

An Adaptive Management Plan for the Restoration of an  
Outdoor Learning Center

By

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## Abstract

### AN ADAPTIVE MANAGEMENT PLAN FOR THE RESTORATION OF AN OUTDOOR LEARNING CENTER

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The process of restoring and reconstructing natural communities is complex and full of uncertainty for land managers. When the prospect of using the natural communities for education purposes is added to these challenges, a comprehensive and adaptive approach of land management is necessary. Adaptive management has proven to be a useful approach to dealing with uncertainty when managing natural resources, and has been chosen as the approach for managing the resources of an outdoor education facility in Raleigh, North Carolina.

This master's project is intended as a living document to guide the management of the natural resources at the Prairie Ridge Ecostation for Wildlife and Learning. Prairie Ridge is the educational field station of the North Carolina State Museum of Natural Sciences, located in Raleigh, North Carolina. The Ecostation hosts students of all backgrounds as they conduct educational field research. These activities can complicate the management and conservation of natural resources. This document is designed to provide a comprehensive plan for the restoration, reconstruction, and management of a variety of natural communities at Prairie Ridge, keeping in mind the need for educational and research use of these resources. These communities include a dry-mesic oak hickory forest, a piedmont bottomland forest, and a piedmont prairie reconstructed from an abandoned pasture.

A framework was developed to guide the management of the diverse projects currently underway at Prairie Ridge. Each of these eleven projects is outlined with clear goals, strategies, and prescriptions for their management. Adaptive management is recommended for the majority of the projects for its ability to manage uncertainty and provide a scientific approach to management decisions. Evaluation methods were developed for each project to measure the effectiveness of the management prescriptions. The potentially conflicting uses of Prairie Ridge, including public visitation, field research, and preservation provide many opportunities for the use of decision analysis as an evaluation tool. Multi-attribute utility analysis is recommended for the evaluation of each management treatment. This plan will guide the management of Prairie Ridge's natural resources and serve as a model for incorporating adaptive management techniques into other educational facilities.

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## CHAPTER ONE INTRODUCTION

### **Purpose**

This plan is a living document to guide the management of the natural resources at the Prairie Ridge Ecostation for Wildlife and Learning (Prairie Ridge). The plan will identify management needs and methods followed by evaluation approaches. The plan will not serve as a detailed list of instructions. Rather, it will act as an overall approach for management projects underway at the Prairie Ridge Ecostation for Wildlife and Learning.

A natural resource management plan should not only outline the ecological requirements of a site, but also the economic and social activities (Ecosystem Management Research Institute 2005). The interactions of both human and natural dimensions must be taken into account when evaluating the success of any management action.

This natural resource management plan will address the following:

- A description of the purpose and mission of the managing organization
- A summary of funding and other assets available for use
- Physical descriptions of the site
- Current biological descriptions of the site
- Desired biological descriptions of the site
- A summary of suitable management approaches
- A summary of appropriate evaluation approaches
- A discussion of management challenges

As a living document, this management plan is designed to evolve as management projects and their environments change.

### **Prairie Ridge**

Prairie Ridge Ecostation is the field station of the North Carolina State Museum of Natural Sciences (Museum). The Museum is currently the third largest natural history museum in the United States and is the largest in the Southeast with collections of more than two million specimens. The Museum, established by the North Carolina General Assembly in 1879, is located in downtown Raleigh, North Carolina. Prairie Ridge is 4.5 miles (7.24 km) from the Museum, situated on the western edge of Raleigh along the Reedy Creek Greenway. Its location forms the eastern end of a contiguous open space corridor formed by William B. Umstead State Park, Carl A. Schenck Memorial Forest, and North Carolina State University horse pasture. Prairie Ridge is organized as a department within the Museum's managerial structure and the Director of Prairie Ridge reports directly to the Director of the Museum. The Museum and Prairie Ridge staff currently uses the field station to facilitate school programs, public workshops, and teacher training.

Prairie Ridge consists of abandoned tall fescue (*Festuca* spp.) pastureland, previously owned by North Carolina State University. Restoration of the site includes a small perennial pond, nine vernal pools, a piedmont prairie reconstruction, an educational lowland arboretum, and upland and bottomland forests. These natural communities enable students and scientists to conduct a variety of natural science research projects. The site is open for public visitation and will be used



for many of the Museum's experiential education programs making Prairie Ridge a premier experiential education facility.

The practice of natural community (Schafale and Weakley 1990) restoration can be complex at best. Add to this the array of potentially conflicting uses associated with an outdoor learning center and the problem becomes extremely difficult. The need to balance public services with natural resource preservation requires more than a traditional prescriptive management plan that depends on trial and error. This document meets these varied needs through the development of an adaptive management plan for natural community restoration, reconstruction, and maintenance. This plan utilizes existing literature to prescribe the best practices for the restoration and reconstruction of natural communities at Prairie Ridge. It also contains baseline descriptions of natural community types that will be used to evaluate the success of the prescribed practices. Upon changes in needs and priorities, a multi-attribute utility decision tool will be used to make changes in the management prescription. This plan not only guides the management of Prairie Ridge, but can also serve as a model for the management of other facilities with similar conflicting uses.

### **Prairie Ridge's Mission**

The need for experiential and inquiry-based science education is not being met by North Carolina's public schools. Many school districts across the state require as little as 45-minutes per week of science education for elementary-aged students. The American Association for the Advancement of Science has referred to the need for improvement in science education as a national crisis (AAAS 1990).

The Museum and Prairie Ridge are positioned to assist in filling the gap in science and environmental education. The Museum's mission is stated as:

*The purpose of the North Carolina State Museum of Natural Sciences is to enhance the public's understanding and appreciation of the natural environment in ways that emphasize the biodiversity of North Carolina and the southeastern United States and relate the region to the natural world as a whole.*

The Museum's urban location requires the addition of a natural area to more efficiently fulfill its mission. The Museum is charged with serving the entire state of North Carolina, yet few school groups from outside the immediate Raleigh area are able to visit within a single day. A residential facility for visiting groups will allow students to visit from greater distances and is a top priority for the Museum. The residential facility will enable groups to engage in multiple-day learning experiences by providing overnight accommodations to visiting students and teachers.

The North Carolina State Museum of Natural Sciences has a long history of pursuing its organizational mission and legislative mandate. Prairie Ridge, as a facility of the Museum, should pursue a mission that not only closely aligns with the Museum's mission but also seeks to support parts of it. The mission can be stated as follows:

The mission of Prairie Ridge is to empower the citizens of North Carolina with the understanding of the scientific principles needed to make enlightened decisions about the environment. Prairie Ridge will pursue this mission by:

- Allowing individuals to take responsibility for their own learning;
- Providing quality, experiential, educational opportunities in nature;
- Allowing students to learn science by *participating* in scientific research;
- Demonstrating more sustainable ways to build and maintain facilities;
- Exposing students to unbiased science;
- Using new technologies as an education tool;
- Involving all students regardless of age, background, or hometown.

Prairie Ridge envisions itself becoming the premier provider of research-driven, experiential, natural science education in the Southeast utilizing both facilities that exemplify sustainable design and natural areas that are models of ecological restoration and reconstruction.

To achieve this vision Prairie Ridge must work towards a set of attainable goals. These goals will be used as mileposts in not only achieving our vision but in our pursuit of our mission. The goals for the next five years are:

- To increase the level of knowledge of North Carolina biodiversity and awareness of nature among the State's citizens
- To utilize scientific research in educational programs
- To increase public understanding of the scientific process and the scientific method
- To reconstruct and restore viable natural communities
- To increase public awareness of sustainable architecture and technology

Prairie Ridge will pursue these goals and vision in ways that reflect a commitment to core ethical values. Prairie Ridge is committed to:

- Valuing biodiversity and resource conservation in everything we do – Staff, instructors, and students shall act in a way that conserves resources for the future.
- Scientific accuracy in the information we share – Only unbiased, scientifically accurate information will be taught.
- An experiential approach to education – First-hand experience is the most valuable teaching tool we have.
- Valuing the shared experience of the group – Staff, instructors, and students are expected to share their knowledge, experiences, and enthusiasm for the benefit of the group. This is incorporated in everything Prairie Ridge does – programs, meetings, planning, etc.

### **Visitor Facilities**

Prairie Ridge serves as a recreational and educational site for the general public. Public visitation is expected to be moderate since it is located along the Reedy Creek Greenway. The following infrastructure has been constructed to support the anticipated level of public and group use.

A gravel driveway along with a small gravel parking lot has been created. The parking consists of two areas, with eight parking places each. A single paved parking place serves the entrance to an Americans with Disabilities Act accessible trail. Entrance fencing, bicycle racks, and an informational kiosk serve visitors as they enter the property.

Three trails have been constructed to allow access to approximately half of the site. The Prairie Trail is 0.25 miles (0.37 km) in length and forms a loop through half of the piedmont prairie reconstruction site. The Forest Trail winds through the educational lowland arboretum and the upland forest restoration and is 0.50 miles (0.75 km) in length. These trails have a natural surface substrate. An Americans with Disabilities Act accessible trail provides access from a parking area to an outdoor amphitheater.

A screened pavilion serves as an outdoor classroom for up to 50 students and is a model of sustainable design. This award winning structure, illustrated in Figure 1, is Leadership in Energy and Environmental Design (LEED) certified for its use of recycled materials, water harvesting, and energy efficiency. A bird blind with seating for 30 students overlooks a perennial pond and serves as a shelter for wildlife observation. A temporary office building houses the staff.

Prairie Ridge is seeking funding for a residential environmental education center that will serve groups from across North Carolina by providing opportunities for residential and multi-day educational experiences. The residential environmental education center is designed to be a demonstration of sustainable architecture. Photovoltaic solar cells have been acquired to provide electricity for all of the facilities at Prairie Ridge.



Figure 1. The Outdoor Classroom at Prairie Ridge is an example of sustainable architecture.

### **Site Description**

Prairie Ridge is located at 4301 Reedy Creek Road, Raleigh, North Carolina near the intersection of Reedy Creek Road and Edwards Mill Road. The property consists of 38.5 acres (15.58 ha.) of land adjacent to the Museum's Research Laboratory. The site has a rolling topography with slopes from 5% to 18% and elevation ranging from 352 feet (107 meters) to 436 feet (133 meters). This topography terminates in a relatively flat floodplain along the site's southern border. Figure 2 indicates the physical features of the site.

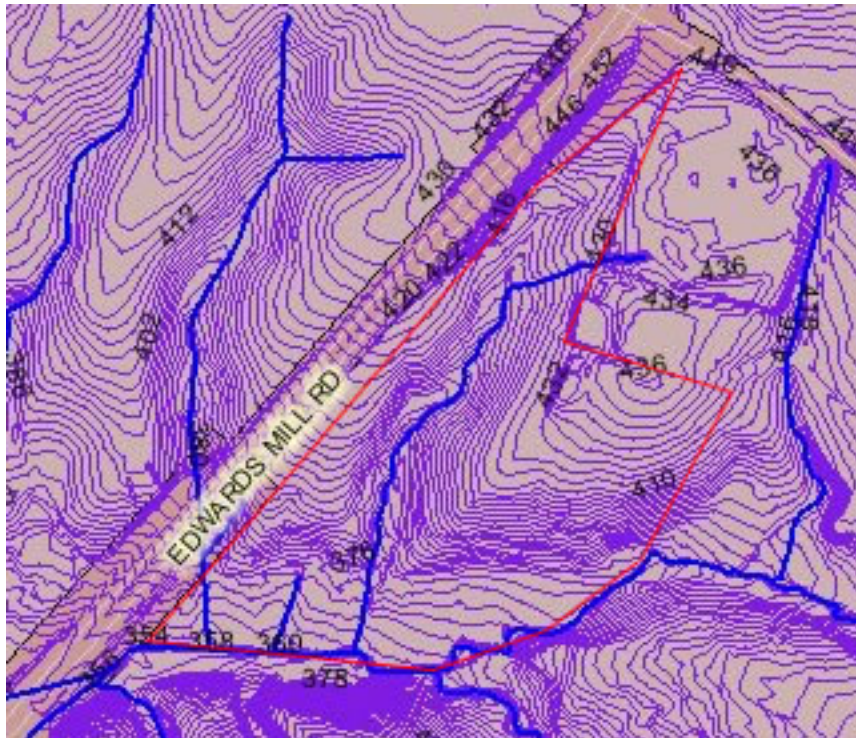


Figure 2. Topographic and development features of Prairie Ridge

The site consists of old pasture that is dominated by tall fescue (*Festuca* spp.), Bermuda grass (*Cynodon dactylon*), and sparse patches of Johnson grass (*Sorghum halepense*). Volunteer species, including common milkweed (*Asclepias syriaca*), blackberry (*Rubus* spp.), and broomsedge (*Andropogon virginicus*), have emerged in the absence of grazing pressure.

Prairie Ridge is bordered along two sides by remnant piedmont bottomland and dry-mesic oak hickory forests (Schafale and Weakley 1990). A mature piedmont bottomland forest extends along the length of the property following a tributary of Richland Creek. The dry-mesic oak hickory forest follows the eastern border of the property and has evidence of prior disturbance and high-grading. A number of invasive exotic species occur in these forested areas. These species include Chinese privet (*Ligustrum sinense*), Bradford pear trees (*Pyrus calleryana*

'Bradford'), Russian olive (*Elaeagnus angustifolia*), Multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stiltgrass (*Microstegium vimineum*).

The soil structure consists primarily of Cecil gravelly sandy loam (CgC2), and Cecil sandy loam (CeD), with areas of Colfax sandy loam (Cn), Cecil clay loam (CIE3), Appling sandy loam (ApD), Warsham sandy loam (Wy), and Wehadkee and Bibb (Wo) (United States 1970).

The site is host to a large variety of fauna given its small size. Over 100 species of birds have been documented, as well as 11 species of fish, 18 species of mammals, 14 species of reptiles, and 14 species of amphibians (see APPENDIX II).

The site has benefited from the initiation of a variety of management projects as can be seen in figure 3.

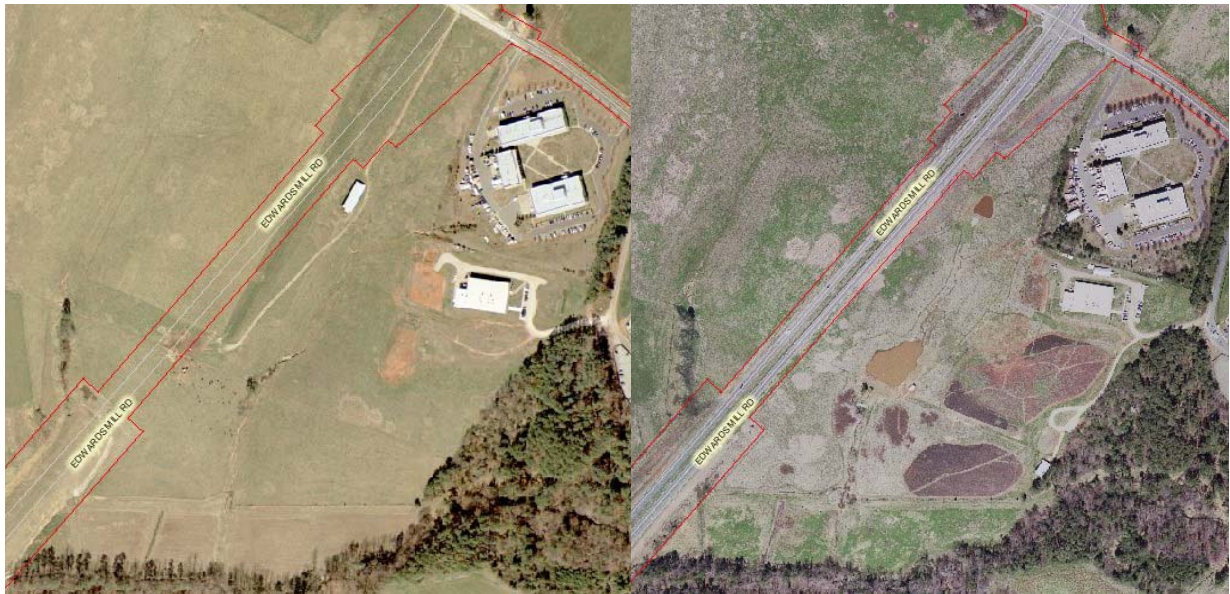


Figure 3. Aerial photographs of the North Carolina State University cow pasture in 1999 and Prairie Ridge in 2005 illustrate the changes in vegetation and the addition of several small ponds.



## CHAPTER TWO MATERIALS AND METHODS

### **Rationale for Management Methods**

Prairie Ridge Ecostation for Wildlife and Learning serves as a demonstration of natural community restoration, reconstruction, and conservation. The Museum has a history of providing credible scientific knowledge to the public. Prairie Ridge continues this tradition by acting as a demonstration of the best management practices related to natural resource management and providing management information to the public. Management problems contain high levels of uncertainty and involve ecological, sociological, and economic interactions (Walters 1978). The potentially conflicting use goals of education, public use, preservation, and conservation complicates many of the management projects at Prairie Ridge.

Managing according to unexamined convention can result in a natural community that is historically inaccurate (Howe 1994). In the face of uncertainty, many management decisions are made based on expert opinion and conventional wisdom with a trial-and-error method. To minimize the effects of uncertainty scientific rationales should be used when making management decisions rather than unexamined conventional wisdom (Howe 1994). Prairie Ridge must utilize scientific source information, original data, and decision analysis methods in making resource management decisions to provide a credible demonstration of proper management techniques.

Objectives and models should be developed for each management project. The objectives provide goals for each project while the models provide a management strategy. To be defensible, realistic models should be generated to include an optimum amount of detail (Walters

and Hilborn 1978). Prairie Ridge's goal of teaching science by engaging participants in scientific research aligns with an adaptive management approach to natural resource management by providing large-scale field projects. Students can actively participate in these projects by collecting monitoring data and evaluating sample data sets.

Whenever possible, active adaptive management should be used to provide robust justifications for management decisions. Adaptive management is especially suited for management problems associated with human influences on ecosystems (Lee 1999). Monitoring and evaluation are key parts of each management project at Prairie Ridge. Although monitoring can require significant resources, it provides unbiased data on what is happening in the project. Data collected as part of continuous monitoring efforts should be evaluated to determine the effectiveness of the chosen management strategy. Evaluation provides information about the strengths and weaknesses of management approaches, allowing the approaches to be altered as necessary (Ecosystem Management Initiative 2004). This is helpful when addressing conservation versus educational uses of natural resources. The use of multi-attribute decision making frameworks should be used to support objective decision making as part of an overall adaptive management strategy.

When possible, the results of various projects should be reported in the scientific literature to gain a broader perspective. Some of the projects at Prairie Ridge focus on topics that have the need for more scientifically based knowledge. The publication of the results of such projects can aid scientists in the further study of these topics.

The mixture of projects on the site dictates a mixture of management approaches. Each management approach should take into account possible effects caused by adjacent projects, educational use, and disturbance by public visitors. The site is divided into eleven management zones to create a spatial structure for managing multiple projects. Table 1 indicates each zone's size. Four of these zones are managed as a piedmont prairie reconstruction. Two of the zones are managed as an educational lowland arboretum. Two of the zones are managed as old pasture. One zone is managed as dry-mesic oak hickory forest. One zone is comprised of a perennial pond. The remaining zone is managed as piedmont bottomland forest. In addition to these zones there are several special project areas. These zones allow management practices to be tailored per project.

Table 1. Size of Prairie Ridge management zones

**Prairie Ridge Management Areas**

| <b>Area Name</b> | <b>Area Description</b>                | <b>Area Size (hectares)</b> | <b>Area Size (acres)</b> |
|------------------|--|-----------------------------|--------------------------|
| Prairie 1A       | Tall grass Prairie planted 2004        | 0.94                        | 2.32                     |
| Prairie 1B       | Tall grass Prairie planted 2007        | 1.30                        | 3.21                     |
| Prairie 2A       | Tall grass Prairie planted 2005        | 0.53                        | 1.31                     |
| Prairie 2B       | Tall grass Prairie planted 2007        | 0.88                        | 2.18                     |
| Upland Forest    | Dry-mesic Oak Hickory Forest           | 0.80                        | 1.98                     |
| Lowland Forest 1 | Lowland Arboretum Open to the Public   | 1.35                        | 3.34                     |
| Lowland Forest 2 | Lowland Arboretum Closed to the Public | 1.35                        | 3.33                     |
| Lowland Forest 3 | Piedmont Bottomland Forest and stream  | 545 linear meters           |                          |
| Old Field 1      | Unmanaged fescue pasture               | 3.62                        | 8.93                     |
| Old Field 2      | Unmanaged fescue pasture               | 2.24                        | 5.54                     |
| Large Pond       | Large pond on western side of property | 0.22                        | 0.54                     |

1 acre = 0.4047 hectare

**Tools and Materials**

A wide variety of tools and materials are used in the management of projects at Prairie Ridge.

This section serves as a guide to tool selection, not as a comprehensive list.

An integrative use of a geographic information system (GIS) should be used to track data spatially and allow a common data structure between management projects. This will require the use of global positioning systems (GPS) to record the location of data points, tracks, and areas. Data can then be assembled in thematic layers to track their relevance between projects. All maps at Prairie Ridge should utilize a GIS to insure a standard level of accuracy. The Museum currently uses ESRI Arcview 9.1 as its primary GIS.

The use of chemicals and herbicides should be kept to a minimum to align with the organization's core values. Cleaning products should be sustainable and biodegradable. Herbicides should only be used when best management practices dictate, and then only as prescribed by a staff member holding a North Carolina pesticide license. Manual and mechanical removal of invasive exotic species should be promoted to serve as a demonstration for visitors and students.

Phenological change should be documented using digital photography using a standardized methodology. The University of New Hampshire's Picture Post project provides a method for the use of digital photography as a record of ecosystem change.

Metadata will be used to record and track data. Internationally recognized standards for metadata will be used to insure that Prairie Ridge's data remains useful for scientific research.

Methods and materials that are considered statistically accurate and as standard practice in the scientific literature should be used. Standard sampling procedures for nest searching, bird banding, insect sampling, belt transects, etc. should be utilized to add credibility to each project. The use of heuristic diagrams to communicate project models and weighted averaging ordination should be used for evaluating each project.

### **Adaptive Management**

The process of natural resource management is filled with uncertainty. This uncertainty derives from our incomplete understanding of the interactions that take place within ecosystems and how our management actions affect them. The traditional approach of many resource managers is to rely on expert opinion and current knowledge to develop models of ecosystem mechanisms with faith that they are accurate (Johnson 1999). Political, economic, and social concerns are difficult to avoid and often affect these management decisions. These concerns can persuade managers to make decisions based on anecdotal knowledge resulting in a trial-and-error approach to management (Lee 1999). A more appropriate response to uncertainty is a research-based approach. The process of adaptive management offers such an approach that allows the resource manager to collect valuable information through both success and failure (Walters and Hilborn 1978).

Current thinking suggests that adaptive management can be divided into two categories: passive and active (Walters and Holling 1990). Passive adaptive management consists of creating models, making the best predictions possible based on these models and current information, monitoring and evaluating the management approaches, and revising both the models and the

management approaches as more information becomes available (Walters and Hilborn 1978). This approach proves somewhat successful at providing an objective approach to management decisions. However, passive adaptive management lacks the ability to definitively associate management activities with their perceived results.

Active adaptive management is similar to passive adaptive management in that it consist of creating models, making the best predictions possible based on these models and current information, monitoring and evaluating the management approaches, and revising both the models and the management approaches as more information becomes available, but it adds the ability to compare the results to a control (Walters and Holling 1990). Figure 4 illustrates an example workflow of active adaptive management. By using a control, active adaptive management can be designed as an experiment to clearly define the results of chosen management actions.

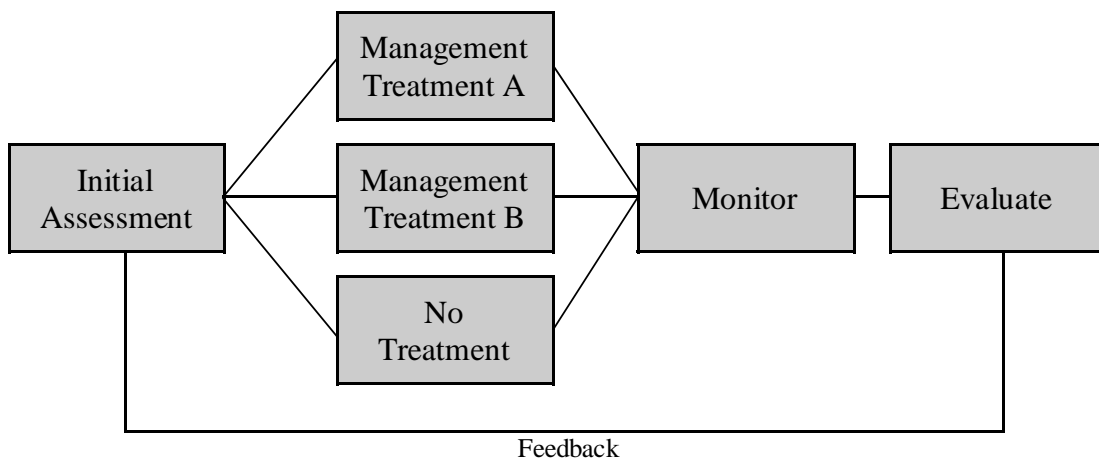


Figure 4. An example of active adaptive management contains a control that receives no treatment.

Active adaptive management is favored due to its experimental approach, but may not always be feasible (Walters and Holling 1990). Both passive and active adaptive management will be used at Prairie Ridge due to a variety of limitations including limited natural, human, and economic resources.

### **Multi-Attribute Decision Making**

To meet the need for justifiable management decisions, quantitative decision analysis should be used when addressing conflicting needs and decisions with high uncertainty. Decision analysis provides a framework for characterizing the decision to be made, identifying the objectives and criteria for evaluating alternatives, evaluating the alternatives in the decision, identifying uncertainties and estimating their probabilities, and assigning values to the possible outcomes (Maguire 1992). Decision analysis provides a framework for both subjective and objective information to be used in guiding decisions.

There are many methods of decision analysis. Decision trees, calculated probabilities, trade-off analysis are used to describe the consequences of competing alternatives, while multi-attribute utility analysis is used when quantifying decisions with numerous objectives. Multi-attribute utility analysis should be utilized when making resource management and research project decisions.

The conflicting uses of Prairie Ridge, including public visitation, field research, and preservation provide many opportunities for the use of decision analysis. The use of quantitative analysis has

been suggested for determining visitation levels in the National Park System (Prato 2001), and is adaptable for use at Prairie Ridge.



## CHAPTER THREE MANAGEMENT PROJECTS

This chapter offers a framework approach to the current management projects at Prairie Ridge. These projects include: a piedmont prairie reconstruction, an educational lowland arboretum, an upland forest restoration, a piedmont bottomland forest restoration, old pasture management, and a variety of special project areas. Each project is addressed separately with notes on possible interactions with areas beyond the project's boundaries. As individual projects progress, their management descriptions will become more detailed. The management project profiles have a variety of sections. Each section is described as follows:

Summary: This section briefly describes the management project.

Goals: This section lists the overall goals the project hopes to achieve.

Site Description: This contains information regarding the physical features of the site.

Zones: This sub-section lists the management zones involved in the management project.

Project Size: This is the overall area of the management project.

Strategy: This is the overall management strategy of the project.

Funding: This section briefly lists funding sources for the project.

Site History and Past Management: This is a brief history of the project site.

Management Objectives: This section lists the project's measurable objectives.

Initial Assessment: This is a brief description of the initial condition of the project site.

Management Prescription: This section describes the management actions for the project.

Monitoring: This is a description of the monitoring protocol of the project.

Evaluation: This describes the project model for the evaluation of the monitoring results.

Management Considerations: This section describes possible issues with the project.

## Piedmont Prairie Reconstruction

Summary: Piedmont prairie is a natural community of historic significance in the Piedmont region of the Eastern United States and will be reconstructed at Prairie Ridge.



Figure 5. The Piedmont Prairie Reconstruction Management Project

Goals: Provide a piedmont prairie reconstruction to host educational programs for students of all backgrounds to learn the historical and ecological significance of this forgotten ecosystem.

Provide a demonstration piedmont prairie for homeowners and organizations that are interested in establishing prairie areas. Enhance habitat potential for prairie and grassland species.

Site Description: The site is made up of five management zones as illustrated in Figure 5. At the time of the property's acquisition these zones were covered with abandoned pasture. Dominant plant species included tall fescue (*Festuca* spp.), Bermuda grass (*Cynodon dactylon*), and Johnson grass (*Sorghum halepense*). The soil is a majority of Cecil gravelly sandy loam (CgC2) and eroded Cecil gravelly sandy loam (CgB2) with areas of Cecil sandy loam (CeD), Appling sandy loam (ApD) and Cecil clay loam (CIE3) (United States 1970). The project site has a Southwestern aspect with slopes ranging from 2 - 15 percent.

Zones: Prairie 1A, Prairie 1B, Prairie 2A, Prairie 2B, Old Pasture 1

Project Size: 17.95 acres (7.26 ha.)

Strategy: Active adaptive management. The removal of non-native grasses and exotic invasive species followed by the introduction of native grasses and forbs. Establish an optimum schedule for management by prescribed fire.

Funding: Additional funding through the Natural Resources Conservation Service (NRCS) Wildlife Habitat Incentives Program (WHIP) grant.

Site History and Past Management: Efforts to reconstruct a Piedmont Prairie on portions of the project site began in 2004 and continue through the present. The following five tables(2-6) chronicle these events by date and management zone.

Table 2. History of Prairie 1A

| Date      | Management Activity  |
|-----------|--|
| 1/14/2004 | Marked parimeters of intended prairie management. David Swanson and Museum staff   |
| 2/9/2004  | Mowed and triple disked the area to be planted. Chuck Baldwin  |
| 4/29/2004 | Sprayed area to be planted with 2 percent Roundup (a formulation of glyphosphate). Chuck Baldwin   |
| 5/11/2004 | Planted by hand casting seed mixture containing: Carthage switch grass ( <i>Panicum virgatum</i> ), Suther indian grass ( <i>Sorgastrum nutans</i> ), big bluestem grass ( <i>Andropogon gerardii</i> ) and little bluestem grass ( <i>Schizachyrium scoparium</i> ); and a mixture of forbs including: plains Coreopsis ( <i>Coreopsis tinctoria</i> ), showy tickseed sunflower ( <i>Bidens aristosa</i> ), black-eyed susan ( <i>Rudbeckia hirta</i> ), indian woodoats ( <i>Chasmanthium latifolium</i> ), Eastern smooth beardtongue ( <i>Penstemon laevigatus</i> ), and broadleaf tickseed ( <i>Coreopsis latifolia</i> ). Museum staff |
| Mar-05    | Burned planted area using prescribed fire. North Carolina Division of Forest Resources   |
| 4/11/2005 | Added hand collected warm season native grass seed in small amounts. Museum staff  |
| 3/10/2006 | Mowed prairie grasses. Museum staff  |
| 2/28/2007 | Burned planted area using prescribed fire. North Carolina Division of Forest Resources   |

Table 3. History of Prairie 1B

| Date       | Management Activity   |
|------------|---|
| 3/10/2006  | Mowed tall fescue. Museum staff   |
| 10/13/2006 | Mowed tall fescue. Museum staff   |
| 10/18/2006 | Sprayed tall fescue with 2 percent Roundup (a formulation of glyphosphate). Museum staff  |
| 2/28/2007  | Burned using prescribed fire. North Carolina Division of Forest Resources   |
| 3/21/2007  | Using a no-till seed drill 24 lbs of the following seed from Ernst Conservation Seeds was planted: 35% Suther big bluestem grass ( <i>Andropogon gerardii</i> ), 35% Suther indian grass ( <i>Sorgastrum nutans</i> ), 30% Carthage switch grass ( <i>Panicum virgatum</i> ). |

Table 4. History of Prairie 2A

| Date      | Management Activity   |
|-----------|---|
| Nov-04    | Sprayed area to be planted with 2 percent Roundup (a formulation of glyphosphate). Peter Hurl   |
| Mar-05    | Burned planted area using prescribed fire. North Carolina Division of Forest Resources  |
| 4/11/2005 | Using a no-till seed drill 40lbs of the following seed from Ernst Conservation Seeds was planted: 10% thin-leaved sunflower ( <i>Helianthus angustifolius</i> ), 10% lance-leaved Coreopsis ( <i>Coreopsis lanceolata</i> ), 10% showy tickseed sunflower ( <i>Bidens aristosa</i> ), 25% purple top grass ( <i>Tridens flavus</i> ), 20% Suther big bluestem grass ( <i>Andropogon gerardii</i> ), 20% Suther indian grass ( <i>Sorghastrum nutans</i> ), 5% Carthage switch grass ( <i>Panicum virgatum</i> ). Laura Fogo |
| 4/11/2005 | Added hand collected warm season native grass seed in small amounts. Museum staff   |
| 3/22/2006 | Mowed prairie grasses. Museum staff   |
| 2/28/2007 | Burned planted area using prescribed fire. North Carolina Division of Forest Resources  |

Table 5. History of Prairie 2B

| Date       | Management Activity  |
|------------|--|
| 3/10/2006  | Mowed tall fescue. Museum staff  |
| 10/13/2006 | Mowed tall fescue. Museum staff  |
| 10/18/2006 | Sprayed tall fescue with 2 percent Roundup (a formulation of glyphosphate). Museum staff   |
| 2/28/2007  | Burned using prescribed fire. North Carolina Division of Forest Resources  |
| 3/21/2007  | Using a no-till seed drill 24 lbs of the following seed from Ernst Conservation Seeds was planted: 35% Suther big bluestem grass ( <i>Andropogon gerardii</i> ), 35% Suther indian grass ( <i>Sorghastrum nutans</i> ), 30% Carthage switch grass ( <i>Panicum virgatum</i> ). |

Table 6. History of Old Pasture 1

| Date            | Management Activity   |
|-----------------|---|
| Summer annually | Periodic mowing of tall fescue. Basil cutting of Bradford Pear trees followed by immediate stump painting with 10 percent Roundup (a formulation of glyphosphate). Museum staff |

Management Objectives: Figure 6 shows how Piedmont Prairies, labeled “Grande Savane”, once covered a significant portion of the North Carolina Piedmont (Barden 1997). This community type was all but destroyed by early European colonists as they converted the grasslands to agricultural fields during the 1600 and 1700’s (Barden 1997). Piedmont prairie remnants have been found in disturbed areas along roadsides, utility right-of-ways, and railways (Davis, et. al., 2002). The majority of these piedmont prairie remnants are located on dry sites, with Iredell and

mafic soil types as key indicators (Earley 2004). Indicative prairie plant species have continued to exist, some of which are listed as threatened or endangered, and have led conservation biologists to infer how to define the natural community for restoration (Daves and Seriff 2003). However, there is no evidence to support the idea that prairie historically occurred at Prairie Ridge. A generic piedmont prairie community will be established using indicative species from a variety of North Carolina remnant prairies. This project aims to provide a prairie reconstruction rather than a restoration (Iowa Prairie Network 2004, Iowa Natural Heritage Foundation 2007).



Figure 6. Historic maps by early explorers show a “Grande Savanna” in the Piedmont. Guillaume Delisle. 1718. Carte de la Louisiane (Cumming 1962)

Given the high amount of uncertainty an active adaptive management (Walters and Holling 1990) technique should be employed to insure the successful reconstruction of Piedmont Prairie.

Active adaptive management will allow project managers to monitor their progress against a control site and make changes in their approach to reconstruction as necessary.

Initial Assessment: The reconstruction process begins with the definition of the desired habitat along with an initial assessment of the site to be managed. The site consists of abandoned cow pasture with compacted soils on a southwestern facing slope. The desired habitat is piedmont prairie, characterized by a dominance of warm season native grasses and forbs that are adapted to rocky xeric soils and are fire dependant (e.g. big bluestem, switch grass, gamma grass, blackberry, etc.). Many piedmont prairie remnants and restorations can be accurately described as *Andropogon virginicus* Herbaceous Alliances (ASW 11-94) (Daves 2003). *Andropogon virginicus* Herbaceous Alliance (ASW 11-94) is described as communities dominated by *Andropogon virginicus* occurring on old fields, pastures, and rocky sites (NatureServe 2006). Using this habitat model it is assumed that a site that is dominated (>75%) by warm season native grasses and forbs that are adapted to rocky xeric soils and are fire dependent is habitat. However, dominant species of remnant prairies are not necessarily a good indicator of other prairie species, and efforts to establish a community of high prairie species diversity should be made (Howe 1994).

The site is divided into five management zones. Each managed zone ranges between 1.31 acres (0.53 ha) and 3.21 acres (1.30 ha) in size, with the unmanaged control zone of 8.93 acres (3.62 ha). These zones are labeled Prairie 1A, Prairie 1B, Prairie 2A, Prairie 2B, and Old Pasture 1. The control zone (Old Pasture 1) is bordered along its western edge by a 4-lane, medium divided roadway.

Indicator species will be identified and used as measures for reconstruction success.

Traditionally only a single species taxon has been used to determine restoration success.

However, given the high amount of uncertainty associated with the natural community definition, sampling for a variety of taxa will provide a more robust model (Collins 1997).

Sampled taxa should be 1) available for sampling; 2) easy to determine occurrence and abundance; 3) be good indicators of success. Given these criteria, grassland birds, insects of the Order Orthoptera (grasshoppers, crickets, and katydids), and plant species indicative of piedmont prairies will be used as indicators. The indicator taxa have different levels of mobility and thus will provide a spatial component to the sampling. The sampled taxa include various abilities to disperse, which yields a dispersal ranking of birds > Orthopteroids > plants (Collins 1997).

Sampling is performed in all five zones using a clustered stratified random sampling method to determine two permanent reference points per management zone. These reference points will be used to determine locations of belt transects, point-intercept transects, bird observation transects and insect sweep sampling transects.

Prairie plant species will be sampled for diversity and percent cover. Species occurrence and diversity will be sampled by performing a 25-meter belt transect from each permanent reference point. The direction of the belt transects will be determined by taking an initial random bearing from each reference point. Subsequent belt transect samplings will follow the same bearings. Each transect consists of 25 adjacent 1-m<sup>2</sup> quadrats between two permanent start and end points. Transects are monitored by stretching a 25 meter tape between the start and end point. The quadrats are formed by placing three 1-meter sticks at 1-meter intervals along the extended tape



(Lesica 1987). Each quadrat is sampled for species diversity and abundance by recording individual stems of each species. The percent cover of different types of vegetation can provide valuable information regarding the effectiveness of different management techniques. The percent cover of four different vegetation types will be measured using the point-intercept method. At each permanent reference point an initial random bearing is taken to establish the direction of a 25-meter point-intercept transect. To form a transect a 25-meter tape is stretched from the reference point. A thin 1-meter long metal rod will be “dropped” vertically at 0.5-meter intervals along the tape. All plant species touching the rod are documented along with the number of times each species touches the rod. An estimate of total percent cover is calculated by dividing the total number of “hits” by the total number of “drops”. This data is converted into relative coverage to add to 100%. Plants are categorized as: shrubs (S), graminoids (grasses) (G), forbs (F), and vines (V). The total values are averaged for each management zone.

Grassland bird species will be sampled during January and May of each year. Sampling will consist of walking permanent midline transects through each zone. At 10-meter intervals birds seen or heard will be recorded. The abundance of each species is the total number of individuals counted along each transect (Collins 1997).

Orthopteroids (grasshoppers, crickets, and katydids) are sampled by sweeping with standard 38-cm sweep nets along 2 permanent 50-meter transects per management zone. These transects are established by taking a random bearing from the permanent reference points in each management zone. Each transect will remain the same for the duration of the project. Sampling consists of 6 sessions, each two weeks apart, beginning in late July to early August. Each session consists of

5 sets of 10 sweeps for a total of 50 sweeps per transect taken at 5-meter intervals. At the end of each session species of the Order Orthoptera (grasshoppers, crickets, and katydids) will be collected in plastic bags, refrigerated, identified, recorded and released.

Management Prescription: The following management prescription will enhance the reconstruction efforts on zones Prairie 1A, Prairie 1B, Prairie 2A, Prairie 2B, while leaving the control zone Old Pasture 1 unaltered. The current management consists of removing the fescue and Johnson grass by the use of broadcast spraying of with 2 percent Roundup (a formulation of glyphosphate) prior to introducing prairie species. Planting of prairie species should occur in the spring after the ground temperature reaches 55°F (Iowa Natural Heritage Foundation 2007). Once the desired species are in place the burn regime should manage the majority of invasive exotic species. Warm season native grasses are then planted, followed by native forbs. The use of native ecotypes is important in achieving an accurate reconstruction (Lown 2001).

Fire was an important part of the historic piedmont prairie community as many of the plant and animal species were dependant on disturbance (Barden 1997). Periodic fires were caused by Native Americans and lightning strikes. Lightning caused fires typically occurred during the summer growing season. Spring burns are most often desirable for warm season grasses with possible dates starting in March and ending in April. However, burning too early may stimulate the growth of unwanted species of clover and Queen Anne's Lace, and may injure blooming plants and over wintering insects (Iowa Natural Heritage Foundation 2007). Prescribed fire treatments result in the dominance of warm season native (C4) grasses and the loss of diversity of prairie plant species (Gibson 1993). The current fire regime consists of early spring burns

every two years and favors the dominance of warm season native grasses. More realistic and varied conditions will promote currently suppressed species and result in greater plant diversity (Howe 1994). Due to the urban location of Prairie Ridge, the scheduling of prescribed burning must be coordinated as not to negatively affect air quality. This prevents the use of prescribed fire between the months of May and September. Grasshopper diversity has been shown to increase with an increase in period between prescribed burns (Evans 1984). Growing season burns, when available, should be considered to promote early season plant species (Howe 1994). The grasslands in Mecklenburg County are burned on a staggered schedule once every three years to provide continuous habitat (Knight and Marshall 2002). The four managed zones should be burned alternately using prescribed fire every year to establish the introduced plants as the dominate species. This staggered approach will provide ample cover and habitat to minimize the disruption of animal species. Only one zone will be burned per year resulting in a total of 25% project area burn, this will allow each zone to be burned once every four years (Iowa Natural Heritage Foundation 2007).

A variety of management treatments should be used to promote diversity (Howe 1994). Mowing is a valuable tool in prairie management. Mowing can result in the establishment of invasive plant species if not combined with periodic prescribed fire (Gibson 1993). When mowing, removal of plant residue will increase the amount of plant diversity (Iowa Natural Heritage Foundation 2007). The Suther prairie site in Cabarrus County has always used the high quality hay produced by piedmont prairie grasslands to feed livestock (Knight and Marshall 2002).

The management approach for Prairie 1A, Prairie 1B, Prairie 2A, and Prairie 2B should include a combination of prescribed fire, mowing, and strategic herbicide treatments of invasive exotic species when necessary. The prescription for each zone is outlined in Table 7 and includes the control zone Old Pasture 1.

Table 7. The management prescription for each management zone

| Zone          | Planting Regime  | Herbicide Regime  | Mowing Regime   | Fire Regime                         | Public Access                           |
|---------------|--|---|---|-------------------------------------|---|
| Prairie 1A    | Initial hand seeded<br><i>Andropogon gerardii</i> ,<br><i>Sorghastrum nutans</i> ,<br><i>Panicum virgatum</i> ,<br><i>Coreopsis tinctoria</i> ,<br><i>Rudbeckia hirta</i> ,<br><i>Chasmanthium latifolium</i> ,<br><i>Penstemon laevigatus</i> ,<br><i>Coreopsis latifolia</i> | Initial 2 percent Roundup, Spot spray of 5 percent Roundup of<br><i>Sorghum halepense</i> | Mar. 2006<br>Jan. 2009<br>Nov. 2010<br>Nov. 2011              | Mar. 2005<br>Feb. 2007<br>Jan. 2008 | Visitor Access Trail                    |
| Prairie 1B    | Initial seed drill<br><i>Andropogon gerardii</i> ,<br><i>Sorghastrum nutans</i> ,<br><i>Panicum virgatum</i>   | Initial 2 percent Roundup, Spot spray of 5 percent Roundup of<br><i>Sorghum halepense</i> | Jan. 2008<br>Nov. 2010<br>Nov. 2011                           | Feb. 2007<br>Jan. 2009              | Visitor Access Trail                    |
| Prairie 2A    | Initial seed drill<br><i>Helianthus angustifolius</i> ,<br><i>Coreopsis lanceolata</i> ,<br><i>Bidens aristosa</i> ,<br><i>Tridens flavus</i> ,<br><i>Andropogon gerardii</i> ,<br><i>Sorghastrum nutans</i> ,<br><i>Panicum virgatum</i>                                      | Initial 2 percent Roundup, Spot spray of 5 percent Roundup of<br><i>Sorghum halepense</i> | Jan. 2008<br>Jan. 2009<br>Nov. 2011                           | Mar. 2005<br>Feb. 2007<br>Nov. 2010 | None                                    |
| Prairie 2B    | Initial seed drill<br><i>Andropogon gerardii</i> ,<br><i>Sorghastrum nutans</i> ,<br><i>Panicum virgatum</i>   | Initial 2 percent Roundup, Spot spray of 5 percent Roundup of<br><i>Sorghum halepense</i> | Jan. 2008<br>Jan. 2009<br>Nov. 2010<br>Nov. 2011              | Feb. 2007<br>Nov. 2011              | Visitor Access Trail along Western Edge |
| Old Pasture 1 | None   | Spot spray of 5 percent Roundup of<br><i>Sorghum halepense</i>                            | Apr. 2007<br>Jan. 2008<br>Jan. 2009<br>Nov. 2010<br>Nov. 2011 | Not Burned                          | None                                    |

Monitoring: All five sites should be monitored every two years using the same protocols as the initial assessment. Two year intervals will allow for the slow growing characteristics of many of the desired plants and provide a staggered period between prescribed burns. Data should be stored both electronically and in print to maximize its future utility.

Evaluation: Indicator plant species are currently used as an evaluation of piedmont prairie restoration (Davis 2002, Illinois – North Carolina Collaborative Environment for Botanical Resources 2003) elsewhere in North Carolina, and are suitable for the evaluation of prairie reconstruction at Prairie Ridge. Table 8 describes indicator species from both western and eastern regions of the North Carolina Piedmont prairie remnants. A conglomeration of the two regions will be used to gain an appropriate generic representation of a piedmont prairie reconstruction.

Sampling data from each management zone will be assessed for the occurrence of indicator species. Each plant species will be given a weighted value dependant on its value as an indicator of piedmont prairie. Invasive, weedy species such as Johnson grass will be assigned low weights. Desirable species will be given high weights stratified according to their value as an indicator, with strongly ubiquitous species weighted higher than species that are indicators of western or eastern piedmont prairies. Table 9 lists these weighted values by indicator category.

Table 8. Plant Indicator Species of N.C. Piedmont Prairies

| Ubiquitous Piedmont  | Ubiquitous (weak)         | Eastern Piedmont              | Western Piedmont   |
|--|---------------------------|-------------------------------|--|
| <i>Allium cernuum</i>  | <i>Manfreda virginica</i> | <i>Ageratina altissima</i>    | <i>Achillea millefolium</i>                                      |
| <i>Andropogon elliotii</i>   | <i>Matalea decipiens</i>  | <i>Berberis canadensis</i>    | <i>Agalinis setacea</i>  |
| <i>Andropogon gerardii</i>   |                           | <i>Cardamine douglassii</i>   | <i>Agalinis tenuifolia</i>                                       |
| <i>Andropogon glomeratus</i>   |                           | <i>Cercis canadensis</i>      | <i>Agave virginica</i>   |
| <i>Andropogon gyrans</i>   |                           | <i>Chionanthus virginicus</i> | <i>Allium bivalve</i>  |
| <i>Andropogon ternarius</i>  |                           | <i>Isoetes piedmontana</i>    | <i>Anemone berfiniana</i>  |
| <i>Andropogon virginicus</i>   |                           | <i>Lathyrus venosus</i>       | <i>Anemone berlandieri</i>                                       |
| <i>Aristida olagantha</i>  |                           | <i>Liatris squarrulosa</i>    | <i>Anemone caroliniana</i>                                       |
| <i>Aristida purpurescens</i>   |                           | <i>Lithospermum canescens</i> | <i>Asclepias amplexicaulis</i>                                   |
| <i>Arundinariagigantea</i>   |                           | <i>Marshallia obovata</i>     | <i>Asclepias incarnata</i>                                       |
| <i>Asclepias verticillata</i>  |                           | <i>Opuntia humifusa</i>       | <i>Asclepias syriaca</i>   |
| <i>Baptisia australis</i>  |                           | <i>Ruellia humilis</i>        | <i>Asclepias tuberosa</i>  |
| <i>Blephilia ciliata</i>   |                           | <i>Talinum teretifolium</i>   | <i>Asclepias variegata</i>                                       |
| <i>Clematis ochroleuca</i>   |                           | <i>Tragia urticifolia</i>     | <i>Asclepias viridiflora</i>                                     |
| <i>Delphinium exaltatum</i>  |                           | <i>Triosteum perfoliatum</i>  | <i>Baptisia albescens</i>  |
| <i>Echinacea laevigata</i>   |                           | <i>Ulmus alata</i>            | <i>Baptisia minor</i>  |
| <i>Elymus virginicus</i>   |                           |                               | <i>Bidens aristosa</i>   |
| <i>Eragrosticus spectabilis</i>  |                           |                               | <i>Bidens frondosa</i>   |
| <i>Isanthus brachiatus</i>   |                           |                               | <i>Castilleja coccinea</i>                                       |
| <i>Juniperus virginiana</i>  |                           |                               | <i>Ceanothus americanus</i>                                      |
| <i>Muhlenbergia capillaris</i>   |                           |                               | <i>Chamaecrista nictitans</i> var. <i>nictitans</i>              |
| <i>Panicum anceps</i>  |                           |                               | <i>Cirsium carolinianum</i>                                      |
| <i>Panicum clandestinum</i>  |                           |                               | <i>Conoclinium coelestinum</i> ( <i>Eupatorium coelestinum</i> ) |
| <i>Panicum virgatum</i>  |                           |                               | <i>Coreopsis major</i>   |
| <i>Parthenium integrifolium</i>  |                           |                               | <i>Coreopsis tinctoria</i>                                       |
| <i>Paspalum floridanum</i>   |                           |                               | <i>Coreopsis tripteris</i>                                       |
| <i>Quercus marilandica</i>   |                           |                               | <i>Desmodium sessilifolium</i>                                   |
| <i>Quercus stellata</i>  |                           |                               | <i>Echinacea pallida</i>   |
| <i>Ruellia caroliniensis</i>   |                           |                               | <i>Eryngium yuccifolium</i>                                      |
| <i>Ruellia purshiana</i>   |                           |                               | <i>Eupatorium album</i> var. <i>album</i>                        |
| <i>Saccarum brevibarbe</i> var. <i>contortum</i><br>( <i>Erianthus contortus</i> ) |                           |                               | <i>Eupatorium altissimum</i>                                     |
| <i>Schizachyrium scoparium</i>   |                           |                               | <i>Eupatorium fistulosum</i>                                     |
| <i>Silphium terebinthinaceum</i>   |                           |                               | <i>Eupatorium perfoliatum</i>                                    |
| <i>Oligoneuron rigidum</i> var. <i>glabratum</i><br>( <i>Solidago rigida</i> )     |                           |                               | <i>Eupatorium roundifolium</i>                                   |
| <i>Sorgastrum elliotii</i>   |                           |                               | <i>Eupatorium serotinum</i>                                      |
| <i>Sorgastrum nutans</i>   |                           |                               | <i>Euphorbia corollata</i>                                       |
| <i>Trichostema dichotomum</i>  |                           |                               | <i>Gentiana villosa</i>  |
| <i>Trichostema setaceum</i>  |                           |                               | <i>Helianthus atrorubens</i>                                     |
| <i>Tridens flavus</i>  |                           |                               | <i>Helianthus divaricatus</i>                                    |
| <i>Tripsacum dactyloides</i>   |                           |                               | <i>Helianthus laevigatus</i>                                     |
| <i>Verbena simplex</i>   |                           |                               | <i>Helianthus microcephalus</i>                                  |
|  |                           |                               | <i>Helianthus schweinitzii</i>                                   |
|  |                           |                               | <i>Helianthus strumosus</i>                                      |
|  |                           |                               | <i>Heterotheca mariana</i> ( <i>Chrysopsis mariana</i> )         |
|  |                           |                               | <i>Hexalectris spicata</i> var. <i>spicata</i>                   |
|  |                           |                               | <i>Lespedeza capitata</i>  |
|  |                           |                               | <i>Lespedeza procumbens</i>                                      |
|  |                           |                               | <i>Lespedeza repens</i>  |
|  |                           |                               | <i>Lespedeza virginica</i>                                       |
|  |                           |                               | <i>Liatris aspera</i>  |

| Ubiquitous Piedmont | Ubiquitous (weak) | Eastern Piedmont | Western Piedmont   |
|---------------------|-------------------|------------------|--|
|                     |                   |                  | <i>Liatris graminifolia</i>                                  |
|                     |                   |                  | <i>Liatris microcephalus</i>                                 |
|                     |                   |                  | <i>Liatris squarrosa</i>                                     |
|                     |                   |                  | <i>Lithospermum canescens</i>                                |
|                     |                   |                  | <i>Lithospermum caroliniense</i>                             |
|                     |                   |                  | <i>Lobelia cardinalis</i>                                    |
|                     |                   |                  | <i>Lobelia puberula</i>                                      |
|                     |                   |                  | <i>Lobelia spicata</i>                                       |
|                     |                   |                  | <i>Lotus helleri</i>   |
|                     |                   |                  | <i>Lysimachia tonsa</i>                                      |
|                     |                   |                  | <i>Mimulus alatus</i>  |
|                     |                   |                  | <i>Penstemon australis</i>                                   |
|                     |                   |                  | <i>Penstemon laevigatus</i>                                  |
|                     |                   |                  | <i>Phlox pilosa</i>  |
|                     |                   |                  | <i>Pityopsis graminifolia</i>                                |
|                     |                   |                  | <i>Pseudognaphalium helleri</i> var. <i>helleri</i>          |
|                     |                   |                  | <i>Rhus michauxii</i>  |
|                     |                   |                  | <i>Rosa carolina</i>   |
|                     |                   |                  | <i>Rudbeckia fulgida</i>                                     |
|                     |                   |                  | <i>Rudbeckia hirta</i>                                       |
|                     |                   |                  | <i>Sabatia angularis</i>                                     |
|                     |                   |                  | <i>Schrankia microphylla</i>                                 |
|                     |                   |                  | <i>Scutellaria elliptica</i>                                 |
|                     |                   |                  | <i>Scutellaria integrifolia</i>                              |
|                     |                   |                  | <i>Silphium asteriscus</i>                                   |
|                     |                   |                  | <i>Silphium compositum</i>                                   |
|                     |                   |                  | <i>Silphium trifoliatum</i>                                  |
|                     |                   |                  | <i>Stylosanthes biflora</i>                                  |
|                     |                   |                  | <i>Symphoricarpos orbiculatus</i>                            |
|                     |                   |                  | <i>Symphyotrichum concolor</i> ( <i>Aster concolor</i> )     |
|                     |                   |                  | <i>Symphyotrichum georgianum</i> ( <i>Aster georgianum</i> ) |
|                     |                   |                  | <i>Symphyotrichum laevis</i> var. <i>concinus</i>            |
|                     |                   |                  | <i>Symphyotrichum linarifolius</i>                           |
|                     |                   |                  | <i>Symphyotrichum patens</i>                                 |
|                     |                   |                  | <i>Symphyotrichum solidagineus</i>                           |
|                     |                   |                  | <i>Tephrosia spicata</i>                                     |
|                     |                   |                  | <i>Tephrosia virginiana</i>                                  |
|                     |                   |                  | <i>Thalictrum macrostylum</i>                                |
|                     |                   |                  | <i>Trifolium reflexum</i>                                    |
|                     |                   |                  | <i>Triostreum angustifolium</i>                              |
|                     |                   |                  | <i>Vernonia gigantea</i>                                     |
|                     |                   |                  | <i>Vernonia noveboracensis</i>                               |

Table 9. Indicator plant species weighted values

| Weighted Score | Vegetation Type  |
|----------------|--|
| 8              | Ubiquitous Piedmont  |
| 6              | Ubiquitous (Weak)  |
| 4              | Eastern Piedmont   |
| 4              | Western Piedmont   |
| 2              | Unlisted native plants                                       |
| 1              | <i>Festuca</i> spp. and <i>Cynodon dactylon</i>              |
| 0              | <i>Sorghum halepense</i> and other unlisted invasive species |

The data will be analyzed by averaging the weighted values of the samples to indicate how much change from pasture to piedmont prairie occurred using our previous habitat model. The results of the managed zones will be compared to the results of the control zone to measure the effectiveness of the management strategy. The physical differences (adjacent roadways, differences in hydrology, etc.) between the control zone and the managed zones should be taken into account to prevent the misinterpretation of the collected data. This could lead to an inaccurate evaluation of the results leading to a sub-optimal management treatment being chosen. The location of an adjacent roadway to the sample plot dictates the use of plant species as indicators due to their resistance to disruption by nearby automobile traffic. The management strategy is changed as needed to increase its effectiveness. The adaptive management model is illustrated by the heuristic diagram in Figure 7.

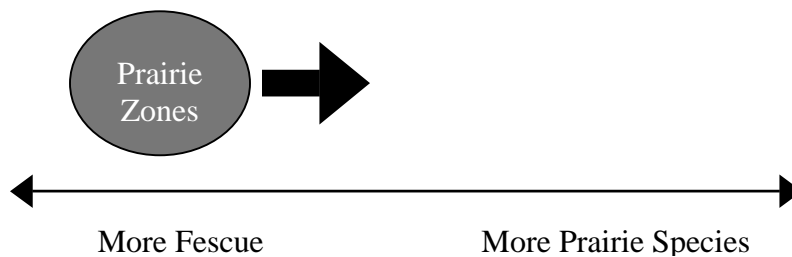


Figure 7. The initial heuristic diagram of the piedmont prairie reconstruction uses plants as indicators.



Many grassland bird species rely on areas with 25% - 70% grass cover and >90% total herbaceous cover (J. Marcus, North Carolina Wildlife Resources Commission, *public comm.*).

To achieve a historically accurate reconstruction a diversity of vegetation types should be promoted. The point intercept transects provide an approximate value of the vegetative diversity of each zone. The initial target values of percent cover for the managed zones are: <10% shrubs, 50% - 80% graminoids, and 20% - 50% forbs and vines.

A highly mobile and selective animal will be used as an indicator of prairie habitat to provide a more robust evaluation model. Grassland bird species will be used to determine the habitat value of the project area. Bird species will be weighted according to their association with tall grass grassland habitats. Species strongly associated will be assigned a higher weight than species that are loosely associated. Table 10 lists bird species and their weighted values by their association to tall grass grasslands. All unlisted birds are assigned a value of zero.

Table 10. Strong and Weak bird indicator species of prairies (Hunter 2001)

| <b>Strong Indicators<br/>Value of 4 each</b> | <b>Weak Indicators<br/>Value of 2 each</b> |
|--|--|
| Grasshopper Sparrow (Summer)                 | Yellow-breasted Chat (Summer)              |
| Eastern Meadowlark                           | Prairie Warbler (Summer)                   |
| Field Sparrow                                | Eastern Bluebird                           |
| Bachman's sparrow                            | Killdeer                                   |
| Loggerhead Shrike                            | Common Nighthawk (Summer)                  |
| American Kestrel                             | Palm Warbler (Winter)                      |
| Northern Bobwhite                            | Blue Grosbeak (Summer)                     |
| Vesper Sparrow (Winter)                      | Orchard Oriole (Summer)                    |
| Barn Owl                                     | Indigo Bunting (Summer)                    |
| Horned Lark                                  |  |
| Northern Harrier (Winter)                    |  |
| Upland Sandpiper (Migration)                 |  |
| Short-eared Owl (Winter)                     |  |
| Savannah Sparrow (Winter)                    |  |
| Bobolink (Migration)                         |  |
| Red-winged Blackbird                         |  |

The combination of both plant and bird indicator species changes the heuristic diagram as shown in Figure 8.

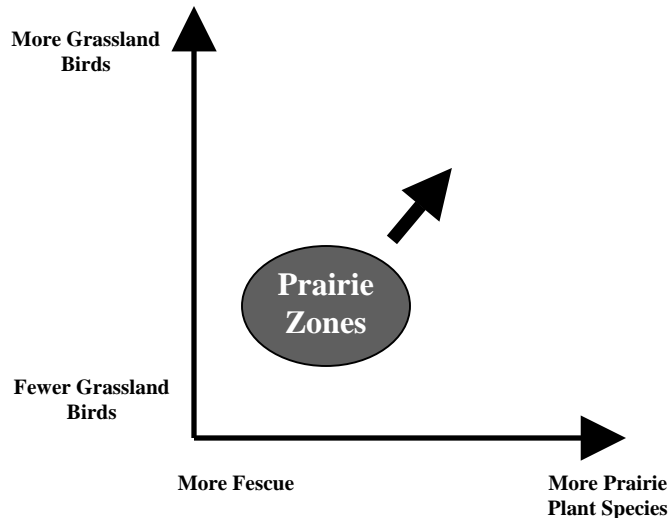


Figure 8. The heuristic diagram now contains both bird and plant indicator species.

Additional indicators can be used to provide a multidimensional assessment. One such proxy indicator is the species diversity of grasshoppers, crickets, and katydids (Order Orthoptera) among the five zones. Many of these species are selective in their diet and only consume select species of plants. They have been studied in regard to their ability to be used as prairie indicators (Bomar 2001). Their selective diets, combined with their size and ease of sampling should make them good indicators. Due to a high level of uncertainty regarding grasshopper diversity as an indicator of prairie, this indicator taxon should only be used in addition to plant and bird indicators, not as an independent decision tool. For the multidimensional assessment our heuristic diagram would be illustrated as in Figure 9.

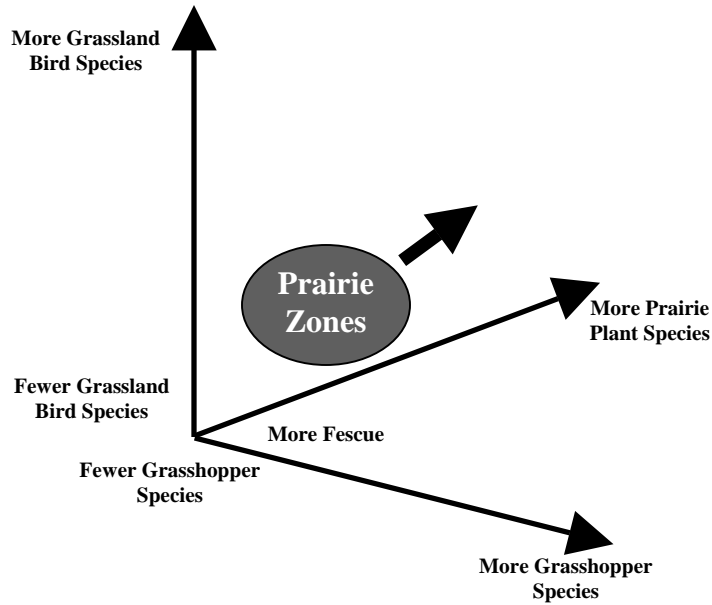


Figure 9. The final multidimensional heuristic diagram for piedmont prairie evaluation contains a variety of taxa.

Orthopteroid (grasshoppers, crickets, and katydids) diversity is measured as the number of species occurring in each management zone. As the pasture is changed to piedmont prairie an increase in orthopteroid diversity, prairie plant indicator species, and grassland bird species should occur. Each of the four managed prairie zones may yield different results due to the differences in management techniques and time of sampling. If the results of the evaluation are not satisfactory, a new management approach may be needed. The following multi-attribute decision making framework should be applied to provide an accurate and objective decision.

The decision consists of deciding which management prescription yields the best results for reconstructing piedmont prairie. The decision criteria include tolerance of public accessibility, levels of indicator species, and cost. Figure 10 represents the hierarchy of objectives for the decision. The primary decision maker is the Director of Prairie Ridge.

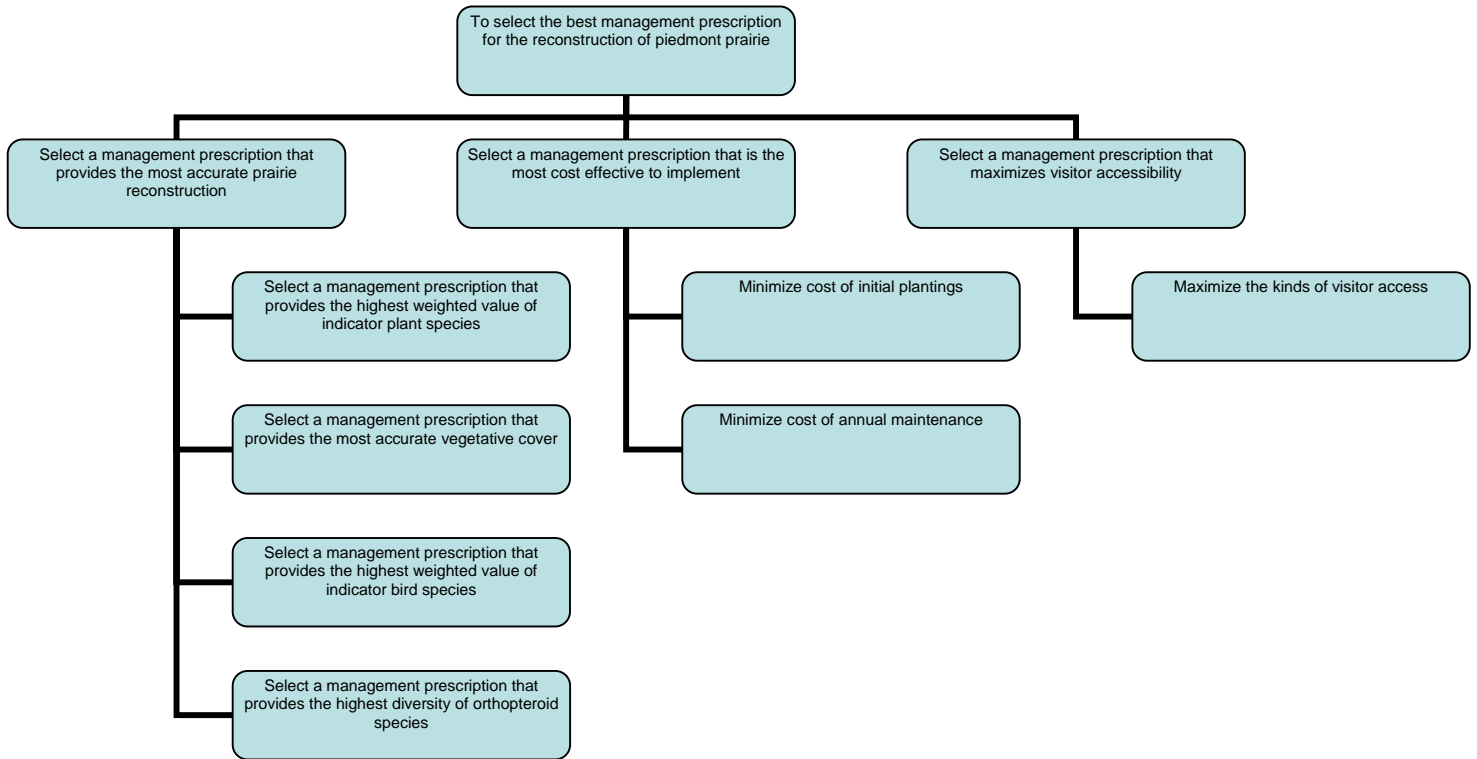


Figure 10. The decision hierarchy for the piedmont prairie reconstruction project incorporates a variety of objectives.

Each sub-element of the decision hierarchy is scored by an attribute. These attributes and their associated scales are described in table 11.

Table 11. Decision attributes and scales for the piedmont prairie reconstruction project

| Attribute                         | Scale  | Source of Data                                 |
|-----------------------------------|--|--|
| Amount of indicator plant species | Averaged total weighted value of sampled species | Averaged value of belt transect samples        |
| Accuracy of vegetative cover type | percentage                                       | Percentage accuracy of point intercept samples |
| Amount of indicator bird species  | Averaged total weighted value of sampled species | Averaged value of observation samples          |
| Amount of orthopteroid diversity  | Amount of species sampled                        | Total species sampled from sweep transects     |
| Initial cost of plantings         | Monetary cost of labor and materials             | Financial records                              |
| Annual cost of maintenance        | Monetary cost of labor and materials             | Financial records                              |
| Amount of visitor access          | Types of visitor access available                | Site inventories and maps                      |

The majority of the attributes are measured using natural scales. Constructed scaling is used for the amount of visitor access. The following scale represents visitor access values, 1=Worst, 6=Best:

- 1 – No visitor access to the management zone
- 2 – Visitor access to the perimeter of the management zone via a public trail
- 3 – Visitor access to the interior of the management zone via a public trail
- 4 – Visitor access to the perimeter and the interior of the management zone via a public trail
- 5 - Visitor and educational group access to the interior of the management zone via a public trail
- 6 - Visitor and educational group access to the perimeter and the interior of the management zone via a public trail

For each evaluation session the attribute scores will be calculated from the identified sources.

The utility of each attribute must be established. Each attribute's utility will be calculated using its score and the following two methods. The proportional method will be used to score the utility values for the following attributes:

- Amount of indicator plant species
- Accuracy of vegetative cover type
- Amount of indicator bird species
- Amount of Orthopteroid diversity
- Initial cost of plantings
- Annual cost of maintenance

The ratio method will be used to determine the utility of the amount of visitor access.

Once the utility scores for each of the five management zone options are determined, the swing weighting solicitation method will be used to assign a weight to each attribute value. An additive multi-attribute utility function can then be calculated to provide an objective best choice.

The adaptive management process dictates that the process now continues to management, followed by monitoring, and back to assessment. This closed loop will continue until only monitoring and assessment are needed.

Management Considerations: The high amount of uncertainty regarding the composition of piedmont prairie natural communities affects the validity of any results. The aim of the

reconstruction project is to provide an area for the study and demonstration of piedmont prairies. To this end, visitor and group access to the project area is important and necessary. Management techniques should be used that are available to the public as a whole. The ability to advise landowners on how to establish piedmont prairie communities on their properties is important and should be considered when making management decisions.

Variation in burn seasons will promote species diversity. Early spring burns will continue to provide a dominance of warm season native grasses and inhibit early flowering forb species. The flowering period of prairie species should be examined and used to determine the season of prescribed fire (Howe 1994). Growing season burns may not be possible due to air quality regulations governing the assignment of burn permits within Raleigh city limits.

As in any restoration or reconstruction project genetic integrity of introduced species is important to maintain an accurate community. Only North Carolina ecotypes should be introduced to the project area. Ideally, only species that are found in remnant communities with similar habitats should be considered. However, the idea of a “generic” piedmont prairie may not provide an accurate model for a valid natural community. The use of seed sources from a variety of remnant North Carolina sites may negatively affect the validity of the reconstruction.

The site of Prairie Ridge’s piedmont prairie reconstruction has a soil type that is different than those of remnant prairie sites. Differences in soil pH, nutrient content, and structure may have a significant effect on the diversity of indicator species that the project site can sustain. Future

reconstruction efforts on the site should include a detailed approach to soil amendments where necessary.

The use of Old Pasture 1 as a control plot is less than ideal. The adjacent location of Edwards Mill Road and the intermittent stream formed by a drainage ditch are features that may affect the results of sampling done in the management zone. The increased level of soil moisture and different soil type could affect plant species diversity found adjacent to the stream. Animal species diversity and abundance sampled adjacent to the roadway could be affected. Caution should be used when inferring information from data collected at these sites.

The conversion of Old Pasture 1 into piedmont prairie should be considered once the adaptive management cycle ceases to provide useful information. The Old Pasture 1 management zone would provide a contiguous grassland corridor to surrounding pastures and thus provide a larger core habitat for grassland species.



## Educational Lowland Arboretum

Summary: The establishment of a lowland forest arboretum showcasing bottomland forest tree species breeding groups from across North Carolina.



Figure 11. The Educational Lowland Arboretum management project

Goals: To establish a diverse planting of native trees and shrubs which will serve as teaching specimens, seed sources for planting at school grounds and other locations, enhance the wildlife potential of the area, serve as an ex-situ preservation site for some species and create a visual and sound buffer zone between the site and Edwards Mill Road (J. Perry, North Carolina State Museum of Natural Sciences, *pers. comm.*)

Site Description: The Lowland Forest 1 zone is dominated by Warsham sandy loam (Wy) soil (United States 1970). The Lowland Forest 2 zone consists of a combination of Wehadkee and Bibb (Wo) soil with Colfax sandy loam (Cn) along wet ditch areas (United States 1970). The project area is predominately flat and bordered along the northern edge by the Hedgerow special project area and along the southern edge by the Piedmont Bottomland Forest Restoration project area as shown in Figure 11. The project area forms the floodplain of Prairie Ridge.

Zones: Lowland Forest 1, Lowland Forest 2

Project Size: 6.67 acres (2.70 ha)

Strategy: Native tree species introduction and maintenance to stimulate seed production. Removal of invasive exotic species is a priority to minimize competition with the arboretum species.

Funding: Additional funding through the Natural Resources Conservation Service's Urban Forestry Program grant.

Site History and Past Management: The project area was previously used as pasture by North Carolina State University. The project area has been used to establish 86 species of lowland trees as an educational arboretum. Table 12 lists the tree species that will make up the completed arboretum. Individual trees are caged to prevent damage from white-tail deer (*Odocoileus virginianus*) and other herbivores. Volunteer native species of shrubs, forbs, and grasses have been allowed to grow up in the absence of grazing pressure. The trees are weeded and watered to aid in establishment.

Table 12. Proposed tree species for the Educational Lowland Arboretum

**Lowland Arboretum Species**

| <b>Scientific Name</b>       | <b>Common Name</b> |
|------------------------------|--------------------|
| <i>Tsuga canadensis</i>      | Eastern hemlock    |
| <i>Pinus strobus</i>         | Eastern white pine |
| <i>Pinus virginiana</i>      | Virginia pine      |
| <i>Pinus echinata</i>        | Shortleaf pine     |
| <i>Pinus palustris</i>       | Longleaf pine      |
| <i>Pinus serotina</i>        | Pond pine          |
| <i>Taxodium distichum</i>    | Bald cypress       |
| <i>Juniperus virginiana</i>  | Eastern red cedar  |
| <i>Quercus shumardii</i>     | Shumard oak        |
| <i>Quercus michauxii</i>     | Swamp chestnut oak |
| <i>Quercus pagoda</i>        | Cherrybark oak     |
| <i>Quercus rubra</i>         | Northern red oak   |
| <i>Quercus alba</i>          | White oak          |
| <i>Quercus lyrata</i>        | Overcup oak        |
| <i>Quercus muehlenbergii</i> | Chinkapin oak      |
| <i>Quercus bicolor</i>       | Swamp white oak    |
| <i>Quercus palustris</i>     | Pin oak            |
| <i>Quercus laurifolia</i>    | Laurel oak         |
| <i>Quercus phellos</i>       | Willow oak         |
| <i>Fagus grandifolia</i>     | American beech     |
| <i>Celtis laevigata</i>      | Sugar berry        |
| <i>Ulmus americana</i>       | American elm       |
| <i>Ulmus rubra</i>           | Slippery elm       |
| <i>Carya ovata</i>           | Shagbark hickory   |
| <i>Carya laciniosa</i>       | Shellbark hickory  |
| <i>Juglans nigra</i>         | Black walnut       |

| Scientific Name                | Common Name            |
|--------------------------------|------------------------|
| <i>Magnolia grandiflora</i>    | Southern magnolia      |
| <i>Magnolia macrophylla</i>    | Bigleaf magnolia       |
| <i>Magnolia virginiana</i>     | Sweet bay              |
| <i>Liriodendron tulipifera</i> | Tulip tree             |
| <i>Amelanchier arborea</i>     | Service berry          |
| <i>Prunus serotina</i>         | Black cherry           |
| <i>Prunus caroliniana</i>      | Carolina laurel cherry |
| <i>Crataegus marshallii</i>    | Parsley hawthorn       |
| <i>Cercis canadensis</i>       | Redbud                 |
| <i>Cladastris kentuckia</i>    | Yellowwood             |
| <i>Ilex opaca</i>              | American holly         |
| <i>Ilex vomitoria</i>          | Yaupon                 |
| <i>Ilex decidua</i>            | Possumhaw              |
| <i>Ilex verticillata</i>       | Winterberry            |
| <i>Acer rubrum</i>             | Red maple              |
| <i>Acer saccharinum</i>        | Silver maple           |
| <i>Acer barbatum</i>           | Southern sugar maple   |
| <i>Aesculus pavia</i>          | Red buckeye            |
| <i>Aesculus sylvatica</i>      | Painted buckeye        |
| <i>Sassafras albidum</i>       | Sassafras              |
| <i>Persea borbonia</i>         | Red bay                |
| <i>Liquidamber styraciflua</i> | Sweetgum               |
| <i>Platanus occidentalis</i>   | American sycamore      |
| <i>Tilia caroliniana</i>       | Carolina basswood      |
| <i>Nyssa sylvatica</i>         | Black gum              |
| <i>Nyssa aquatica</i>          | Water tupelo           |
| <i>Cornus florida</i>          | Flowering dogwood      |
| <i>Symplocos tinctoria</i>     | Sweetleaf              |
| <i>Myrica cerifera</i>         | Southern wax myrtle    |
| <i>Halesia carolina</i>        | Carolina silverbell    |
| <i>Diospyros virginiana</i>    | American persimmon     |
| <i>Chionanthus virginicus</i>  | Fringe tree            |
| <i>Fraxinus pennsylvanica</i>  | Green ash              |
| <i>Fraxinus profunda</i>       | Pumpkin ash            |
| <i>Fraxinus americana</i>      | White ash              |
| <i>Salix nigra</i>             | Black willow           |
| <i>Populus deltoides</i>       | Eastern cottonwood     |
| <i>Populus heterophylla</i>    | Swamp cottonwood       |
| <i>Pawpaw</i>                  | Asimina triloba        |

Management Objectives: The project's objectives include the establishment of an educational arboretum of native lowland tree species. This arboretum will serve as a seed source of native lowland tree species from across North Carolina.

Initial Assessment: The project area is currently free of invasive exotic species. More than two thirds of the 350 individual trees have been planted thus far with the remaining to be planted in late 2007. Many of the trees are juveniles and will take some time to produce seeds.

Management Prescription: Continue the monitoring and maintenance of established trees and the removal of invasive exotic species.

Monitoring: Pedestrian surveys should be done twice per year to locate invasive species. Population size and location should be recorded for all species. The health and vigor of established trees should be visually surveyed on a periodic basis.

Evaluation: The project should be evaluated on the successful fruiting of the established tree species. The continued absence of invasive exotic species should also be evaluated.

Management Considerations: The continued maintenance of individual trees will continue to be a time consuming task for Museum staff. Volunteers should be trained and used for this continued maintenance.

The project area currently serves as nesting habitat for many grassland and shrubland bird species. As the project area ages and grows, this nesting habitat will be replaced by nesting habitat for woodland species. The Hedgerow special project area is needed to provide a continued shrub layer for these nesting birds.

## Upland Forest Restoration

Summary: The restoration of a dry-mesic oak hickory forest by removing invasive exotic species and re-establishing native herb, shrub and understory species.



Figure 12. The Upland Forest Restoration Management Project

Goals: To restore a severely disturbed dry-mesic oak hickory forest to its natural state while providing recreation opportunities via hiking trails and educational opportunities via exotic invasive species research.

Site Description: Figure 12 illustrates this project's site. Cecil gravelly sandy loam (CgC2) and Cecil sandy loam (CeD) make up the soil types for this project area (United States 1970). The area has a significant southeastern slope and is covered in a disturbed dry-mesic oak hickory forest (Schafale and Weakley 1990).

Zones: Upland Forest

Project Size: 1.98 acres (0.80 ha)

Strategy: Exotic invasive species will be removed in conjunction with native understory species introduction. A Museum facilitated educational research project will establish the effectiveness of the strategy by comparing sample plots.

Funding: Additional funding for the educational research component through the National Geographic Society's *Strange Days on Planet Earth* grant.

Site History and Past Management: The project area was previously owned and managed by North Carolina State University. The history of the university's management of the site is as of yet unknown. A single track public access trail was established through the project area in the

spring of 2006. A portion of the trail was renovated to provide Americans with Disabilities Act access in January of 2007. During construction of the trail, invasive exotic species were partially removed from the project area.

Management Objectives: The project will restore the area to a viable remnant of a dry-mesic oak hickory forest and provide a study area for the removal of invasive exotic plant species. The project will provide a vegetative barrier to a future road right-of-way.

Initial Assessment: Remnant tree species found in the project area combined with soil type and topography indicates the project area is a disturbed dry-mesic oak hickory forest (Schafale and Weakley 1990). The project area includes several invasive exotic species including: Chinese privet (*Ligustrum sinense*), Bradford pear trees (*Pyrus calleryana* 'Bradford'), Multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stiltgrass (*Microstegium vimineum*).

Management Prescription: Mechanically remove Bradford pear trees (*Pyrus calleryana* 'Bradford'), Chinese privet (*Ligustrum sinense*), Multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stiltgrass (*Microstegium vimineum*), painting the stumps of Bradford pear trees (*Pyrus calleryana* 'Bradford'), Chinese privet (*Ligustrum sinense*) and Multiflora rose (*Rosa multiflora*) with 10 percent Roundup (a formulation of glyphosphate). Establish native shrub, understory tree, and herbs indicative of dry-mesic oak hickory forest to inhibit the re-establishment of invasive exotics and provide a visual barrier to a



future road right-of-way. Paired meter quadrats will be reserved for the study of invasive plant removal studies along the southern half of the project area.

Monitoring: Pedestrian surveys should be done twice per year to locate Bradford pear trees (*Pyrus calleryana* 'Bradford'), Chinese privet (*Ligustrum sinense*), Multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stiltgrass (*Microstegium vimineum*). Population size and location should be recorded for all species. The health and vigor of re-established native species should be surveyed. Monitoring of study quadrants should be used as a proxy for the entire project area.

Evaluation: A successful restoration will be accomplished once three consecutive annual surveys demonstrate the absence of invasive exotic species and the continued presence of species indicative of the dry-mesic oak hickory forest natural community (Schafale and Weakley 1990).

A statistical analysis of the study quadrants should be used as a proxy for the entire project area's success.

Management Considerations: The extensive ingrowth of invasive exotic species will require a long term approach. The future road construction will fragment the project area from the surrounding woodlands and may cause a decline in species diversity.

## Piedmont Bottomland Forest Restoration

Summary: The restoration of a piedmont bottomland forest through the removal of invasive exotic species.



Figure 13. The Piedmont Bottomland Forest Restoration Management Project

Goals: To restore a disturbed piedmont bottomland forest to its natural state to enhance the wildlife potential of the area and to provide a demonstration of the piedmont bottomland forest natural community.

Site Description: This narrow site is located on the northern banks of a perennial tributary of Richland Creek that forms the southern boarder of Prairie Ridge, as shown in Figure 13. The project area is 545 meters in length and 2 – 6 meters in width. The Educational Lowland Arboretum borders the project's northern edge. The soil type is predominately Warsham sandy loam (Wy) (United States 1970). The natural community can be best described as piedmont bottomland forest (Schafale and Weakley 1990).

Zones: Lowland Forest 3

Project Size: 545 linear meters

Strategy: The removal of invasive exotic species in conjunction with native understory species introduction.

Funding: Additional funding through the Natural Resources Conservation Urban Forestry Program grant and in-kind assistance by the North Carolina State University Student Fisheries Society.

Site History and Past Management: The project area has been the site of selective removal of invasive exotic species by Museum staff paid through the Urban Forestry Program. The North Carolina State University Student Fisheries Society held annual volunteer workdays in 2005 and 2006. During these workdays, club volunteers and Museum staff cleared the stream of construction debris and removed large quantities of Japanese stiltgrass (*Microstegium vimineum*) followed by planting the disturbed areas with Virginia wild rye (*Elymus virginicus*). The club is expected to continue its relationship with the project area in the future.

Management Objectives: The primary objective is to restore the project area to a Piedmont Bottomland Forest natural community (Schafale and Weakley 1990), by the removal of invasive exotic species and the reintroduction of native herb, shrub, and understory species.

Initial Assessment: The natural community can be best described as piedmont bottomland forest (Schafale and Weakley 1990). A pedestrian survey of the project area has shown that the canopy is dominated by tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), and red maple (*Acer rubrum*). There are scattered individuals of black walnut (*Juglans nigra*), common persimmon (*Diospyros virginiana*), black cherry (*Prunus srotina*), and boxelder (*Acer negundo*). There are significant patches of river cane (*Arundinaria gigantean*) along the stream bank and blackberry (*Rubus spp.*) shrubs along the northern edge. The understory is lacking diversity due to the impact of invasive exotic species. Chinese privet (*Ligustrum sinense*), Russian olive (*Elaeagnus angustifolia*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stiltgrass (*Microstegium vimineum*) occur along the northern edge of the project area.

Management Prescription: The initial step is the removal and control of invasive exotic species. Mechanical removal of invasive exotics should be utilized. Due to the project area's high concentration of native species and its location adjacent to a stream herbicides are not appropriate. The removal of herbaceous invasive exotic species such as Japanese stiltgrass (*Microstegium vimineum*) can be removed with the appropriate use of controlled fire when weather conditions are appropriate. Once cleared, areas should be immediately replanted with native herbs, shrubs and understory trees characteristic to the piedmont bottomland forest natural community (Schafale and Weakley 1990). Where appropriate, river cane (*Arundinaria gigantea*) should be established. This will form a natural barrier to help prevent the reestablishment of invasive exotics.

Monitoring: Continued monitoring of the project area will be needed to 1) monitor for the presence of invasive exotic species and 2) monitor the health of reintroduced native species. This monitoring can take the form of simple pedestrian surveys of the entire project area at the minimum frequency of once per year.

Evaluation: A successful restoration will be accomplished once three consecutive annual surveys demonstrate the absence of invasive exotic species and the continued presence of species indicative of the Piedmont Bottomland Forest natural community (Schafale and Weakley 1990).

Management Considerations: Blackberry (*Rubus spp.*) should be controlled and kept to a minimum to prevent it from becoming invasive. Newly established plants should be protected or

caged to prevent damage from herbivory and deer rubbing. The mechanical removal of invasive exotics is a good opportunity to utilize volunteer groups.

## Old Pasture Management

Summary: To maintain the current old pasture area until further management decisions can be made and funded.



Figure 14. The Old Pasture Management Project

Goals: This project will maintain the current old pasture area until further management decisions can be made and funded while managing against invasive exotic species.

Site Description: The project area is bordered to the northwest by Edwards Mill Road, a 4-lane medium divided route as illustrated in Figure 14. There is a significant southeastern slope that runs along the project area and is punctuated by a ditch that forms an intermittent stream. This ditch has been dammed to form the Perennial Pond special project area. Both zones contain an ephemeral pool special project area, and the Old Pasture 1 zone contains a Milkweed special project area. The Old Pasture 2 zone contains a Blackberry (*Rubus spp.*) Thicket special project area. The soils are Cecil gravelly sandy loam (CgC2) with Colfax sandy loam (Cn) along the wet ditch area (United States 1970).

Zones: Old Pasture 1, Old Pasture 2

Project Size: 14.47 acres (5.86 ha)

Strategy: This project aims to remove invasive exotic species.

Funding: In-kind assistance by Hands-on Raleigh volunteers, no additional funding has been identified.

Site History and Past Management: The project area was previously managed as a tall fescue (*Festuca spp.*) pastureland. The removal of grazing pressure has resulted in the establishment of invasive Bradford pear trees (*Pyrus calleryana* 'Bradford') and native blackberry (*Rubus spp.*)



and common milkweed (*Asclepias verticillata*). The project area is mowed every summer to maintain the grassland. The drainage ditch was dammed to form the Perennial Pond special project area. Volunteer groups assisted Museum staff in the removal of Bradford pear trees (*Pyrus calleryana* 'Bradford') in the spring and summer of 2006.

Initial Assessment: Tall fescue (*Festuca* spp.), Bermuda grass (*Cynodon dactylon*), and sparse patches of Johnson grass (*Sorghum halepense*) dominate the project area. Volunteer species include thickets of common milkweed (*Asclepias verticillata*) and blackberry (*Rubus* spp.), and individual Bradford pear trees (*Pyrus calleryana* 'Bradford').

Management Prescription: A systematic removal of exotic invasive species including Bradford pear trees (*Pyrus calleryana* 'Bradford') and Johnson grass (*Sorghum halepense*). Bradford pear trees (*Pyrus calleryana* 'Bradford') should be mechanically cut at ground level, removed, and the stumps painted with 10 percent Roundup (a formulation of glyphosphate). Johnson grass (*Sorghum halepense*) should be broadcast sprayed with 2 percent Roundup (a formulation of glyphosphate).

Monitoring: Pedestrian surveys should be conducted twice per year to locate Bradford pear trees (*Pyrus calleryana* 'Bradford') and Johnson grass (*Sorghum halepense*). The population size and location should be recorded for both species.

Evaluation: The removal of invasive exotics should be evaluated on the success of current methods. Continued growth of Bradford pear trees (*Pyrus calleryana* 'Bradford') and Johnson

grass (*Sorghum halepense*) populations will indicate the failure of control methods and will dictate the need for more aggressive action.

Management Considerations: The invasive exotic species should be controlled as soon as possible to prevent the spread into adjacent project areas. Volunteers should be supervised when removing invasive exotic species. Zone Old Pasture 1 will be used as a control plot for the Piedmont prairie reconstruction project and will be a future extension of prairie habitat. The Old Pasture 2 zone should be converted to native species grassland to prevent the spread of Tall fescue (*Festuca* spp.) and Bermuda grass (*Cynodon dactylon*) into adjacent project areas until other management plans for the zone are developed.

## Blackberry Thicket Special Project Area

Summary: Large thickets of native volunteer blackberry (*Rubus spp.*) will be managed to provide cover for reptiles and mammals and nesting habitat for a variety of grassland and shrubland birds.



Figure 15. The Blackberry Thicket Special Project Area

Goals: This project will provide nesting habitat for grassland and shrubland bird species while improving wildlife forage and cover.

Site Description: Figure 15 shows the location of the special project areas. The soil of the thickets is primarily Cecil sandy loam (CeD) (United States 1970). The thickets form an impenetrable shrub layer that readily spreads into the neighboring pasture and prairie.

Zones: Prairie 2B, Old Pasture 2

Project Size: < 0.5 acres (0.40 ha) in total area.

Strategy: The project will manage native blackberry (*Rubus spp.*) thickets.

Funding: No additional funding has been identified.

Site History and Past Management: The project areas were managed by North Carolina State University as pasture. In the absence of grazing, blackberry (*Rubus spp.*) has been allowed to thrive. The project area's perimeter has been maintained by annual mowing. Mist nets have been used to sample the bird species in and near the project area.

Management Objectives: The objective of the project is to maintain blackberry (*Rubus spp.*) thickets as shrubland bird nesting sites and wildlife cover.

Initial Assessment: Numerous species of birds have been observed foraging in the project area. Eastern cottontail rabbits and groundhogs have been observed using the project area as cover.

Management Prescription: Continue to maintain the project area by annually mowing the edges of the thickets to prevent further colonization of blackberry (*Rubus spp.*).

Monitoring: The mist netting and banding bird of species should continue. An inventory of bird species caught in and adjacent to the project area should be compiled. A small mammal survey should be done every two years to sample the diversity and population size of mammals using the project area.

Establishing an annual breeding season point count survey will monitor bird species breeding behavior in the project area.

Evaluation: Evaluation of bird and mammal species that are using the project area can be used as a proxy for the health of the surrounding zones. Bird and mammal surveys should be evaluated to measure population or diversity increases or declines. Changes in these populations could indicate problems in the surrounding management zones.

Management Considerations: The size and inaccessibility of the project area prevents bird nest surveys. Herbicides and pesticides should not be used in close proximity of the project area due to human consumption of the mast.

## Ephemeral Pool Special Project Area

Summary: A series of constructed vernal pools will provide breeding habitat for a wide variety of amphibians.



Figure 16. The Ephemeral Pool Special Project Area

Goals: The project will enhance amphibian, crustacean, and aquatic insect larva breeding potential.

Site Description: The project area spans several zones as shown in Figure 16. The project area contains a variety of soil types: Cecil gravelly loam (CgC2), Colfax sandy loam (Cn), Warsham sandy loam (Wy), Wehadkee and Bibb (Wo), and Cecil sandy loam (CeD) (United States 1970). Each ephemeral pool is 223 square meters in area on average.

Zones: Lowland Forest 1, Lowland Forest 2, Old Pasture 1, Old Pasture 2

Project Size: 0.36 acres (0.14 ha) total area

Strategy: To establish and maintain a series of artificial vernal pools.

Funding: Natural Resources Conservation Service Wetlands Reserve Program grant, no additional funding has been identified.

Site History and Past Management: The various project sites were previously used as pasture by North Carolina State University. The excavation of six ephemeral pools and three ditch plugs along a secondary drainage provide breeding areas for amphibians and insects. Casual visual surveys of the project sites have provided evidence of amphibian and insect colonization. Water levels in the three ditch plug areas and the northern most ephemeral pool have proven to be perennial.

Management Objectives: To provide breeding habitat for native amphibian and insect species.

Initial Assessment: Casual surveys by Museum staff indicate that the two northern ephemeral pools and the three ditch plugs are sites of amphibian breeding with numerous tadpoles. An increased diversity of *Odonata* species have been observed on the property, however this does not indicate that the species are breeding in the project area. The remaining ephemeral pools have retained less water and amphibians have not been observed in them.

Management Prescription: Native species of herbs and shrubs should be allowed to colonize the edges of the project areas to provide cover for amphibians and perches for *Odonata* species. In the absence of voluntary colonization such vegetation should be established.

Monitoring: A systematic auditory survey of mating amphibians should be done annually to monitor the population size and diversity of amphibian species utilizing the project area. Educational opportunities should be explored through the use of Project Frogwatch or other citizen science amphibian surveys. Visual surveys of *Odonata* species should be done annually to record their use of the project area.

Evaluation: The project area should be evaluated for species diversity and population size of amphibians and *Odonata* species.



Management Considerations: Educational programs that involve sampling aquatic fauna from the project areas should be monitored closely to prevent erosion and species depletions. Invasive exotic species should be prevented from colonizing the project area.

## Perennial Pond Special Project Area

Summary: A perennial pond has been established to manage stormwater runoff erosion and provide wildlife habitat improvement.



Figure 17. The Perennial Pond Special Project Area

Goals: To provide best management practices for storm water runoff and enhance wildlife habitat potential for shorebirds, waterfowl, and amphibians.

Site Description: The underlying soil of the project area is Colfax sandy loam (Cn) (United States 1970). An earthen dam that impedes an intermittent stream defines the project area. A drainage ditch, shown in Figure 17, forms the stream.

Zones: Large Pond

Project Size: 0.54 acres (0.22 ha)

Strategy: The project will establish and maintain a perennial pond by damming an ephemeral stream.

Funding: Additional funding provided by the North Carolina Clean Water Trust Fund.

Site History and Past Management: The project site was originally an incised drainage ditch. An effort to improve stormwater management and wildlife habitat resulted in damming the area in 2005. No management of the project area has been done since construction.

Management Objectives: To prevent the erosion of the pond shoreline, improve habitat for migratory waterfowl, and increase breeding habitat for amphibians.

Initial Assessment: The pond's shoreline has voluntarily re-vegetated. Native wetland species of rushes and sedges have colonized the pond's edge providing cover for adult amphibians and migratory waterfowl. Diverse populations of frogs, waterfowl, and shorebirds have been surveyed at the project area.

Management Prescription: Vegetation along the pond's edge should be preserved to provide cover for wildlife and prevent erosion.

Monitoring: A systematic auditory survey of mating amphibians should be done annually to monitor the population size and diversity of amphibian species utilizing the project area. Educational opportunities should be explored through the use of Project Frogwatch or other citizen science amphibian surveys. Visual surveys of waterfowl and shorebirds should be done annually to record their use of the project area.

Evaluation: The project area should be evaluated for species diversity and population size of amphibians and migratory waterfowl and shorebirds.

Management Considerations: Educational programs that involve sampling aquatic fauna from the pond should be monitored closely to prevent erosion and species depletions. Invasive exotic species should be prevented from colonizing the project area.

## Hedgerow Special Project Area

Summary: An invasive exotic species infested fence will be converted into a hedgerow of native species.



Figure 18. The Hedgerow Special Project Area

Goals: To manage the current hedgerow for wildlife habitat enhancement. The hedgerow will provide nesting habitat for a variety of grassland and shrubland birds and cover for a variety of reptiles and mammals.

Site Description: Figure 18 illustrates the project area that is defined by a remnant barbed wire fence that runs along the northern edge of the Lowland Forest 1 and 2 zones. This fence has become colonized by a combination of native and invasive exotic species of early successional shrubs. The soils are a combination of: Warsham sandy loam (Wy), Cecil sandy loam (CeD), and Colfax sandy loam (Cn).

Zones: Lowland Forest 1, Lowland Forest 2

Project Size: 483 linear meters

Strategy: Passive adaptive management through invasive species and barbed wire removal in conjunction with native vine and shrub species introduction will be used to manage the project.

Funding: No additional funding has been identified.

Site History and Past Management: The site consists of a wire and barbed wire fence separating two pastures. The lack of grazing pressure has allowed Bradford pear (*Pyrus calleryana* 'Bradford') and multiflora rose (*Rosa multiflora*) to colonize the project area. Regular mowing along both sides of the fencerow have prevented the spread of vegetation.

Management Objectives: The objectives include the removal of exotic invasive species and remnant barbed wire fencing from the hedgerow, establishing a diversity of native early successional shrub species, and increasing the abundance of nesting grassland and shrubland birds within the hedgerow.

Initial Assessment: Pedestrian surveys indicate early successional native species including Eastern red cedar (*Juniperus virginiana*), black cherry (*Prunus srotina*), and pokeberry (*Phytolacca americana*) are established along the fencerow. Bradford pear (*Pyrus calleryana* 'Bradford') and multiflora rose (*Rosa multiflora*) are in abundance, completing the hedgerow.

Management Prescription: Mechanical removal of the remnant barbed wire fencing followed by the removal of invasive exotic species. Invasive exotic species should be removed mechanically if their size allows. For larger individuals, cut the specimen at ground level followed by an immediate application of a 5 percent Roundup (a formulation of glyphosphate). A diversity of native early successional shrub species should be planted along the fencerow to fill in the hedge and prevent the re-establishment of invasive exotic species.

Monitoring: Monitoring for invasive exotic species should be accomplished with bi-annual pedestrian surveys in July and November. Any invasive exotic species that are found should be recorded and removed.

Additional monitoring for an increase in nesting by grassland and shrubland birds should be done annually through a project area nest survey using nest search methods (Martin and Geupel 1993). A guide to these methods can be is available from the National Forest Service on the world wide web at <http://www.fs.fed.us/psw/publications/documents/gtr-144/05-nest.html> (Ralph, et. al. 1993). These survey results should be used as part of the Museum's partnership with the Cornell Laboratory of Ornithology's citizen science nest monitoring project NestWatch.

Evaluation: Exotic invasive species have been shown to impact the nesting success of shrubland birds (Schmidt and Whelan 1999). Nests built in multiflora rose (*Rosa multiflora*) are predated upon 25% more often than those in native shrubs (Borgmann and Rodewald 2004). The project area should be evaluated on the loss of invasive exotic species coupled with the increase in nesting success of grassland and shrubland birds shown by the heuristic diagram shown in Figure 19.

Management Considerations: The monitoring phase of this project may require significant time and resources. The lack of additional funding for this project and the limited staff time may prevent this project from being monitored successfully. Student interns, volunteers, and the Educator of Excellence in Residence should be encouraged to adopt this project.



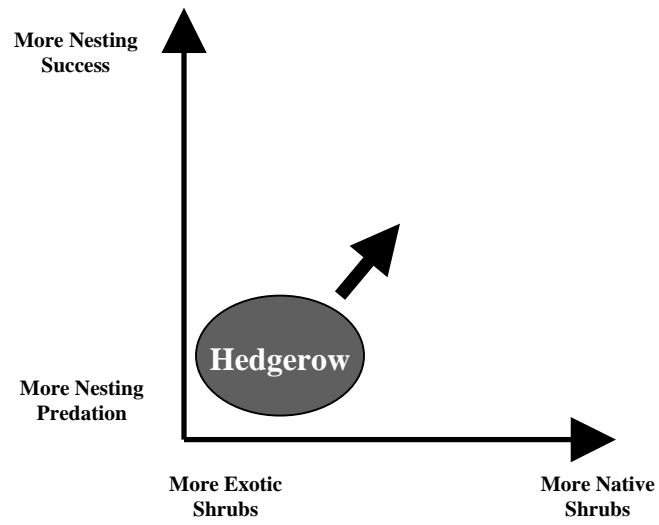


Figure 19. The heuristic diagram of the evaluation model of the Hedgerow special project area includes two types of indicators

## Wildlife Habitat Garden Special Project Area

Summary: A collection of thematic gardens serves as demonstrations of how to provide wildlife habitat in residential areas.



Figure 20. The Wildlife Habitat Garden Special Project Area

Goals: To provide demonstration areas of how to enhance wildlife habitat in urban and suburban sites using landscaping. To provide a research area for citizen science projects including low level ozone monitoring and the Monarch Larval Monitoring Project.

Site Description: The soil of the project area is Cecil gravelly sandy loam (CgC2) (United States 1970). The area has a southwestern slope and is surrounded by deer fencing and individual deer caging. The project area is shown in Figure 20.

Zones: N/A

Project Size: 0.32 acres (0.13 ha) in total area.

Strategy: The creation of wildlife habitat using a variety of gardens including: a nectar garden, a larval garden, aquatic gardens, a bog garden, an ozone garden, and mast producing gardens.

Funding: No additional funding has been identified.

Site History and Past Management: The site has been used as cow pasture in the past. The project areas have been planted with raised beds including plants for nectar and bird forage. An ozone monitoring plot has been established with specially cloned specimens for citizen science monitoring.

Management Objectives: To provide aesthetically pleasing landscapes to demonstrate and encourage homeowners to establish similar wildlife friendly landscapes of their own. Manage plantings to maintain study areas for a variety of citizen science projects. To provide enhanced wildlife forage for a variety of animals.

Initial Assessment: The current garden areas are largely undeveloped. These areas are affected by poor quality soil and the lack of artificial irrigation.

Management Prescription: Develop a wildlife habitat garden master plan. Install hardscape and irrigation first, followed by garden bedding and the establishment of native species of plants that are beneficial to wildlife and easily maintained and available to local homeowners.

Monitoring: Weekly monitoring of plant health is essential to identify specimens under stress. A simple weekly pedestrian survey should be sufficient.

Evaluation: Ensure that the project area is serving its purpose by providing aesthetically pleasing gardens and educational opportunities in the form of citizen science study sites.

Management Considerations: The clear communication of the purpose of the gardens should be made a priority. Irrigation should be considered a good investment due to the temperate climate and the small facility staff to maintain the project area.

## Milkweed Study Special Project Area

Summary: Two separate patches of common milkweed (*Asclepias verticillata*) are used as data collection sites for the Monarch Larval Monitoring Project. Growth season mowing will be used to postpone natural senescence of the plants.



Figure 21. The Milkweed Study Special Project Area

Goals: To provide patches of common milkweed to enhance wildlife habitat and provide study areas for citizen science projects such as the Monarch Larval Monitoring Project.

Site Description: Both areas of the project are shown in Figure 21. The Old Pasture 1 zone project area is located on a moderate southeasterly slope adjacent to the Large Pond zone. The soil is Cecil gravelly sandy loam (CgC2) (United States 1970). The project area is surrounded by tall fescue (*Festuca* spp.).

The Lowland Forest 2 zone project area is located on moderately level ground running east to west along the northern edge of the Lowland Forest 2 zone. The Hedgerow Special Project Area is located immediately to the north. The soil is Cecil sandy loam (CeD) (United States 1970).

Zones: Old Pasture 1, Lowland Forest 2

Project Size: Less than 0.50 acre (0.20 ha) in total area.

Strategy: The adaptive management of two large patches of common milkweed including strategic mowing to prolong the growing season.

Funding: No additional funding has been identified.

Site History and Past Management: Both areas were utilized as pasture by North Carolina State University previous to 2000. The program areas have been used by Museum staff to collect data

for the Monarch Larval Monitoring Project, facilitated by the University of Minnesota, in 2004, 2005, and 2006.

Management Objectives: To promote the healthy annual growth of common milkweed (*Asclepias verticillata*) in patches of >100 stems through September.

Initial Assessment: Both areas consist of common milkweed (*Asclepias verticillata*) populations of >100 stems that have emerged in the absence of grazing by large herbivores. Both patches demonstrate high annual senescence in August and September.

Management Prescription: To prolong growth, half of the Old Pasture 1 zone project area should be mowed in late July to prevent senescence and encourage new growth. The Lowland Forest 2 zone project area should remain unmown. Both areas should continue to be monitored.

Monitoring: Monitoring of the project areas will follow the Monarch Larval Monitoring Project protocol recording vegetative cover and health.

Evaluation: Vegetative cover and health should be compared using the Monarch Larval Monitoring Project data to gauge the effectiveness of the mowed area in preventing senescence and prolonging the growth season of common milkweed (*Asclepias verticillata*). If the mowed area demonstrates a significantly longer growth season, defined by the prevention of senescence in the mowed area until the end of September, then the management prescription should be

altered to include partial mowing of both areas. If there is no demonstrable difference then mowing should be stopped.

Management Considerations: Both areas are considered study sites of the Monarch Larval Monitoring Project and care should be given when disturbing them. Detailed descriptions of any management activities should be kept to reference during data submission to the project. Care should be taken to note any abnormal growth conditions (e.g. weather) to prevent false results when evaluating the effectiveness of the management activity.



## CHAPTER FOUR DISCUSSION

### **Management on a Landscape Scale**

Prairie Ridge cannot be managed as an island. External sources of both physical and biological resources play a major role in shaping the area. Highly mobile species such as birds, insects, and large mammals utilize Prairie Ridge for foraging, but may not depend on the site for breeding or survival. Prairie Ridge currently lacks the minimum core habitat needed to sustain many of the bird species documented on at site (J. Marcus, North Carolina Wildlife Resources Commission, *public comm.*). Many of the mammal species found at the site disperse from neighboring forests. When making management decisions neighboring habitat and disturbances must be taken into account.

Prairie Ridge is located at the southeastern end of a corridor of State owned open space. This corridor includes William B. Umstead State Park, Carl Alwin Schenck Memorial Forest, North Carolina State University agricultural pasture, and to a lesser extent the North Carolina Art Museum's Art Park. Figure 22 illustrates this open space corridor. The open space within this corridor provides habitat for a diverse amount of native flora and fauna. As the neighboring properties experience changes so will the diversity of animals and plants currently found at Prairie Ridge. The North Carolina National Guard is located adjacent to Prairie Ridge along the site's eastern border. As part of a major base expansion, a two lane public road is planned to run along this border establishing a barrier for many species of animals. The forest remnants that are currently found along the eastern border will be removed for the base expansion and will impact the biodiversity at Prairie Ridge. In addition to the North Carolina National Guard base

expansion, the property along the southern border of Prairie Ridge will become home to a new State office building resulting in the loss of additional forested acres.

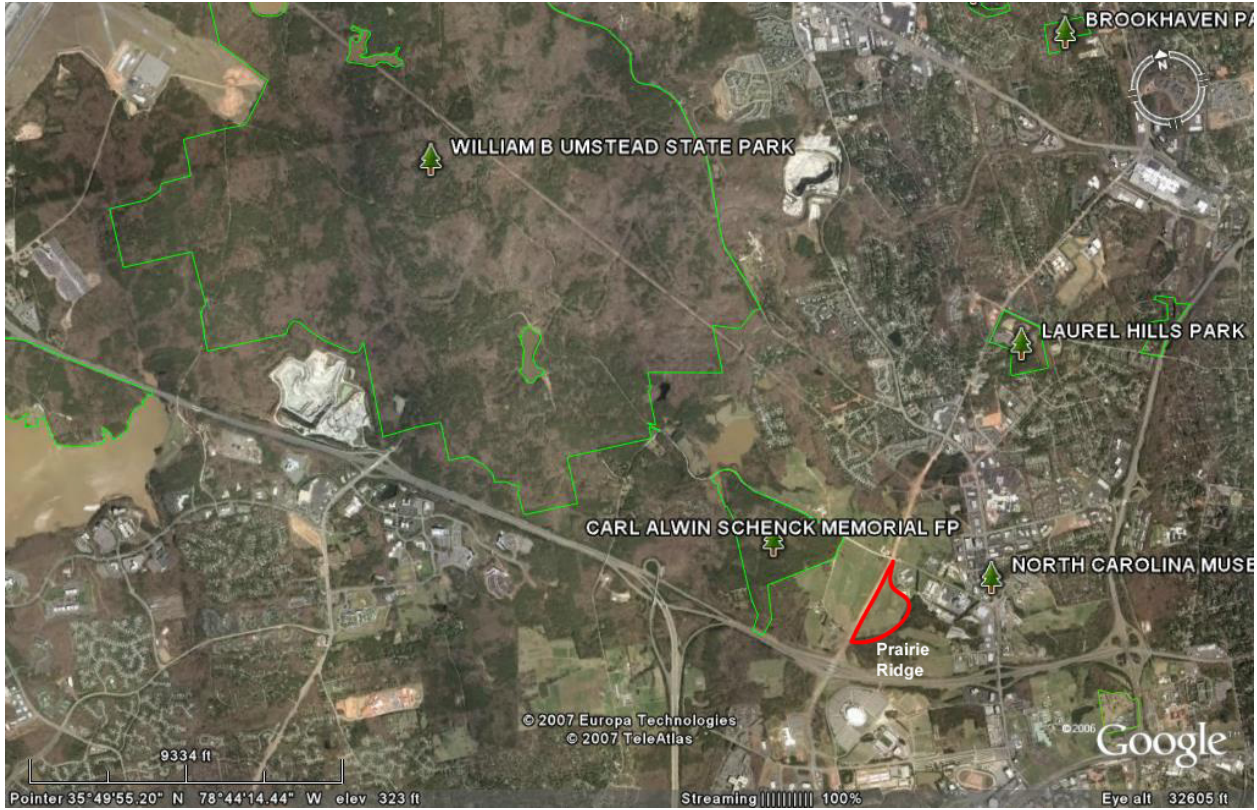


Figure 22. The open space corridor

The Museum should seek to mitigate the impacts of these projects whenever possible. In addition to working with neighboring landowners, the Museum should consider purchasing adjacent properties of open space to preserve the effects of the current corridor and expand the amount of potential habitat at Prairie Ridge. Figure 23 illustrates potential properties to consider for purchase.

Prairie Ridge should plan its resource management to coincide with that of its neighbor's. This will allow Prairie Ridge to take advantage of adjacent habitats and expand the utility of its own.

Large grassland areas that remain un-fragmented are important to a variety of grassland bird species (Hunter et al 2001). With the restoration of large, un-fragmented grasslands many prairie associated birds species have been re-established (Earley 2004). The piedmont prairie reconstruction project should be allowed to expand into zone Old Pasture 1 to take advantage of adjacent pasture to create a contiguous grassland habitat for birds and insects.



Figure 23. Properties to consider for purchase

## **Education Versus Preservation**

The primary purpose for Prairie Ridge is to provide a venue for educational research and programming. Secondary to this purpose is the promotion and conservation of natural resources. These purposes are complimentary on the surface. However, public visitation, research and educational activities can damage the resources they use. This creates a potential for conflicting purposes that should be managed using decision analysis tools (Prato 2001).

As Prairie Ridge continues to develop, its use by public visitors and student groups will grow. An analytic approach, determining the carrying capacity of public and study areas within Prairie Ridge, should be developed to provide a conservation-based approach to resource use.

With prior planning and forethought the negative effects of intensive use can be minimized and abated.

## **Needs for further Study**

The Museum's creation of a field station for education and research presents many opportunities and challenges. Natural resource management is a new challenge for the Museum and presents an opportunity to examine ecosystems with a new lens, that of ecology. The Museum has historically focused on the taxonomy and systematics of individual taxa. Prairie Ridge will showcase the interactions of these taxa with one another and their physical surroundings.

The use of decision analysis to determine the carrying capacity of visitors should be examined and developed on the management project level.

A comprehensive planting regime should be developed for the Upland Forest Restoration and the Lowland Forest Restoration projects. A quantitative monitoring and evaluation method should be developed to measure the success of these projects.

The restoration of cane break natural communities should be examined as a possible special area management project. Cane breaks have become an increasingly rare habitat in North Carolina and should be promoted and preserved.

The flora colonizing the assorted vernal and perennial pools and ponds should be monitored and categorized.

The various management projects present many opportunities for participation by student groups. Whenever possible these groups should be involved in the monitoring activities of the projects. Similar projects should be promoted on school grounds to facilitate the comparison of results.

## APPENDIX I.

### SPECIES DOCUMENTED AT PRAIRIE RIDGE

#### **Snails**

*Gastrocopta contracta*

*Glyphalinia wheatleyi*

*Triodopsis hopetonensis*

*Triodopsis juxtidentis*

*Ventridens cerinoideus*

*Ventridens gularis*

*Zonitoides arboreus*

*Deroceras reticulatum* Gray Garden Slug

#### **Centipedes**

*Hemiscolopendra marginata*

*Scolopocryptops sexspinosus*

*Scutigera coleoptrata*

#### **Millipedes**

*Narceus americanus*

*Oxidus gracilis*

#### **Crayfishes**

*Cambarus* “*acuminatus* complex” (= “species C”)

*Cambarus (Depressicambarus) latimanus*

#### **Grasshoppers**

*Melanoplus keeleri*

Keeler's Spurthroated Grasshopper

*Schistocerca americana*

American Bird Grasshopper

*Orchelimum vulgare*

Red Faced Meadow Katydid

*Conocephalus strictus*

Straight-lanced Meadow Katydid

*Oecanthus celerinictus*

Fast Calling Tree Cricket

#### **Dragonflies/damselflies**

*Anax junius*

Common Green Darner

*Celithemis eponina*

Halloween Pennant

*Libellula luctuosa*

Widow Skimmer

*Orthemis ferruginea*

Roseate Skimmer

*Perithemis tenera*

Eastern Amberwing

*Erythemis simplicicollis*

Eastern Pondhawk

*Tramea carolina*

Carolina Saddlebags

*Enallagma civile*

Familiar Bluet

*Libellula lydia*

Common Whitetail

**Butterflies**

|                                    |                           |
|------------------------------------|---------------------------|
| <i>Battus philenor</i>             | Pipevine Swallowtail      |
| <i>Papilio glaucus</i>             | Eastern Tiger Swallowtail |
| <i>Papilio polyxenes</i>           | Black Swallowtail         |
| <i>Colias eurytheme</i>            | Alfalfa Butterfly         |
| <i>Phoebis sennae</i>              | Cloudless Sulphur         |
| <i>Pieris rapae</i>                | Cabbage Butterfly         |
| <i>Pontia protodice</i>            | Checkered White           |
| <i>Everes comyntas</i>             | Eastern Tailed Blue       |
| <i>Danaus plexippus</i>            | Monarch                   |
| <i>Euptoieta claudia</i>           | Variiegated Fritillary    |
| <i>Junonia coenia</i>              | Common Buckeye            |
| <i>Limenitis arthemis astyanax</i> | Red-spotted Purple        |
| <i>Phyciodes tharos</i>            | Pearl Crescent            |
| <i>Vanessa atalanta</i>            | Red Admiral               |
| <i>Vanessa virginiensis</i>        | American Lady             |
| <i>Atalopedes campestris</i>       | Sachem                    |
| <i>Lerema accius</i>               | Clouded Skipper           |
| <i>Epargyreus clarus</i>           | Silver-spotted Skipper    |
| <i>Pyrgus communis</i>             | Checkered Skipper         |

**Fish**

|                                |                      |
|--------------------------------|----------------------|
| <i>Luxilus albeolus</i>        | White Shiner         |
| <i>Nocomis leptocephalus</i>   | Bluehead Chub        |
| <i>Semotilus atromaculatus</i> | Creek Chub           |
| <i>Erimyzon oblongus</i>       | Creek Chubsucker     |
| <i>Ameiurus natalis</i>        | Yellow Bullhead      |
| <i>Lepomis auritus</i>         | Redbreast Sunfish    |
| <i>Lepomis cyanellus</i>       | Green Sunfish        |
| <i>Lepomis gibbosus</i>        | Pumpkinseed          |
| <i>Lepomis macrochirus</i>     | Bluegill             |
| <i>Micropterus salmoides</i>   | Largemouth Bass      |
| <i>Gambusia holbrooki</i>      | Eastern Mosquitofish |
| <i>Etheostoma nigrum</i>       | Johnny Darter        |

### **Amphibians**

|                                  |                                |
|----------------------------------|--------------------------------|
| <i>Desmognathus fuscus</i>       | Northern Dusky Salamander      |
| <i>Eurycea chamberlaini</i>      | Chamberlain's Dwarf Salamander |
| <i>Eurycea cirrigera</i>         | Southern Two-lined Salamander  |
| <i>Bufo americanus</i>           | American Toad                  |
| <i>Bufo fowleri</i>              | Fowler's Toad                  |
| <i>Acris crepitans</i>           | Northern Cricket Frog          |
| <i>Hyla chrysoscelis</i>         | Cope's Gray Treefrog           |
| <i>Hyla cinerea</i>              | Green Treefrog                 |
| <i>Hyla squirella</i>            | Squirrel Treefrog              |
| <i>Pseudacris feriarum</i>       | Upland Chorus Frog             |
| <i>Rana catesbeiana</i>          | Bullfrog                       |
| <i>Rana clamitans</i>            | Green Frog                     |
| <i>Rana sphenoccephala</i>       | Southern Leopard Frog          |
| <i>Rana palustris</i>            | Pickerel Frog                  |
| <i>Gastrophryne carolinensis</i> | Eastern Narrowmouth Toad       |

### **Reptiles**

|                                 |                               |
|---------------------------------|-------------------------------|
| <i>Chelydra serpentina</i>      | Common Snapping Turtle        |
| <i>Terrapene carolina</i>       | Eastern Box Turtle            |
| <i>Eumeces fasciatus</i>        | Five-lined Skink              |
| <i>Eumeces inexpectatus</i>     | Southeastern Five-lined Skink |
| <i>Eumeces laticeps</i>         | Broadhead Skink               |
| <i>Scincella lateralis</i>      | Ground Skink                  |
| <i>Carphophis amoenus</i>       | Eastern Worm Snake            |
| <i>Coluber constrictor</i>      | Black Racer                   |
| <i>Diadophis punctatus</i>      | Ringneck Snake                |
| <i>Elaphe obsoleta</i>          | Black Rat Snake               |
| <i>Lampropeltis calligaster</i> | Mole Kingsnake                |
| <i>Nerodia sipedon</i>          | Northern Water Snake          |
| <i>Opheodryx aestivus</i>       | Rough Green Snake             |
| <i>Storeria dekayi</i>          | Brown Snake                   |
| <i>Thamnophis sirtalis</i>      | Eastern Garter Snake          |

### **Birds**

|                              |                     |
|------------------------------|---------------------|
| <i>Anser anser</i>           | Greylag Goose       |
| <i>Branta canadensis</i>     | Canada Goose        |
| <i>Anas platyrhynchos</i>    | Mallard             |
| <i>Anas clypeata</i>         | Northern Shoveler   |
| <i>Lophodytes cucullatus</i> | Hooded Merganser    |
| <i>Ardea herodias</i>        | Great Blue Heron    |
| <i>Butorides virescens</i>   | Green Heron         |
| <i>Cathartes aura</i>        | Turkey Vulture      |
| <i>Pandion haliaetus</i>     | Osprey              |
| <i>Circus cyaneus</i>        | Northern Harrier    |
| <i>Accipiter striatus</i>    | Sharp-shinned Hawk  |
| <i>Accipiter cooperii</i>    | Cooper's Hawk       |
| <i>Buteo lineatus</i>        | Red-shouldered Hawk |
| <i>Buteo platypterus</i>     | Broad-winged Hawk   |



**Birds** (continued)

|                                   |                               |
|-----------------------------------|-------------------------------|
| <i>Buteo jamaicensis</i>          | Red-tailed Hawk               |
| <i>Haliaeetus leucocephalus</i>   | Bald Eagle                    |
| <i>Falco sparverius</i>           | American Kestrel              |
| <i>Charadrius vociferus</i>       | Killdeer                      |
| <i>Tringa melanoleuca</i>         | Greater Yellowlegs            |
| <i>Tringa flavipes</i>            | Lesser Yellowlegs             |
| <i>Tringa solitaria</i>           | Solitary Sandpiper            |
| <i>Actitis macularia</i>          | Spotted Sandpiper             |
| <i>Calidris minutilla</i>         | Least Sandpiper               |
| <i>Gallinago delicata</i>         | Wilson's Snipe                |
| <i>Scolopax minor</i>             | American Woodcock             |
| <i>Larus delawarensis</i>         | Ring-billed Gull              |
| <i>Columba livia</i>              | Rock Pigeon (Feral Pigeon)    |
| <i>Zenaida macroura</i>           | Mourning Dove                 |
| <i>Coccyzus americanus</i>        | Yellow-billed Cuckoo          |
| <i>Tyto alba</i>                  | Common Barn-Owl               |
| <i>Bubo virginianus</i>           | Great Horned Owl              |
| <i>Chaetura pelagica</i>          | Chimney Swift                 |
| <i>Archilochus colubris</i>       | Ruby-throated Hummingbird     |
| <i>Ceryle alcyon</i>              | Belted Kingfisher             |
| <i>Melanerpes erythrocephalus</i> | Red-headed Woodpecker         |
| <i>Melanerpes carolinus</i>       | Red-bellied Woodpecker        |
| <i>Sphyrapicus varius</i>         | Yellow-bellied Sapsucker      |
| <i>Picoides pubescens</i>         | Downy Woodpecker              |
| <i>Picoides villosus</i>          | Hairy Woodpecker              |
| <i>Colaptes auratus</i>           | Northern Flicker              |
| <i>Dryocopus pileatus</i>         | Pileated Woodpecker           |
| <i>Empidonax vireescens</i>       | Acadian Flycatcher            |
| <i>Sayornis phoebe</i>            | Eastern Phoebe                |
| <i>Myiarchus crinitus</i>         | Great Crested Flycatcher      |
| <i>Tyrannus tyrannus</i>          | Eastern Kingbird              |
| <i>Lanius ludovicianus</i>        | Loggerhead Shrike             |
| <i>Vireo olivaceus</i>            | Red-eyed Vireo                |
| <i>Vireo griseus</i>              | White-eyed Vireo              |
| <i>Cyanocitta cristata</i>        | Blue Jay                      |
| <i>Corvus brachyrhynchos</i>      | American Crow                 |
| <i>Corvus ossifragus</i>          | Fish Crow                     |
| <i>Progne subis</i>               | Purple Martin                 |
| <i>Stelgidopterx serripennis</i>  | Northern Rough-winged Swallow |
| <i>Hirundo rustica</i>            | Barn Swallow                  |
| <i>Poecile carolinensis</i>       | Carolina Chickadee            |
| <i>Baeolophus bicolor</i>         | Tufted Titmouse               |
| <i>Sitta canadensis</i>           | Red-breasted Nuthatch         |
| <i>Sitta carolinensis</i>         | White-breasted Nuthatch       |
| <i>Sitta pusilla</i>              | Brown-headed Nuthatch         |
| <i>Certhia americana</i>          | Brown Creeper                 |
| <i>Thryothorus ludovicianus</i>   | Carolina Wren                 |
| <i>Troglodytes aedon</i>          | House Wren                    |
| <i>Regulus satrapa</i>            | Golden-crowned Kinglet        |

**Birds** (continued)

|                                  |                        |
|----------------------------------|------------------------|
| <i>Regulus calendula</i>         | Ruby-crowned Kinglet   |
| <i>Poliophtila caerulea</i>      | Blue-gray Gnatcatcher  |
| <i>Sialia sialis</i>             | Eastern Bluebird       |
| <i>Hylocichla mustelina</i>      | Wood Thrush            |
| <i>Turdus migratorius</i>        | American Robin         |
| <i>Dumetella carolinensis</i>    | Gray Catbird           |
| <i>Mimus polyglottos</i>         | Northern Mockingbird   |
| <i>Toxostoma rufum</i>           | Brown Thrasher         |
| <i>Sturnus vulgaris</i>          | European Starling      |
| <i>Bombycilla cedrorum</i>       | Cedar Waxwing          |
| <i>Parula americana</i>          | Northern Parula        |
| <i>Dendroica petechia</i>        | Yellow Warbler         |
| <i>Dendroica coronata</i>        | Yellow-rumped Warbler  |
| <i>Dendroica pinus</i>           | Pine Warbler           |
| <i>Dendroica discolor</i>        | Prairie Warbler        |
| <i>Dendroica palmarum</i>        | Palm Warbler           |
| <i>Dendroica striata</i>         | Blackpoll Warbler      |
| <i>Geothlypis trichas</i>        | Common Yellowthroat    |
| <i>Piranga rubra</i>             | Summer Tanager         |
| <i>Pipilo erythrophthalmus</i>   | Eastern Towhee         |
| <i>Spizella passerina</i>        | Chipping Sparrow       |
| <i>Spizella pusilla</i>          | Field Sparrow          |
| <i>Chondestes grammacus</i>      | Lark Sparrow           |
| <i>Passerculus sandwichensis</i> | Savannah Sparrow       |
| <i>Ammodramus savannarum</i>     | Grasshopper Sparrow    |
| <i>Melospiza melodia</i>         | Song Sparrow           |
| <i>Melospiza georgiana</i>       | Swamp Sparrow          |
| <i>Zonotrichia leucophrys</i>    | White-crowned Sparrow  |
| <i>Zonotrichia albicollis</i>    | White-throated Sparrow |
| <i>Junco hyemalis</i>            | Dark-eyed Junco        |
| <i>Cardinalis cardinalis</i>     | Northern Cardinal      |
| <i>Passerina caerulea</i>        | Blue Grosbeak          |
| <i>Passerina cyanea</i>          | Indigo Bunting         |
| <i>Sturnella magna</i>           | Eastern Meadowlark     |
| <i>Dolichonyx oryzivorus</i>     | Bobolink               |
| <i>Agelaius phoeniceus</i>       | Red-winged Blackbird   |
| <i>Quiscalus quiscula</i>        | Common Grackle         |
| <i>Molothrus ater</i>            | Brown-headed Cowbird   |
| <i>Icterus spurius</i>           | Orchard Oriole         |
| <i>Icterus galbula</i>           | Baltimore Oriole       |
| <i>Carpodacus mexicanus</i>      | House Finch            |
| <i>Carduelis tristis</i>         | American Goldfinch     |
| <i>Passer domesticus</i>         | House Sparrow          |

**Mammals**

|                                 |                             |
|---------------------------------|-----------------------------|
| <i>Didelphis virginiana</i>     | Virginia Opossum            |
| <i>Blarina carolinensis</i>     | Southern Short-tailed Shrew |
| <i>Eptesicus fuscus</i>         | Big Brown Bat               |
| <i>Lasiurus borealis</i>        | Red Bat                     |
| <i>Homo sapiens</i>             | Human                       |
| <i>Sylvilagus floridanus</i>    | Eastern Cottontail          |
| <i>Marmota monax</i>            | Woodchuck                   |
| <i>Sciurus carolinensis</i>     | Eastern Gray Squirrel       |
| <i>Castor canadensis</i>        | Beaver                      |
| <i>Sigmodon hispidus</i>        | Hispid Cotton Rat           |
| <i>Mus musculus</i>             | House Mouse                 |
| <i>Canis latrans</i>            | Coyote                      |
| <i>Canis familiaris</i>         | Dog                         |
| <i>Vulpes vulpes</i>            | Red Fox                     |
| <i>Urocyon cinereoargenteus</i> | Gray Fox                    |
| <i>Felis catus</i>              | House Cat                   |
| <i>Procyon lotor</i>            | Common Raccoon              |
| <i>Lontra canadensis</i>        | River Otter                 |
| <i>Odocoileus virginianus</i>   | White-tailed Deer           |

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