d.).

MANAGEMENT OBJECTIVES

Implementation 1: Improvements for Species of Interest

Wood Duck – Keys to management for the Wood duck consist of providing habitat for the species including the creation of wetlands, marshes, or ponds. In addition to this, planting or managing hardwood/mast bearing trees in or around selected habitat provide sufficient nesting locations, and desired food resources. Another effective management strategy is the implementation of artificial nesting boxes. The young within the nest have high mortality rates due to nest predation and insufficient nesting locations. Nesting boxes are a great way to provide adequate nesting sites for breeding pairs and when built/placed correctly have been known to decrease nest predation thus, decrease mortality rates for the chicks (*Wood Duck | Audubon Field Guide*, n.d.).

Mallard Duck – Keys to management for the mallard consist of providing habitat for species including the creation of marshes, wetlands, and ponds. Furthermore, the practice of planting and managing for food resources within this habitat will aid mallards through harsh winters/migration and provide sufficient nutrients needed during reproduction (*Understanding Waterfowl*, n.d.). Like many other ground nesting bird species, nest predation adds to the mortality rate of young. There are a few management techniques to try and counter this. Among the many reasons regarding the importance of riparian buffers, it is paramount that the area around the water's edge is managed for dense vegetation providing adequate nesting locations for mallards and other ground nesting waterfowl species (*Riparian Buffers for Wildlife*, n.d.). Beyond this, the implementation of islands, peninsulas, and mallard tubes within selected habitats are effective in decreasing nest predation and therefore mortality rates of young chicks (*Waterfowl Research & Science*, n.d.).

Belted Kingfisher – Keys to management for the Belted kingfisher consists of creating habitat such as wetland/marshes and managing the banks of these or already existing water sources for suitable nesting locations. Steep, sanded or densely earthen banks are desirable for this species but not necessarily desirable for most landowners. Measures and management that improve or maintain high water quality will help mitigate the pollution levels in fish consumed by belted kingfishers. Other management strategies include the protection of nesting sites and minimizing human activity/disturbance around nesting locations (*Belted_kingfisher_conservation_summary_12-31-2014.Pdf*, n.d.).

Implementation 2: Plants and Trees

After looking into the ecology and plants of wetlands, we have decided that the following plants and tree species have high value to wetland bird species with everyone providing cover, food, a

buffer, and/or suitable nesting habitat. For food we are proposing common duckweed (*Lemna minor*) since it provides food for the waterfowl that will live within the wetland (*Algae & Duckweed: The Costs and Benefits | Brandywine Conservancy and Museum of Art*, n.d.).; bulltongue arrowhead (*Sagittaria lancifolia*) since it is a good food source for muskrats, waterfowl, micro/macro invertebrates and fish (*Bull Tongue Arrowhead - AquaPlant*, n.d.); hardstem bulrush *(Schoenoplectus acutus)* since the plans is eaten by small mammals and the seeds are eaten by waterfowl and passerines (*Illinois Native Plant Guide - Hardstem Bulrush - Pages 130-131 | NRCS Illinois*, n.d.); narrowleaf cattails *(Typha angustifolia)*; and manna grass (*Glyceria striata*) which are both sources of food for waterfowl (*Fowl Manna Grass*, n.d.)(Peterson, n.d.). For cover and nesting habitat manna grass and narrowleaf cattails both grow thickly within the wetland and will provide an excellent source of cover to hide from predators and have the ability to raise and protect young (*Fowl Manna Grass*, n.d.)(Peterson, n.d.). For providing a buffer we have chosen swamp white oak (*Quercus bicolor*), red-osier Dogwood (*Cornus sericea*), and Speckled Alder (*Alnus rugosa*) in the since these three plants will be able to provide food and cover to the animals that would use the buffer (Campbell, n.d.). Finally, we want to plant the turtlehead flower (*Chelone glabra*) since it thrives in wetlands and would be a good food source for pollinating species and is essential for the Baltimore Checkerspot Butterfly (*White Turtlehead | Chelone Glabra*, n.d.)

Plant Species	**Benefit of Plant**	**Price**
Turtlehead Flower (*Chelone glabra*)	Thrive in wetlands and provide a source of food for a variety of species, more importantly the Baltimore Checkerspot Butterfly.	$64 pre 1oz pack
Manna Grass (*Glyceria striata*)	Provide a source of cover and viable option for food consumption	$76.80 per ¼ lb bag of seed
Narrowleaf cattails *(Typha angustifolia)*	Provides cover and food for wetland dwelling species	$2.85 per pack of 150 seeds
Hardstem Bulrush *(Schoenoplectus acutus)*	Plant is a food for muskrats and small mammals. The seeds are eaten by waterfowl and passerines	$25 per oz
Bulltongue Arrowhead *(Sagittaria lancifolia)*	Waterfowl, muskrats, micro/macro invertebrates, and fish use them for food	$104 per ¼ lb
Common Duckweed (*Lemna minor*)	Many waterfowl species eat the duckweed so it would provide food	$34.95 per lb
Swamp White Oak (*Quercus bicolor*)	Used to provide cover in the buffer zone. Acorns provide food for the animals that use or live in the	$34.99 per tree

	buffer zone.	
Red-osier Dogwood (Cornus sericea)	Berries and twigs provide food to animals that live in the buffer. Roots also stabilize the bank of the wetland.	$13.99 for 15 seeds
Speckled Alder (Alnus rugosa)	Provides good cover for animals in the buffer zone. Roots also stabilize the bank of the wetland.	$39.95 per oz

Implementation 3: Proposed Layout

Within the GIS map layouts, we have created a wetland proposal in which we wish to create. The introduced perimeter is in a general location that is not yet official (Figure 1). A topographic map that provides the elevation will help determine an accurate and precise location. Upon looking at the first map, the five points indicated within the wetland perimeter are the soil sample sites. The soil samples were taken and sent to the Penn State extension, where we were provided an analysis of the soil. Doing this helps to identify what kind of soil needs to be added or restored in order to create and hold a wetland. The second map located below has a hypothetical layout of peninsulas and islands that could be implemented into the wetland. These created structures would provide a viable and suitable area for species of animals to roost, nest, lay eggs, and mate. Not only this, but they would offer a place of refuge and shelter within the wetland, but out of the water, to protect from predators and the elements.

We want to put a 15ft buffer (minimum) on the outskirts of the wetland to create cover for species that would be nesting and/or raising young in the wetland. This would lead to a decrease in adult and young mortality since the buffer would create cover for the animals from predators. Buffers also provide other important services such as preventing runoff, providing cover to help control water temperature, and help increase biodiversity (*Wetlands Are Incredibly Important and Biologically Diverse*, n.d.). Providing cover to help the water temperature would prevent the water from becoming too hot and decreasing the dissolved oxygen levels that would lead to a mass die-off of fish that inhabit the wetlands. The increase in biodiversity would help keep the water and air clean while also helping control pests. The biodiversity would also help draw people in to do activities near the wetland such as bird watching or hiking (Loza, n.d.). We would accomplish this by having Swamp White Oaks, shrubs, and bushes planted around the wetland and allowing the planted species and grass to grow in those areas.

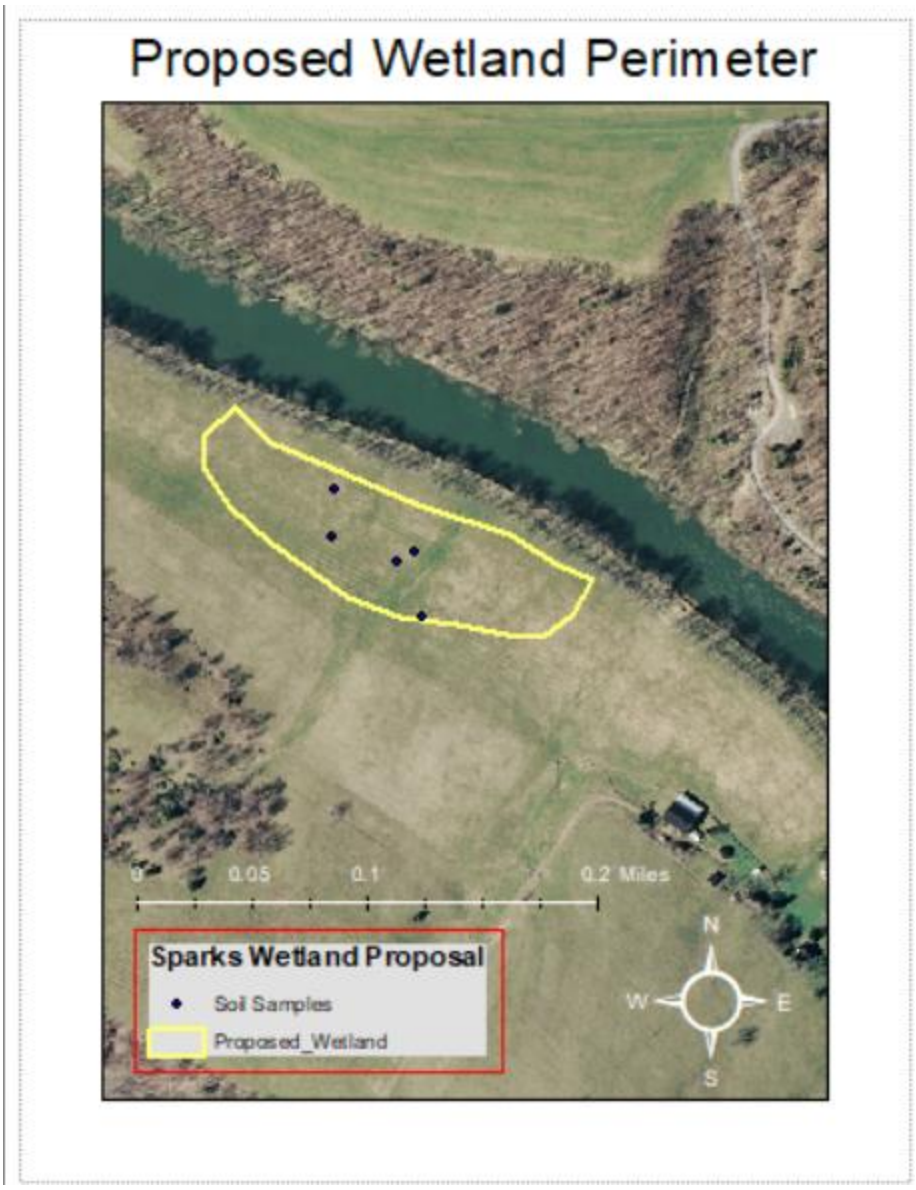


Figure 1: Proposed map of the perimeter of the planed wetland, located at Sparks Farm, with the five soil sample sites indicated within it.

Figure 2: Proposed wetland at Sparks Farm, with the layout of peninsulas and islands located within the area of the wetland.

POST MONITORING

There are multiple factors that we are planning on using to measure success after the wetland has been built. We want to focus on both biotic and abiotic aspects of the wetland since both of these factors are interlinked with biotic factors affecting the abiotic factors and vice versa.

The first success marker would be if all the targeted species (i.e. wood ducks, mallard ducks, and belted kingfishers) appear at the wetland. This would be linked to measuring species diversity both in plants and animals around the wetland. This would allow us to see if the wetland is drawing in species allowing for the biodiversity that is needed to maintain the health of a wetland (Danielson, 2002, p. 8). We would also want to make sure that all of the plants that are growing within the wetland are native to prevent native plants from being choked out and possibly discouraging animals from moving into or living in the wetland. Invasive plants to keep an eye out for are didymo (*Didymosphenia geminata*), phragmites (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), fanwort (*Cabomba caroliniana*), hydrilla (*Hydrilla verticillata*), parrotfeather (*Myriophyllum aquaticum*), curly-leaf pondweed (*Potamogeton crispus*), eurasian

watermilfoil (*Myriophyllum spicatum*), water chestnut (*Trapa natans*), and yellow floating heart (*Nymphoides peltata*) (*A-Field-Guide-to-Aquatic-Plants-in-PA.Pdf*, n.d.).

The next measurements that could be taken would be the water chemistry (i.e. nutrient levels, pH, dissolved oxygen, etc.). This would allow for the health of the wetland to be monitored to prevent the destruction of the wetland from pollutants. Aquatic plants and animals can only live in some specific conditions that can change due to a variety of reasons. This could be done easily with a water quality meter that measures multiple water quality aspects with one device. The final measurements would be looking at the soil chemistry. This would be checking the soil nutrients and the soil pH to maintain plant health. All of the components combined would lead to the true and accurate measure of success (Danielson, 2002, p. 15).

These measures of success could be done by ESS students as a class project or even as a research project. This could be a good learning experience for students since it would introduce the concepts for looking at biodiversity and the health of a wetland. The years could be compared to see if the biodiversity is increasing, decreasing, or staying the same. We would also be able to look at the chemistry of the water and soil to see if the wetland is staying healthy or if the health is declining.

Mammal Management Plan

INTRODUCTION

Role of Mammals

Mammals of all kinds play important roles in ecosystems and therefore in this plan. Species like voles, moles, muskrats, and mice play dual roles as consumers and as prey for larger mammals and birds of prey. Predator species like foxes, raccoons, opossums, and skunks keep populations of prey in check. Small mammals in general will benefit from the listed masting species, as well as the soft edge (outlined in *Implementation 3: "Formation of a Soft Edge"*). Large mammals are not explicitly listed in this management strategy, but will benefit from the habitat implementations and improvements. Although many of these key species are not listed directly, know that they have value in the ecosystem and were considered when making decisions about management.

SPECIES OF INTEREST

Bat (Chiroptera)

The following bat species will be the focus for our bat-based habitat improvements: Little Brown Bat (*Myotis lucifugus*), Indiana Bat (*Myotis sodalis*), Northern Long Eared (*Myotis septentrionalis*), and the Big Brown (*Eptesicus fuscus*). Bats of interest to us that are not threatened and not at risk for WNS include the Hoary Bat (*Lasiurus cinereus*) and the Eastern Red (*Lasiurus borealis*).

Bats are a key species for the environment they inhabit. They help with pest control, keeping insects that could potentially carry diseases, (for example, mosquitos carrying West Nile Virus), from transmitting it to humans. They also aid in pollination of various plants within their respective habitats. The species that we focus on utilize bodies of water for drinking, hunting aquatic insects and insects that are found near water. When it comes to roosting, they will take advantage of caves, loose bark on trees, hollow openings and potentially attics and barns in warmer weather.

Threats to the bat species present at Sparks Farm are numerous. One of the most detrimental to all bat populations is White Nose Syndrome (WNS). WNS is a fungal disease caused by *Pseudogumnoascus destructans* fungus. It is spread throughout a hibernating population through direct contact with an infected bat, or from contact with a surface where they are hibernating. During hibernation, WSN can cause bats to wake up before the hibernation period is over. This results in the use of fat reserves before the arrival of spring and starvation (Ballmann et al., 2017; *What Is White-Nose Syndrome?*, n.d.). Additionally, the loss of roosting sites due to destruction, fragmentation and degradation has been detrimental to bat populations. The destruction and fragmentation of habitats from opening space for urban development or for land to be converted into farmland can decrease areas that are important for shelter. Habitat degradation can occur through the use of pesticides or other chemicals hindering the amount of areas bats are able to live (*What Is White-Nose Syndrome?*, n.d.).

Eastern Cottontail (*Sylvilagus floridanus*)

The Eastern Cottontail rabbit serves as a prey species for predatory mammals as well as birds of prey. Besides serving as a food source, rabbits keep plant species in check, and their nutrient rich urine and feces maintains soil quality (Pratt, 2020). They prefer habitats that offer plenty of food and protective cover, exploiting brush piles.

Threats to rabbits include predation and habitat destruction, although they have been implemented in the plan primarily as prey for larger mammals or birds.

American Mink (*Neovison vison*)

While also maintaining prey populations in the surrounding area, American Mink would serve as an educational tool, one that would bring more visitors to the area. Mink mainly hunts aquatic prey. They den near water, specifically along lakes, streams and marshes within wooded and rocky areas.

The south bank of the Raystown Branch Juniata River on the Sparks Farm property has a steep and rocky bank that consists mainly of large rock and boulders that create ideal den and hunting sites for both mink and otter. This bank when connected to a more level bank with a strong soft edge will provide these mustelids with ideal habitat, cover, and hunting grounds. Although they are one the top predators, mink are often an indicator species for pollutants in aquatic systems since they are sensitive to pollutants and susceptible to chemical compounds accumulating in tissues. Other threats include disease and predation from bobcats, foxes, and owls.

North American River Otter (*Lontra canadensis*)

The importance of the river otter is based on its ability to serve as an educational tool, or "charismatic megafauna". The hope is that the otters will serve as an eyecatching species-- one that brings visitors to the area. Increasing the public knowledge and awareness of the habitat and benefit of river otters is a management goal included in the Pennsylvania Game Commission River Otter Management Plan (Hardisky, 2013). River otters are predators, and keep prey levels within river ecosystems at acceptable levels. River otters are streamlined and muscular, they belong to the mustelid, weasel, family, and weigh between 10 and 25 pounds. River otters have recently been reintroduced into Bedford county, but populations are slowly rising (*River Otter Wildlife Note*, 2021). River otters are generally non-selective fish eaters with crustaceans, reptiles, and amphibians as secondary food sources. The smaller and faster the fish species, the less vulnerable they are to otters, whereas the larger and slower the fish species, the more vulnerable they are to otter predation. Similarly with minks, river otters are indicators of a healthy ecosystem (Hardisky, 2013). The portion of the Raystown Branch of the Juniata River that flows along the Sparks farm property is characterized as slow flowing, making it ideal habitat for larger and slower fish, and therefore river otter as well.

River otters are facing many threats in regards to their habitat. Pollution, fragmentation, and overall destruction resulted in eliminations from many parts of their range. According to the Pennsylvania Game Commission's River Otter Management Plan, the issue challenging their survival is water quality (Hardisky, 2013). The creation of a soft edge along the river shore at Sparks Farm will allow for better water filtration as it flows and seeps into the river.

MANAGEMENT OBJECTIVES

Implementation 1: Bat Boxes

Bat boxes provide shelter for hibernating bats, and give females a place to raise pups. For most efficient use, boxes should be hung in the spring so they can be utilized the first summer. The dimensions of the boxes used at Sparks are: 7” deep, 30” length, 20” wide, and can house as many as 200 bats. Placement of the boxes is vital to promote proper bat use. Boxes should be placed about 15 feet up, in a place where they receive 6-8 hours of direct morning sunlight (facing east or south) (*Bat Houses*, 2021). While the box should be placed near trees, flyways to the box should not be obstructed by them (Chenger, 2017). Bat boxes should also be placed away from artificial lights.

The boxes require very little upkeep, but should be resealed and painted every three years as the direct heat from the sun can cause gaps to form (*Installing Your Bat House*, 2021). While painting the box is not crucial, the color can be used to manage the temperature if necessary. The slats on the inside may warp over time, so it is imperative to replace these (as needed) as warped slats can reduce carrying capacity of the box. Proposed areas for the 3 bat boxes can be seen in Figure: *Sparks Farm Mammal Implementations, 2021*.

Implementation 2: Brush Piles

Brush Piles are mounds and piles of woody debris for the purpose of providing small mammals and birds ideal habitat and cover. While providing crucial cover for small mammals, brush piles also offer effective hunting locations for birds of prey and predatory mammals. This wildlife management implementation works best in field, meadow, and riparian ecosystems and along edge habitats. Brush piles are most effective when used in conjunction with soft edges or to help create soft edges.

Brush piles have a specific form, as larger logs are used for the base, and smaller logs and sticks are placed perpendicular as the pile gets taller. Dimensions of the log and brush piles prescribed by NRCS are fifteen feet in diameter and six feet tall. Several brush piles should be created within the area being managed to provide the most abundantly available habitat and cover. These piles should be placed no less than two-hundred feet away from another pile and should line the majority of the edges in the area. The maintenance of the brush piles is fairly simple, as they require reinforcement when the materials begin to decompose every few years, generally 3-5 years. Brush piles work alongside other management practices as they use forest management byproducts (logs and sticks) for assembly materials, and accompany soft edge habitat management that benefits several additional species (*Creating Brush Piles for Upland Wildlife*, 2009). Specifically at Sparks Farm, 6-8 brush piles can be installed. Proposed areas for these brush piles can be seen in Figure: *Sparks Farm Mammal Implementations, 2021*.

Implementation 3: Formation of a Soft Edge

Softening an edge is an easy way to increase biodiversity, connect fragmented habitats, and give cover to species. A soft edge consists of shrubby undergrowth, grasses, and bushes that extend from the forest line (Clift, 2018). A soft edge allows for a transition between two different habitats, and provides food for many different species (Hart, 2021). The proposed area for the soft edge is shown in Figure: *Sparks Farm Mammal Implementations, 2021* .

Around the bank area, a patch of pasture should remain unmowed. Ideally, the width of this area is 20 meters or more. Over time, new trees will grow, and if left alone, the area will progress into forest. Trees should be removed once they reach 10 feet in height, to allow for uninterrupted sun to the area. Most of the growing will take care of itself over time, but to speed up the process, certain plants could be added to make the edge more beneficial.

In terms of overall maintenance, the soft edge requires much upkeep but in turn provides many benefits. Throughout the riverbank and the upperbank (area outlined in Figure 1), fallen trees should not be disrupted, and no mowing should be conducted. Fallen trees near the river serve as vital river otter habitat. It is important to keep the area from becoming too shaded by tree growth, as this will block "understory" plants from surviving. In a few years time, it may be important to evaluate the status of the edge, removing trees that are over 10' high and thinning undesirable invasives. The edge can be mowed and thinned in accordance with information listed in *Pollinators, Implementation 3– "Ongoing Management"*, although this should not be done regularly—only as an attempt to remove a particularly pesky invader.

Plants of the Edge

Shagbark hickories (*Carya ovata*) provide excellent cover for bats and can be utilized around the river for the greatest effect. They should be planted closest to the existing treeline and forest edge, and the height of plants should decrease as the soft edge extends outward. **Crabapple trees (*Malus rosaceae*)** can be planted sparingly in this area to provide mast for small mammals, such as mice, voles, foxes and badgers. **Blackberry bushes (*Rubus pensilvanicus*)** are moderately resistant to deer and provide cover for all sorts of animals (*Rubus Pensilvanicus (Blackberry, Dewberry, Pennsylvania Blackberry)*, 2021)**. Bottlebrush buckeye (*Aesculus parviflora*)** is also deer resistant, providing dense cover and late-flowering blooms for pollinators. The rest of the soft edge can be supplemented by the naturally growing grasses in the area, as well as barberry alternatives, like **ninebark (*Physocarpus opulifolius*)**, **wild hydrangea (*Hydrangea arborescens*)**, and **silky dogwood (*Cornus racemosa*)** which provide additional cover (Rhoads & Block, 2002). To improve visitor appeal, the grassy area of the edge can contain wildflower seed mixes mentioned in *Pollinators: Implementation 3–"Seed Mix"*. **Sumac (*Rhus spp*)**, a flowering shrub, also brings visitor appeal and contributes to pollinator success. A small plant, **Cut-leaved Evening-Primrose (Oenothera laciniata)** is a night blooming plant and is beneficial for bats (*Oenothera Laciniata (Cutleaf Evening-Primrose)*, 2019).

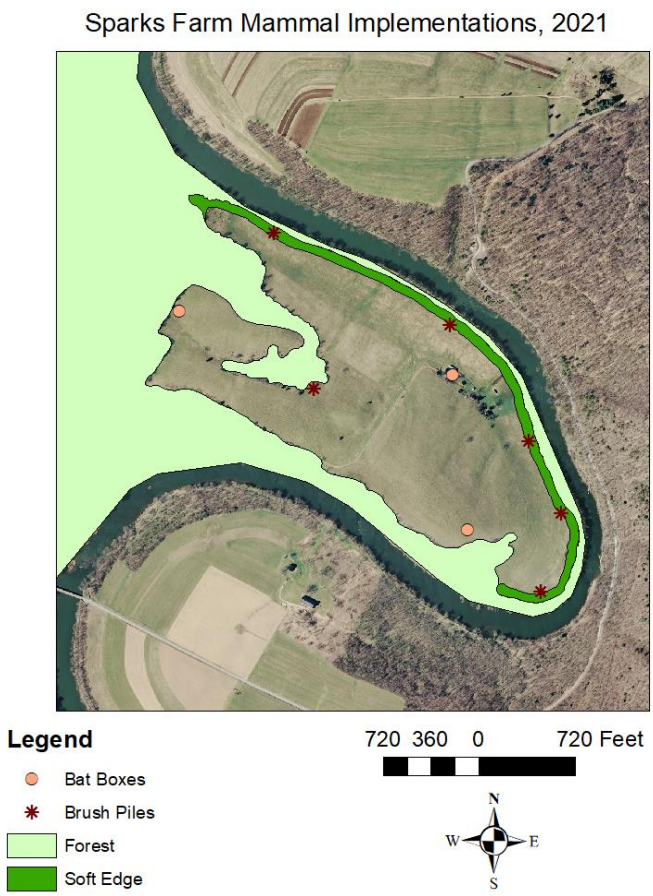


Fig 1. The proposed areas for the soft edge, bat boxes, and brush piles at Sparks Farm.

To improve the health of the bank itself, **highbush blueberries (*Vaccinium corymbosum*)** can be planted 15 feet from the water. For optimal performance, the pH of the soil (at present, pH 6.5 along the bank) can be supplemented with ground sulfur to make it more appropriate for the crop. Ground sulfur is applied by weight: 1988 pounds per acre. The Penn State soil report contains more information regarding the optimal levels of nutrients for this crop. Besides blueberries, **Paw Paw trees (*Asimina triloba*)** would do well on the bank, primarily in places right after the bank has leveled out from the incline to the water. They make an interesting addition to the edge, providing valuable mast as well as visitor appeal and educational value.

Table 2: Information on plants to improve the health of the area and provide habitat for species to utilize (Baeulieu, 2021; Balogh, n.d.; Beaulieu, 2021, 2021; Carroll, n.d.; Goldwitz Jimenez, n.d.; *Hickory Shagbark*, n.d.; *How to Grow Pawpaw Trees in Your Garden - 2021*, 2021; "Wild Hydrangea," n.d.; Myers, 2021; Schiller, 2020).

Species	Spacing	Planting Time	Lighting	Maintenance	Height
Shagbark Hickory	15'x15'	Early spring	Full to part sun	None	60'-80'
Crabapple Tree	6'-15'	Spring or fall, avoid freezing temperatures and extreme heat	Full sun	Remove damaged twigs and suckers as they appear. Pruning after June reduces fruit and flowering capabilities	15-20'
Paw Paw	Requires another Paw Paw within 15' to encourage pollination.	Plant in fall or spring	Full to part sun	Prune in late winter or early spring (optional).	12'-25'
Bottlebrush Buckeye	Allow 8'-15' for spreading.	Plant in late winter or early spring.	Full sun, part sun, or full shade.	Prune when flowers fade in spring (optional).	8-12'
Highbush Blueberries	Requires 5' between each plant. 8-10' to separate rows.	Plant in fall (mid-October) or early spring	Full sun.	Remove flower clusters in spring (first two years).	6-12'

Silky Dogwood	Can be planted close together to form a thicket.	Plant in spring.	Part shade, full shade. Will tolerate full sun.	Prune in early spring (optional).	6’-10’
Ninebark	Requires 6-7’ for spreading.	Plant in early spring	Full sun to partial shade, will flower more in full sun.	Prune after it flowers or no later than mid-August.	5’-10’
Wild Hydrangea	Plant 3’ apart to allow for thicket growth.	Plant in fall.	Full sun to partial shade. Tolerates deep shade.	Can be cut down to ground in early spring to control size.	3-6’
Blackberry Bush	Requires at least 5’ of spacing.	Plant in late fall to early spring.	Full sun required for best berry yields.	Fruits appear on last year’s branches, so pruning should be done cautiously.	2-5’’
Cut-leaved Evening Primrose	Thin seedlings approximately one foot apart.	Best sown in early spring or late fall.	Part shade	Self-seeds can be thinned at the start of summer before seeding begins (if desired).	2’

POST MONITORING

Bat boxes should be resealed and painted every three years (*Installing Your Bat House*, 2021). Temperature adjustments to the box can be made by painting the box a different color. To evaluate the success of the boxes, check the ground beneath them. If in use, piles of bat guano will be situated immediately beneath the box. If no such signs of presence are found, the box should be relocated in the following season.

As the brush piles begin to decompose, they can be reinforced with new woody material. These piles can be replaced as needed, but will generally last 3-5 years. Small mammal surveys can be implemented to determine success of the brush piles over time.

Plants in the soft edge can be regulated according to maintenance listed in table 2. Thicket-forming plants should be monitored for density. To evaluate their use, small mammal surveys could also be conducted in the soft edge. Mast-producing plants, like blueberries and crabapples, should be monitored for yield over time. A successful soft edge will contain producing masting species as well as areas of dense cover. In general, a soft edge has achieved its purpose when it has provided a continuous transition from a field area to a forested area.

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