

Loess Bluffs National Wildlife Refuge Habitat Management Plan 2018



Image: Snow geese migration at Loess Bluffs. Photo courtesy: USFWS staff.



Habitat Management Plans provide long-term guidance for management decisions; set forth goals, objectives and strategies needed to accomplish refuge purposes; and, identify the Fish and Wildlife Service's best estimate of future needs. These plans detail habitat management activities which are sometimes substantially above current budget allocations and as such, are primarily for Service strategic planning and program prioritization purposes. The plans do not constitute a commitment for staffing increases, operational and maintenance increases, or funding for future land acquisition.

The National Wildlife Refuge System, managed by the U.S. Fish and Wildlife Service, is the world's premier system of public lands and waters set aside to conserve America's fish, wildlife and plants. Since the designation of the first wildlife refuge in 1903, the System has grown to encompass more than 150 million acres, more than 560 national wildlife refuges and other units of the Refuge System, plus 38 wetland management districts.

Habitat Management Plan
for
Loess Bluffs National Wildlife Refuge

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Table of Contents

Executive Summary	1
 Chapter 1. Introduction	
1.1 Scope and Rationale.....	3
1.2 Legal Mandates.....	3
1.3 Relation to Other Plans.....	5
 Chapter 2. Background	
2.1 Refuge Location and Description.....	12
2.2 Geographical Setting.....	16
2.3 Historical Perspective of Ecological Landscape.....	22
2.4 Current Natural and Anthropogenic Disturbances.....	27
2.5 Current Refuge Conditions and Resources.....	27
2.6 Climate Change.....	34
 Chapter 3. Resources of Concern	
3.1 Introduction.....	37
3.2 Potential Resources of Concern.....	37
3.3 Biological Integrity, Diversity, and Environmental Health.....	38
3.4 Comprehensive Resources of Concern.....	48
3.5 Priority Habitat Types and Associated Priority Resources of Concern.....	50
3.6 Conflicting Habitat Needs.....	55
3.7 Adaptive Management.....	56
 Chapter 4. Habitat Goals and Objectives	
4.1 Background.....	58
4.2 Habitat Goals and Objectives.....	60
 Chapter 5. Management Strategies and Prescriptions	
5.1 Development of Management Strategies and Prescriptions.....	74
5.2 Management Strategies and Prescriptions by Habitat Objective.....	75
 Literature Cited	92

List of Figures

Figure 1.1 Location of Tallgrass Prairie Ecoregion.....	6
Figure 1.2. Location of NABCI Bird Conservation Regions.....	7
Figure 2.1. LBNWR Geographical Location.....	13
Figure 2.2. Loess Bluffs Wildlife Management District.....	14
Figure 2.3. LBNWR Land Cover.....	15
Figure 2.4. Location of Bird Conservation Region 22.....	16
Figure 2.5. Partners in Flight Physiographic Area.....	16
Figure 2.6. Location of Mississippi Flyway.....	17
Figure 2.7. Location of Missouri River Basin.....	18
Figure 2.8. Location of LCCs in Missouri.....	19
Figure 2.9. Conservation Areas near LBNWR.....	21
Figure 2.10. LBNWR Historical Land Cover.....	24
Figure 2.11. LBNWR Soil Map.....	29
Figure 2.12. LBNWR Watershed Map.....	31
Figure 3.1. LBNWR Natural Communities Map.....	43
Figure 4.1. LBNWR Management Units Map.....	59
Figure 4.2. LBNWR Burn Units Map.....	82

List of Tables

Table 3.1. BIDEH table (Natural Community Types and NVCS Classification).....	39
Table 3.2. BIDEH table (Natural Processes and Limiting Factors).....	44
Table 3.3. Priority Resources of Concern and Associated Species.....	49
Table 3.4. Priority Resources of Concern and Habitat Requirements.....	51
Table 3.5. Priority 1 & 2 Habitat Types.....	54
Table 4.1 Differences between CCP and HMP Objectives.....	58
Table 4.2 Desirable Stand Conditions for Loess Hills Forest.....	69
Table 4.3 Desirable Stand Conditions for Bottomland Forest.....	70

List of Appendices

Appendix A - Resource of Concern Selection Committee.....	97
Appendix B - Comprehensive List of Resources of Concern.....	98

Executive Summary

On January 11, 2017, U. S. Fish and Wildlife Service Director Daniel M. Ashe officially changed the name of Squaw Creek National Wildlife Refuge to Loess Bluffs National Wildlife Refuge. For this document the refuge will be referred to as Loess Bluffs National Wildlife Refuge (LBNWR; refuge). Located along the eastern edge of the Missouri River floodplain in a historic wetland area, LBNWR is used as a refuge and breeding ground for migratory birds and other wildlife. This 7,440-acre refuge includes approximately 6,700 acres of floodplain that is managed as wetland, grassland and riparian habitats. LBNWR's habitat diversity emphasizes both wetland and grassland, interspersed with stands of mixed shrubs and woodlands, managed on a scale to minimize habitat fragmentation for waterfowl, shorebirds, neo-tropical migrants, and other indigenous species.

The Comprehensive Conservation Plan (CCP) for the refuge was completed in 2005 as a means of providing long-term guidance for management decisions. The Habitat Management Plan (HMP) is a step-down plan from the CCP. The HMP adds specific guidance for the implementation of habitat management strategies originally intended under the CCP (Habitat Management Practices 620 FW 1).

The refuge's Resources of Concern (ROC) were identified by reviewing the focal species in the Loess Bluffs CCP, as well as those identified in local and regional conservation plans, and analyzing their relation to the biological integrity diversity and environmental health (BIDEH) of the refuge habitats. Based on this analysis, the refuge identified a total of 17 focal species. Focal species serve as indicators and representatives for other species and groups that may utilize similar habitat. As part of our ROC identification, we also evaluated our priority habitats for future management. Priorities were based on each habitat's ability to support rare natural communities and support resources of conservation concern. Based on our review of habitats present on the refuge, marsh and wet shoreline, bottomland (wet/wet-mesic/mesic) prairie, loess/glacial till prairie were identified as the Priority 1 habitats.

The HMP builds upon the goals, objectives, and strategies identified in the Loess Bluffs CCP. As part of the step-down process, objectives and strategies were revised and updated based on current conditions and refuge management. In general, only minor changes to acreages and time frames were updated. Some new objectives were added when the necessary, while objectives that were either accomplished or no longer applicable to the refuge were omitted. In addition to updating existing strategies, new strategies were identified to guide refuge management in light of the original guidance provided in the CCP.

Chapter 1. Introduction



Image: Loess Bluffs National Wildlife Refuge Headquarters (Formerly, Squaw Creek National Wildlife Refuge) and welcome signs. Photo courtesy: USFWS staff.

1.1 Scope and Rationale

Loess Bluffs National Wildlife Refuge (LBNWR; refuge) is managed by the U.S. Fish and Wildlife Service (USFWS) as part of the National Wildlife Refuge System (NWRS; System). The USFWS is the primary federal agency responsible for conserving, protecting, and enhancing fish and wildlife and their habitats for the continuing benefit of the American people. The role of the USFWS includes managing the NWRS, the world's largest collection of lands specifically managed for fish and wildlife. The mission of the NWRS is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the United States.

Loess Bluffs National Wildlife Refuge, located in northwest Missouri near Mound City, was established August 23, 1935, by Executive Order 7156 “in order to effectuate further the purpose of the Migratory Bird Conservation Act” and lands were to be used “as a refuge and breeding ground for migratory birds and other wildlife.” Most of the land comprising the refuge is located along the eastern edge of the Missouri River floodplain in a historic wetland area. Habitat types include wetlands, grasslands, forests, croplands, and developed land (Bell 2005). LBNWR’s habitat diversity emphasizes both wetland and grassland, interspersed with stands of mixed shrubs and woodlands, managed on a scale to minimize habitat fragmentation for waterfowl, shorebirds, neo-tropical migrants, and other indigenous species.

Meeting the wildlife conservation challenges of the 21st century and fulfilling the mission and vision of the NWRS requires strategic planning and maintaining and/or creating new partnerships to achieve those objectives. The Comprehensive Conservation Plan (CCP) and the Habitat Management Plan (HMP) for each refuge are essential to the System’s ability to meet these challenges. This HMP provides vision and specific guidance on managing habitat for the resources of concern at LBNWR. The contributions of the refuge on a landscape scale for wildlife, habitat, and biodiversity are incorporated in the HMP. This document has been developed in detail through a set of goals, objectives, and strategies that will mesh with the CCP and will direct refuge management for the next 15 years.

1.2 Legal Mandates

Refuge Purpose Statements are primary to the management of each refuge within the System. The Purpose Statement is derived from the legislative authority used to acquire specific refuge lands and is, along with NWRS goals, the basis on which primary management activities are determined. Refuges also provide unique opportunities for people. When it is appropriate and compatible with wildlife and habitat conservation, they are places where people can enjoy wildlife-dependent recreation such as hunting, fishing, wildlife observation, photography, environmental education, and interpretation. Many refuges have visitor centers, wildlife trails, automobile tours, and environmental education programs. Nationwide, approximately 41 million people visit national wildlife refuges a year.

The stated purposes for Loess Bluffs National Wildlife Refuge include:

- “...as a refuge and breeding ground for migratory birds and other wildlife: ...” Executive Order 7156, dated August 23, 1935
- “... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds...”, 16 U.S.C. - 715d (Migratory Bird Conservation Act)
- “... suitable for- (1) incidental fish and wildlife oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species ...”, 16 U.S.C. - 460k-1 (Refuge Recreation Act)
- “...for conservation purposes”, (1985 Food Security Act in conjunction with the transfer of Farm Service Agency, formerly Farmers Home Administration, property)

While the Refuge Purpose is the foremost determinant of a particular refuge’s management, managing trust resources is also a priority of refuges. Trust resources include:

- Migratory Birds: A list of all species of migratory birds protected by the Migratory Bird Treaty Act (16 U.S.C. 703–711) and subject to the regulations on migratory birds is contained in subchapter B of title 50 CFR § 10.13.
(<http://www.fws.gov/migratorybirds/RegulationsPolicies/mbta/mbtandx.html>)
- Interjurisdictional Fish: Fish “...populations that two or more states, nations, or Native American tribal governments manage because of their geographic distribution or migratory patterns.” (710 FW 1.5H). Examples include anadromous species of salmon and free-roaming species endemic to large river systems, such as paddlefish and sturgeon. (601 FW 1)
- Threatened and Endangered Species: The Endangered Species Act (16 U.S.C. §§ 1531-1544, December 28, 1973, as amended 1976-1982, 1984 and 1988) states in SEC. 8A.(a) that “The Secretary of the Interior... is designated as the Management Authority and the Scientific Authority for purposes of the Convention and the respective functions of each such Authority shall be carried out through the United States Fish and Wildlife Service.”
- Marine Mammals: The Marine Mammal Protection Act of 1972 (16 U.S.C. 1361-1407) prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. See Handbook for species under USFWS in addition to a refuge’s purpose statements there are a number of legal acts or executive orders that are important for refuge management and administration. These acts or executive orders are listed in Appendix E of LBNWR CCP.

1.3 Relation to Other Plans

Important guidance for wildlife habitat management on LBNWR has already been provided by several important regional, national and refuge plans. Summaries and relevance of these plans follow below. Specific species listed under each regional and national plan are included in the comprehensive list of resources of concern in Appendix B.

Regional and National Plans

Nongame Birds of Management Concern- the 1995 List

This document revises the 1987 list of nongame migratory birds that are thought to be of management concern. Birds selected for this list are designated as species of special concern when they have documented or apparent population declines, small or restricted populations, or dependence on restricted or vulnerable habitats. The 1995 list contains 122 species that were determined to be of management concern at the national level. Due to the importance of the refuge as a stopover location for migratory birds, the 44 species from the 1995 list which occur at LBNWR will be considered for inclusion in the HMP for the refuge (USFWS 1995).

Fish and Wildlife Resource Conservation Priorities

The Fish and Wildlife Resource Priorities of 2002 report identifies the 243 species of concern considered to be in greatest need of attention within Region 3 (Great Lakes Region) of the USFWS under its full span of authorities. The species listed in this report are indicated as a result of their status as rare, declining, harvested, or nuisance species. Of the 243 species listed, the refuge has documented occurrence of 74 species with at least 6 other potential species. The priority species identified and their associated conservation management recommendations were considered in development of this HMP (USFWS 2002).

Migratory Bird Program Strategic Plan

The Migratory Bird Program Strategic Plan (2004–2014) provided direction for the USFWS migratory bird management in the last decade. The plan addressed three main priorities including: decreasing the loss and degradation of migratory bird habitat; increasing and improving scientific information on migratory bird populations; and strengthening and expanding regional, national, and international partnerships to achieve comprehensive bird conservation. This HMP, along with other refuge planning documents, when practical, includes recommendations that staff use standard monitoring protocols, conduct habitat assessments and management, participate in regional and national monitoring programs, conduct adaptive management projects, and promote compatible wildlife-dependent recreation and education to forward the vision of the Migratory Bird Program Strategic Plan (USFWS 2004).

Birds of Conservation Concern 2008

The Birds of Conservation Concern plan was developed in response to the 1988 amendment to the Fish and Wildlife Conservation Act which mandates the USFWS to “identify species, subspecies and populations of all migratory nongame birds that, without conservation actions, are likely to become candidates for listing under the Endangered Species Act (ESA).” The overall goal of the Birds of Conservation Concern is to accurately identify the migratory and non-migratory bird species (beyond those already designated as federally threatened or endangered) that represent the USFWS highest conservation priorities. Lists of Birds of Conservation Concern are broken into Bird Conservation Regions (BCR). The national list comprises 147 species, with 39 species included in BCR 22 (Eastern Tallgrass Prairie). Of these 39 species, 34 species are known to occur on LBNWR (USFWS 2008).

Central Tallgrass Prairie Ecoregion Assessment

The plan was written by The Nature Conservancy in 2008 for the Central Tallgrass Prairie (CTP) ecoregion (Figure 1.1). This region encompasses 110,468 square miles in North America, with the Mississippi, Missouri and Illinois Rivers forming the central network of the CTP’s freshwater ecosystem diversity. The priority species identified and their associated conservation management recommendations were considered in development of this HMP. The CTP assessment lists 55 aquatic ecological systems, 43 aquatic species, 24 terrestrial ecological systems, 135 terrestrial plant communities, and 59 terrestrial species as targets. Habitats and species that were listed in the plan for LBNWR include Northern Cordgrass Wet Prairie, Midwest Ephemeral Pond, and Massasauga rattlesnake. The refuge has also documented occurrence of 4 terrestrial ecological systems, 1 aquatic species, 6 primary terrestrial species and 8 secondary terrestrial target species that are not currently listed in the plan for LBNWR (TNC 2008).



Figure 1.1. Figure indicates the Central Tallgrass Prairie Ecoregion as designated by the Nature Conservancy.

Source: [Illinois University](http://www.illinois.edu)

North American Waterfowl Management Plan

The North American Waterfowl Management Plan (NAWMP) seeks to restore waterfowl populations in Canada, United States, and Mexico to benchmark levels similar to those experienced in the 1970s (USDOJ et al. 2012). The NAWMP was signed in 1986 and later updated in 1994, 1998, 2004 and 2012 for conservation of waterfowl in North America. The NAWMP was the first major bird initiative to create a number of landscape scale partnerships comprised of governmental (local, state, and federal), university, and non-governmental organizations (e.g. Joint Ventures). The NAWMP and the Upper Mississippi River and Great Lakes Joint Venture (UMRGLV) Waterfowl Habitat Conservation Strategy have identified priority species and conservation strategies, focused primarily around habitat that will address the needs of those groups. The UMRGLV Waterfowl Habitat Conservation Strategy recognizes 10 priority species and 7 focal species, all of which have been documented on LBNWR. The priority and focal species identified and their associated conservation management recommendations were considered in development of this HMP.

North American Bird Conservation Initiative in the United States 2000

In response to significant patterns of decline in several bird populations, federal, state, university, and non-governmental agencies throughout North America united to form the North American Bird Conservation Initiative (NABCI). The vision of the NABCI in the United States is to see populations and habitats of North America's birds protected, restored, and enhanced through coordinated efforts at international, national, regional, state, and local levels, guided by sound science and effective management (NABCI 2000). The NABCI used the NAWMP joint venture model to create Bird Conservation Regions (BCR). The refuge occurs in BCR 22, which is located within the UMRGLJV (Figure 1.2).

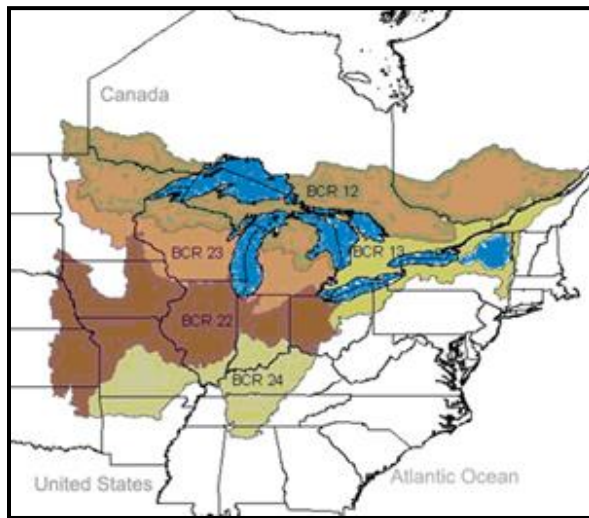


Figure 1.2. Midwest Bird Conservation Regions as designated by the North American Bird Conservation Initiative. Source of the map is the [Upper Mississippi River & Great Lakes Region Joint Venture](#).

Partners in Flight North American Landbird Conservation Plan

The Partners in Flight (PIF) mission is expressed through three related concepts: helping species at risk, maintaining species identified as common, and developing voluntary partnerships for birds, habitat and people. The North American Landbird Conservation Plan (NALCP) provides a continental perspective on North American landbird conservation, which has been proven valuable since many species breed, migrate and winter across the entire continent. In order to evaluate species' conservation vulnerability, the NALCP and UMRGLJV Landbird Habitat Conservation Strategy utilized a combination of six factors including population size, breeding distribution, nonbreeding distribution, threats to breeding, threats to nonbreeding, and population trend to identify priority species and conservation strategies focused around habitat conservation, which will address the needs of those groups. The priority species identified and their associated conservation management recommendations were considered in development of this HMP. The NALCP lists 192 species as Species of Continental Importance in North America and 27 Species of Continental Importance in the Prairie Avifaunal Biome, within which LBNWR resides. The refuge has documented the occurrence of 16 of the 27 Species of Continental Importance. For the UMRGLJV Landbird Habitat Conservation Strategy, the refuge has documented 23 of the 30 identified focal species (Rich et al. 2004).

U.S. Shorebird Conservation Plan

The U.S. Shorebird Conservation Plan (USSCP) summarizes all of the major technical reports and recommendations produced by partner organizations committed to the conservation of shorebirds who participated in developing the Plan. These include conservation goals for each region of the country, as well as critical habitat conservation and key research needs in relation to identified priority species. The Upper Mississippi Valley/Great Lakes region for the USSCP contains 32 species of shorebirds. For this region, 23 species are of moderate to higher concern with 9 species being high priority. The UMRGLJV recognizes 10 focal shorebird species, all of which occur on the refuge. The priority and focal species identified and their associated conservation management recommendations were considered in development of this HMP (Brown et al. 2001).

North American Waterbird Conservation Plan

The North American Waterbird Conservation Plan (NAWCP) is the product of an independent partnership of individuals and institutions interested in waterbird conservation, which was created to support a vision in which the distribution, diversity, and abundance of populations and habitats of breeding, migratory, and nonbreeding waterbirds are sustained or restored throughout the lands and waters of North America, Central America, and the Caribbean. The NAWCP provides a continental-scale framework for conservation and management of 210 identified priority species of waterbirds, including seabirds, coastal waterbirds, wading birds and marsh birds. The refuge lies in the Upper Mississippi Valley/Great Lakes region for the NAWCP that contains 46 species of waterbirds, of which 26 are listed as priority species for monitoring. The refuge has documented occurrence for 25 of the 26 priority species. Furthermore, the UMRGLJV recognizes 5 focal species in which all have been documented on LBNWR. The focal and priority species identified and their associated conservation management recommendations were considered in development of this HMP (Kushlan et al. 2002).

Missouri Wildlife Action Plan

Each state was instructed by Congress to create a wildlife action plan. These plans evaluate the vitality of wildlife populations and recommend actions to conserve the targeted species and their habitats. Missouri's Comprehensive Wildlife Strategy promotes management that benefits all wildlife, rather than targeting single species. The strategy identifies 33 Conservation Opportunity Areas (COA), including areas similar to LBNWR. The refuge resides in the Central Dissected Till Plains and the Loess Hills COA. The HMP incorporates plans such as the Missouri Wildlife Action Plan to prioritize conservation needs at a variety of scales including the state level (MDC 2005a, 2005b).

Big Rivers Biological Network

A network was formed to provide a forum to communicate and share biological information on a regular basis amongst refuge and private lands biologists, refuge managers, and regional resource staff from the Upper Mississippi River, Lower Missouri River, Lower Illinois River and Iowa River Ecoregions.

Important Bird Areas of Missouri

This report defines and outlines Important Bird Areas (IBA) in Missouri. The IBA program is an international bird conservation model designed to identify, monitor and conserve areas that are most important to birds. These areas provide habitat for species of conservation concern, those with restricted ranges, species occurring in rare habitats, and those species that congregate in large numbers. There are currently 47 IBAs identified in Missouri, of which LBNWR is designated as one. Criteria for LBNWR IBA establishment include the following species of concern: bald eagle (*Haliaeetus leucocephalus*), American bittern (*Ixobrychus exilis*), and king rail (*Rallus elegans*). LBNWR also includes valuable wetland habitat and exceptional concentrations of waterfowl and shorebirds (Jensen and Forbes 2006).

Refuge Plans

Loess Bluffs National Wildlife Refuge Comprehensive Conservation Plan

The National Wildlife Refuge System Improvement Act of 1997 established several important mandates aimed at making the management of national wildlife refuges more cohesive. The preparation of the Comprehensive Conservation Plan (CCP) is one of those mandates. The CCP aims to guide the biological integrity, diversity, environmental health, and public use actions on the refuge for a 15-year period. The CCP for LBNWR was approved in July 2005. This HMP is a step-down plan, where the habitat goals and objectives from the CCP have been incorporated into this plan (Bell 2005).

Refuge-Specific “Step-Down” Plans

In addition to the LBNWR CCP, local, state, regional, and national plans; a number of other “step-down” refuge program-specific plans have provided guidance either in their draft or final format, including but not limited to:

Fire Management Plan

A Fire Management Plan was updated and approved in 2007 for Loess Bluffs NWR as mandated by Service policy for any refuge that has “vegetation capable of sustaining fire.” The Fire Management Plan covers wildland fire suppression and prescribed fire operations and monitoring. The use of prescribed fire needs to mimic natural processes and manage habitats which have been incorporated into the Habitat Management Plan.

Prescribed Fire Plan

A Prescribed Fire Plan identifies management objectives for prescribed fires, outlines specific prescriptions to achieve the objectives, recognizes resources needed to complete the objectives, outlines safety procedures, analyzes the complexity of the fire, and includes contingency planning for managing the fire. This HMP includes prescribed fire as a strategy for achieving certain management objectives.

Water Management Plan

The refuge has completed annual Water Management Plans for wetland and moist soil management from 1946 to the present. The plans list management objectives, specific management strategies per wetland or moist soil unit, pictures of conditions, and water level

monitoring. The HMP will incorporate management objectives and strategies from the Water Management Plan. Once the HMP is approved, the Water Management Plan will be integrated into the Annual Habitat Work Plan.

Annual Habitat Work Plan

Each refuge should prepare an Annual Habitat Work Plan that includes review of the habitat management activities of the previous year, an evaluation of monitoring programs, recommendations for habitat management strategies for the coming year, and incorporate adaptive management principles. Once the HMP is approved, an Annual Habitat Work Plan will incorporate the Water Management Plan and other management activities that occur on LBNWR on an annual basis.

Inventory and Monitoring Plan

An Inventory and Monitoring Plan (IMP) is a required refuge plan and will be developed in conjunction with the HMP. Management objectives and strategies developed in the HMP provide the framework for how refuge staff will measure progress towards achievement of goals. The IMP will be completed in 2017.

Visitor Services Plan

The Visitor Services Plan (VSP) identifies a refuge's goals, objectives, strategies, audiences, current program status, future actions, monitoring and evaluation for each. The overall goal of any USFWS VSP is to welcome visitors and provide quality hunting, fishing, wildlife observation, photography, environmental education, and interpretation opportunities, when its use is compatible with wildlife and habitat conservation. The refuge completed its draft VSP in 2012.

Additional Plans

Several other management plans of varying scopes have been created for LBNWR. A Hunt Plan was approved in 1986 to deal with deer management issues. Other plans that have been completed for the refuge include: a Station Crowd Control Plan completed in 1972, Migratory Bird Depredation Plan completed in 1978, Disease Management Plan completed in 1983, Fisheries Management Assessment completed in 1987, and a Law Enforcement Plan completed in 1988.

Chapter 2. Background



Image: (from top left) Loess Bluffs National Wildlife Refuge: Bluff shelter '71, Eagle Pool, Eagle Pool with geese, historic aerial photo. Photo courtesy: USFWS staff

2.1 Refuge Location and Description

Loess Bluffs National Wildlife Refuge is located in Holt County in northwest Missouri, approximately midway between Kansas City, Missouri, and Omaha, Nebraska (Figure 2.1). This 7,440-acre refuge includes approximately 6,700 acres of floodplain that is managed as wetland, grassland and riparian habitats. In addition, the refuge manages 33 easements obtained from the Farm Service Agency, previously known as the Farmers Home Administration (FmHA). These easements lie in 11 of the 15 counties that make up the Loess Bluffs Wildlife Management District (Figure 2.2).

The refuge originally derived its name from Squaw Creek, a major stream flowing through the Missouri River floodplain which drains the Loess Hills via a man-made ditch and empties into the Missouri River approximately 5 miles south of the refuge. Davis Creek, which has also been ditched, flows along the eastern refuge boundary and joins Squaw Creek just after leaving the refuge. The refuge is bordered by two major highways to the north and east, private farm lands to the south and east, and the Burlington Northern Santa Fe Railway to the west (Figure 2.3).

LBNWR's habitat diversity encompasses both wetlands and grasslands interspersed with stands of mixed shrubs and woodlands, which are managed on a scale to minimize habitat fragmentation for waterfowl, shorebirds, neo-tropical migrants, and other indigenous species. According to 2007 Land Cover Land Use Data, the refuge includes approximately 3,812.8 acres of wetlands; 1,850.4 acres of wet, mesic and upland prairie; 1,200.4 acres of bottomland and Loess Hill forest; 325 acres of cropland; and 251.4 acres of developed land (2007 Land Cover Land Use Data; ESRI 2012; Figure 2.3). Wildlife includes a record of 476 bald eagles (*Haliaeetus leucocephalus*), more than 1,400,000 snow geese (*Chen caerulescens*), and 200,000 other waterfowl during migration. In addition, the refuge hosts a diverse amount of vertebrates including: 310 species of birds, 33 mammals, and 35 reptiles and amphibians (Bell 2005). Based on unpublished refuge data the current total number of mammal species is 41 (LBNWR bat acoustical data 2012-2016) and reptile and amphibian species is 37 (LBNWR drift fences, cover boards and incidental encounters data 2011-2014).

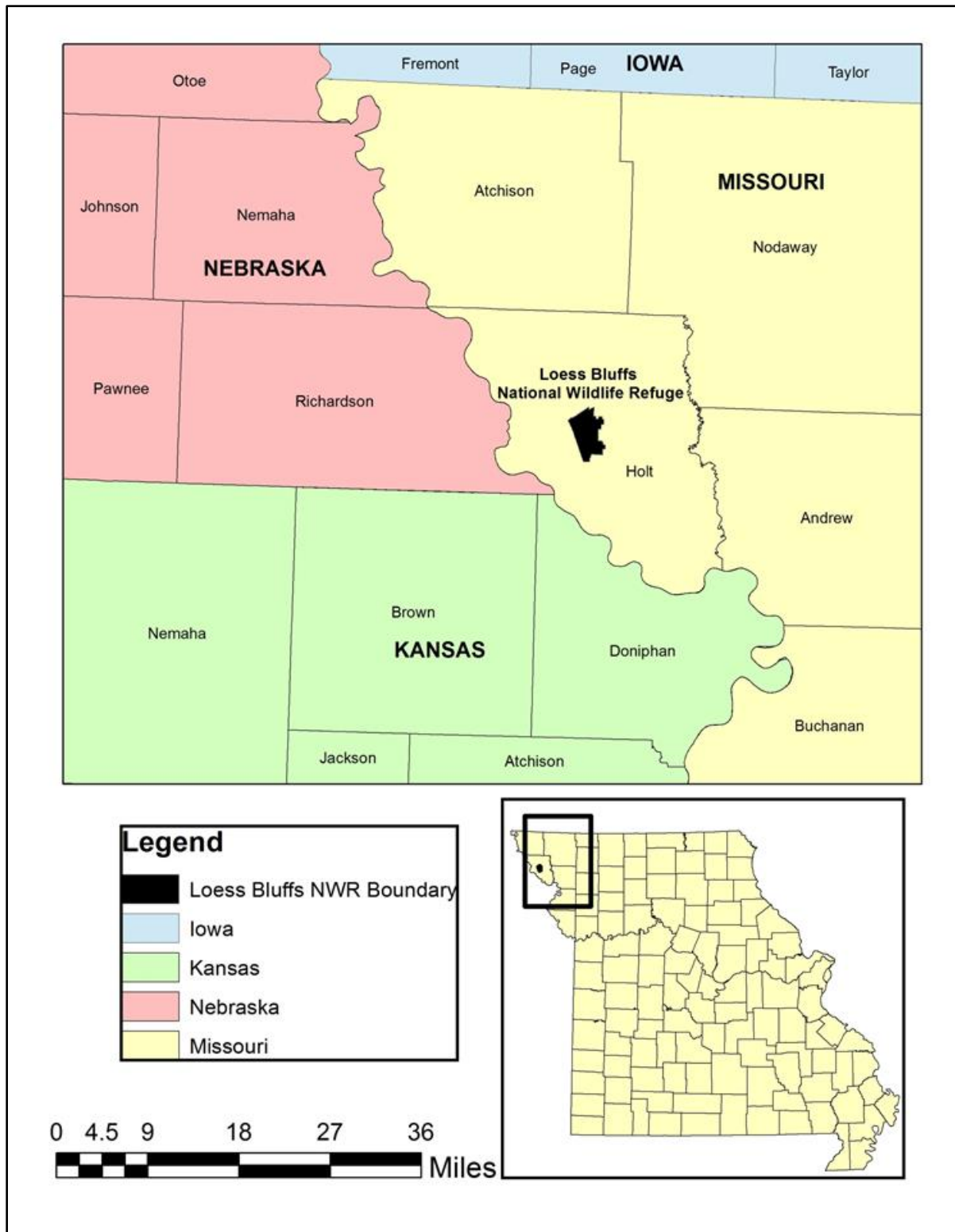


Figure 2.1. Loess Bluffs National Wildlife Refuge geographic location and surrounding states (Iowa, Kansas and Nebraska) including counties names. Source: LBNWR_Geographic_Location.jpg created 5/1/2017 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

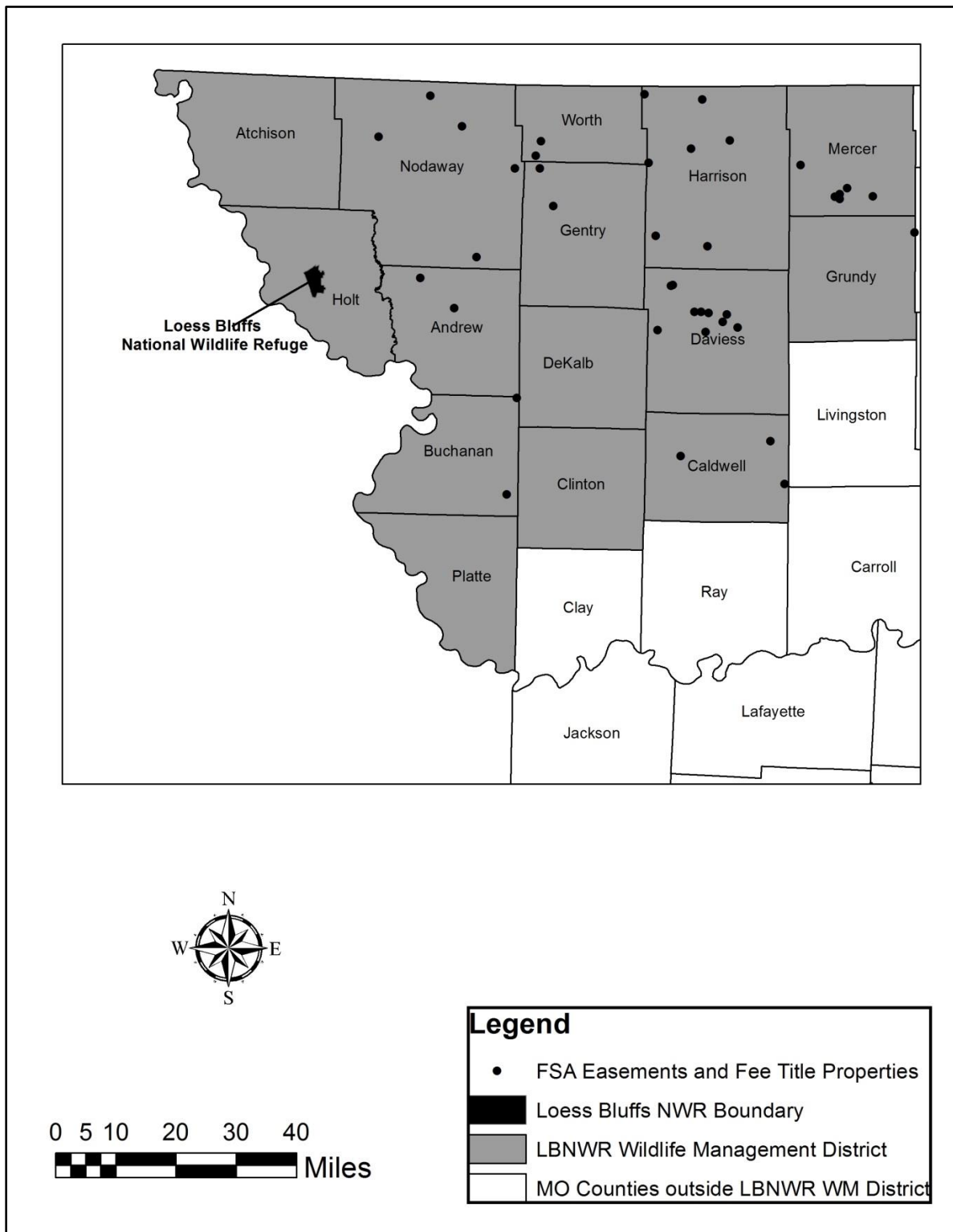


Figure 2.2. Loess Bluffs Wildlife Management District showing the location of LBNWR, Missouri counties in the District, easements and fee title properties. Source: LBNWR_Wildlife_ManagementDistrict.jpg created 5/2/2017 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

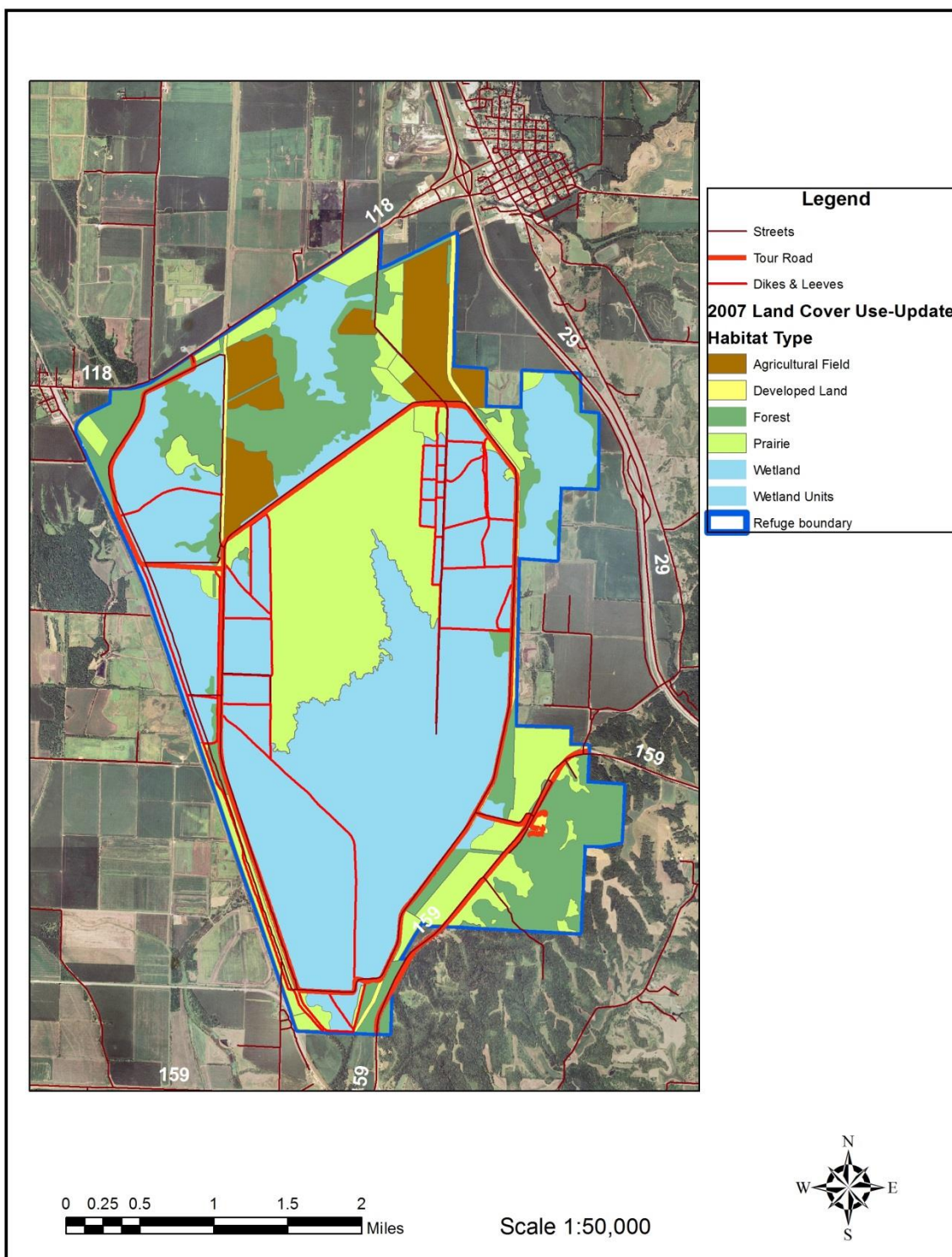


Figure 2.3. Boundary of Loess Bluffs National Wildlife Refuge with highways labeled and 2007 land cover found on the refuge. Source: LBNWR_2007LCU.jpg created 5/2/2017 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

2.2 Geographical Setting

Bird Conservation Region and Partners in Flight Physiographic Area

Several nongame bird initiatives have been developed in recent years to facilitate delivery of the full spectrum of bird conservation through regionally-based, biologically-driven, landscape-oriented partnerships (Bell 2005). The regional planning efforts completed by the North American Bird Conservation Initiative (NABCI) and Partners in Flight (PIF) created a series of regional conservation planning units across a national scale. NABCI efforts seek to unite all bird conservation efforts on a regional scale within Bird Conservation Regions (BCRs). PIF planning focus is conservation of landbirds within biologically based regions identified as Physiographic Areas. Bird Conservation Regions are generally larger in scale than PIF Physiographic Areas. The refuge lies within PIF Physiographic Area Number 32, the Dissected Till Plains, and BCR 22, the Eastern Tallgrass Prairie (Figure 2.4, 2.5).

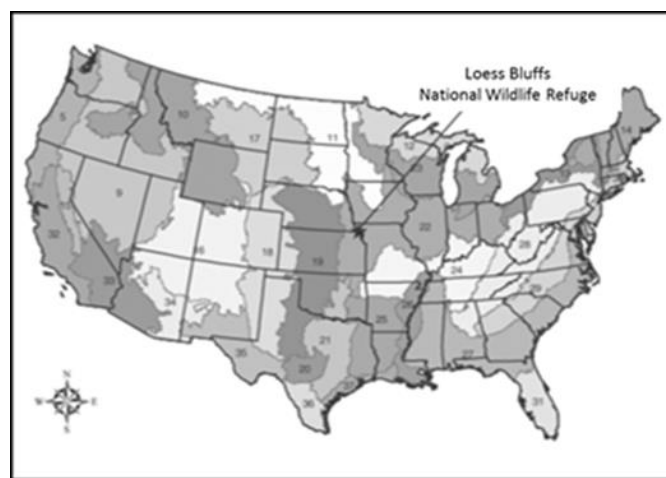


Figure 2.4. Loess Bluffs NWR location within Bird Conservation Region 22. Source of the map is from LBNWR CCP signed in 2005 ([Bell 2005](#)).

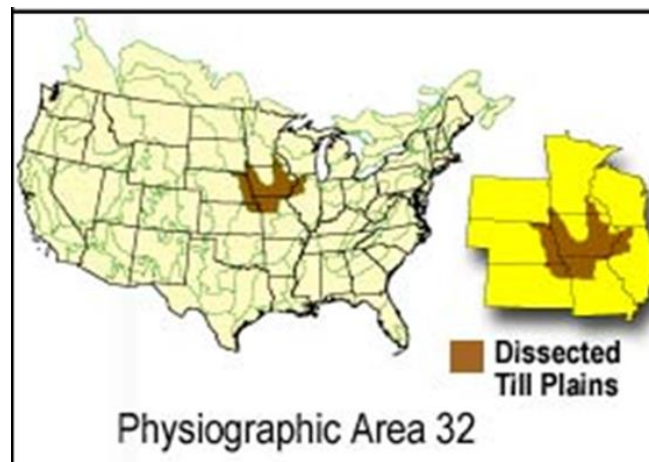


Figure 2.5. Loess Bluffs NWR is located in Partners in Flight Physiographic Area 32 the Dissected Till Plains. Map shows Physiographic Area 32 location in the United States and surrounding states. Source for the map is [Partners in Flight](#).

Mississippi Flyway

The Mississippi Flyway is one of four major migration routes (Pacific, Central, Mississippi and Atlantic Flyways) on the continent and is best known for large numbers of ducks and geese that follow the Mississippi River, its tributaries, flood plains, and associated wetlands (Figure 2.6). This flyway serves as a vital corridor for landbirds, shorebirds, as well as wading birds. The Mississippi Flyway is composed of the following states: Alabama, Arkansas, Indiana, Illinois, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Ohio, Tennessee and Wisconsin, along with the Canadian provinces of Saskatchewan, Manitoba and Ontario (Hawkins et al. 1984). The refuge is located on the western part of the Mississippi Flyway near the Central Flyway. Millions of birds, representing over 300 different species, rely on the waters, wetlands, forests and grasslands along the Mississippi River and lower Missouri River Ecosystems for places to rest and feed during the fall and spring migration.

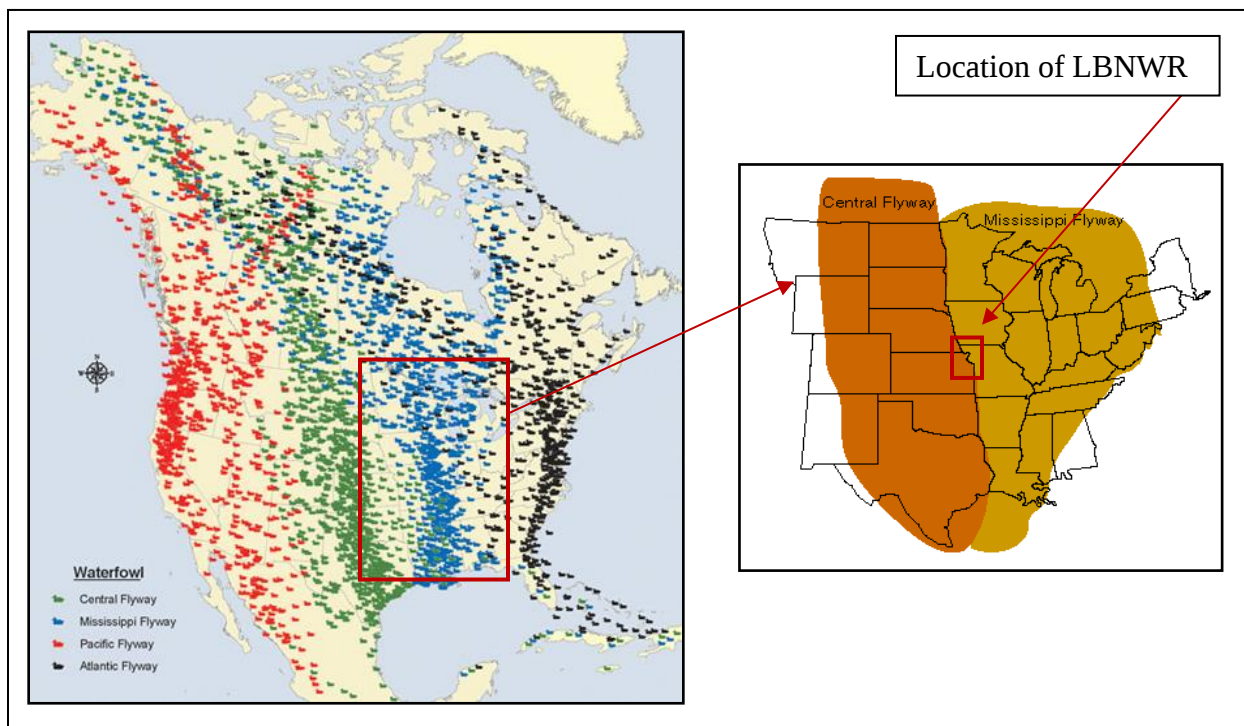


Figure 2.6. Figure shows all four flyways, highlighting the Mississippi Flyway, along with the location of LBNWR within the flyways. Source: [USFWS](#)

Missouri River Watershed

The U.S. Fish and Wildlife Service implemented an ecosystem approach to fish and wildlife conservation. The Service's goal with this approach is to integrate the expertise and resources of many Service divisions that will contribute to the effective conservation of natural biological diversity through perpetuation of dynamic, healthy ecosystems. The refuge resides in the Lower Missouri River Ecosystem which is one of eight defined ecosystems within Region 3, U.S. Fish and Wildlife Service.

The Lower Missouri River Ecosystem encompasses all of the Missouri River Basin that drains portions of Iowa and Missouri (USFWS 2001). The ecosystem includes lower portions of several tributary basins: the Little Sioux, Platte, Kansas, Nishnabotna, Grand, Chariton, Gasconade and Osage rivers (USFWS 2001; TNC 2008)(Figure 2.7). The Missouri River and its floodplain feature a variety of habitats including braided channels, sloughs, islands, sandbars, backwater areas, wetlands, and other natural flood plain communities (USFWS 2001). Agriculture is the predominant land use in the Lower Missouri River Ecosystem (USFWS 2001). Starting with the Flood Control Act of 1944, the Missouri River Basin has been greatly altered by the creation of numerous reservoir and dam systems. The Missouri River Main Stem System consists of six reservoirs constructed by the U.S. Army Corps of Engineers for the primary purposes of flood control, navigation, irrigation, power, water supply, water quality control, recreation and fish and wildlife (USACE 1979).



Figure 2.7. The Missouri River Basin, along with dams and reservoirs constructed along the main river channel and major tributaries. Location of Northwest Missouri and Loess Bluffs National Wildlife Refuge is indicated in red. Source of the map is the Committee on Missouri River Recovery and Associated Sediment Management Issues created in 2010 by [International Mapping Associates](#).

The refuge is located 5 miles northeast of the Missouri River and lies within the eastern border of the Missouri River floodplain. The main portion of the refuge lies on the broad plain that slopes gently to the Missouri River. Although the refuge is 5 miles from the Missouri River, flood events impact the refuge when Davis, Little Tarkio, and Squaw creeks back up. Additional precipitation in the watershed creates more damage by over-topping roads, levees, water control structures, and bridges. This was evident in 1993 with a record flood level of 858.0 feet above sea level (10 feet above ground level) observed on July 24, 1993 on the dike at Eagle Pool. Similar flood conditions were observed during the 2007, 2011, 2014 and 2015 floods.

Western Hemisphere Shorebird Reserve Network

The Western Hemisphere Shorebird Reserve Network (WHSRN) is a conservation strategy launched in 1986 which aims to protect key habitats throughout the Americas in order to sustain healthy populations of shorebirds. The WHSRN is a voluntary, non-regulatory coalition that identifies and promotes conservation of crucial sites used by shorebirds during their breeding, migratory and winter season. Loess Bluffs NWR was added to this network in 2007 based on its use by more than 60,000 shorebirds annually (WHSRN 2007).

Landscape Conservation Cooperative

Given the broad impacts of climate change, management responses to such impacts must be coordinated on a landscape-level basis. Interior bureaus and agencies will work to develop a network of collaborative Landscape Conservation Cooperatives (LCC). LCCs collectively form a national network of land, water, wildlife and cultural resource managers, scientists, and interested public and private organizations that share a common need for applied research to inform conservation management decisions (Salmon and White 2015). LCC structure helps to limit duplication of effort, and provide scientific and technical support to inform landscape-scale conservation using adaptive management principles or Strategic Habitat Conservation in the USFWS (Salmon and White 2015).

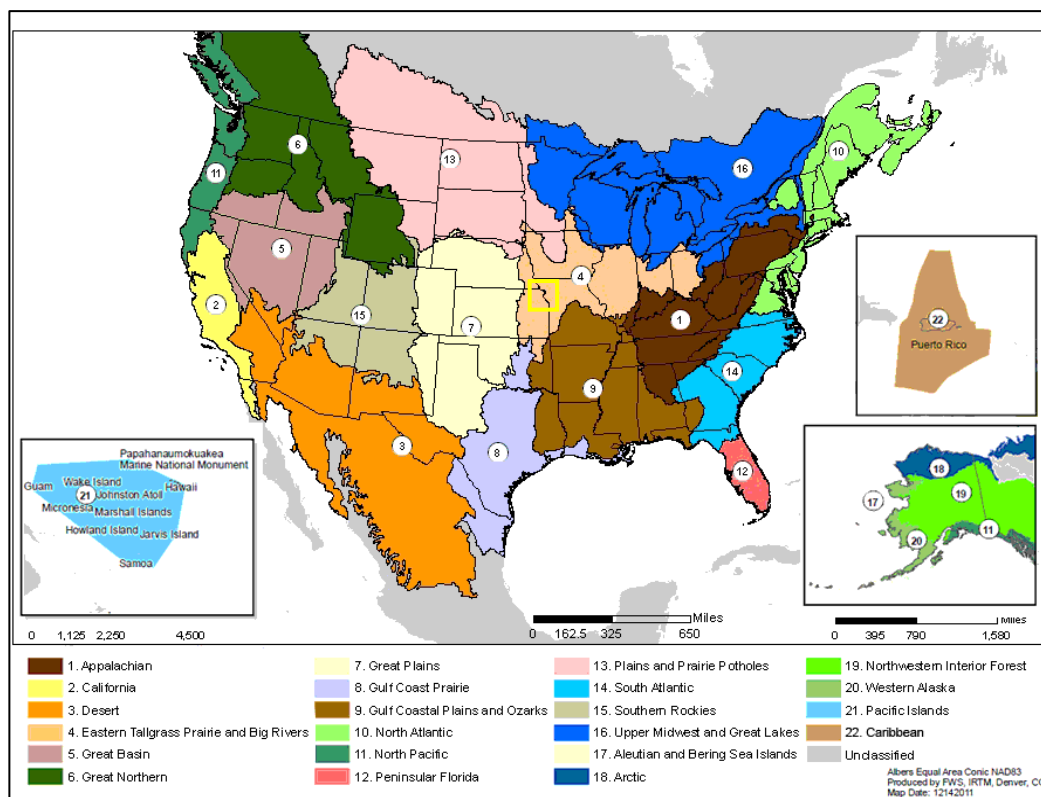


Figure 2.8. Figure shows the network of Landscape Conservation Cooperatives (LCC) with the Eastern Tallgrass Prairie and Big Rivers LCC indicated. Source of the map is [Eastern Tallgrass Prairie and Big Rivers LCC](#).

There are currently 22 LCCs in the United States. Loess Bluffs NWR is located within the Eastern Tallgrass Prairie and Big Rivers LCC (Figure 2.8). The Eastern Tallgrass Prairie and Big Rivers LCC is dedicated to addressing the conservation challenges of a heavily agricultural landscape that stretches from southwest Ohio westward across to parts of eastern Kansas, Oklahoma and Nebraska and northward into segments of Iowa, South Dakota and Minnesota (Salmon and White 2015).

Regional Conservation Context

Refuge lowlands were once a part of a large natural marsh in the Missouri River floodplain. Historically, this area was heavily used by waterfowl and other migratory birds during their spring and fall migrations (Bell 2005). Loess Bluffs NWR is surrounded primarily by private hunting clubs and agriculture. The majority of the hunting clubs around the refuge are used for waterfowl hunting in the form of flooded corn fields, managed wetlands and/or moist soil units. Although the target species or guild is waterfowl, management actions in turn benefit other wildlife including wetland dependent reptiles, amphibians, shorebirds, wading birds, raptors, and passerines. Portions or all of some hunt clubs are managed for white-tailed deer (*Odocoileus virginianus*) by providing woodlands and food plots as habitat to attract this species. By doing so, those hunt clubs provide additional habitat for other non-target species including reptiles, amphibians, and birds.

In addition to private property, LBNWR is in close proximity to several state properties. The Missouri Department of Conservation (MDC) manages a number of Conservation Areas (CA) throughout Holt County (Bell 2005) (Figure 2.9). These CAs include: Jameson C. McCormack CA (227 acres) located adjacent to the refuge; the Bob Brown CA (3,302 acres) near Forest City, Missouri; H.F. Thurnau CA (366 acres); Little Tarkio Prairie CA (129 acres); Riverbreaks CA (2,307 acres); Monkey Mountain CA (787 acres); Nodaway Valley CA (3,813 acres); Maitland Access and Payne Landing Access. The Missouri Department of Natural Resources manages the 435-acre Big Lake State Park 11 miles southwest of Mound City. The park offers camping, cabins, a swimming pool, and public recreational activities including fishing and picnicking.

Loess Bluffs NWR is located in several larger focus areas. The refuge is part of MDC's Loess Hills Conservation Opportunity Area. Three Research Natural Areas are located on the refuge including the Loess Hills (100 acres), Bluejoint-Slough Grass-Prairie (250 acres) and Cordgrass Prairie (210 acres) Research Natural Areas (Kramer 1993). Loess Bluffs NWR is recognized as an Important Bird Area (IBA) by the National Audubon Society because of species of concern (bald eagles, American bittern, and king rail), wetland habitat and exceptional concentrations of waterfowl and shorebirds (Jensen and Forbes 2006). The refuge is recognized by The Nature Conservancy as an important conservation area for northern cordgrass wet prairie, ephemeral ponds and massasauga rattlesnake (TNC 2008). In addition, the Upper Mississippi River and Great Lakes Region Joint Venture lists LBNWR as an area with high management potential for shorebirds (Potter et al. 2007).

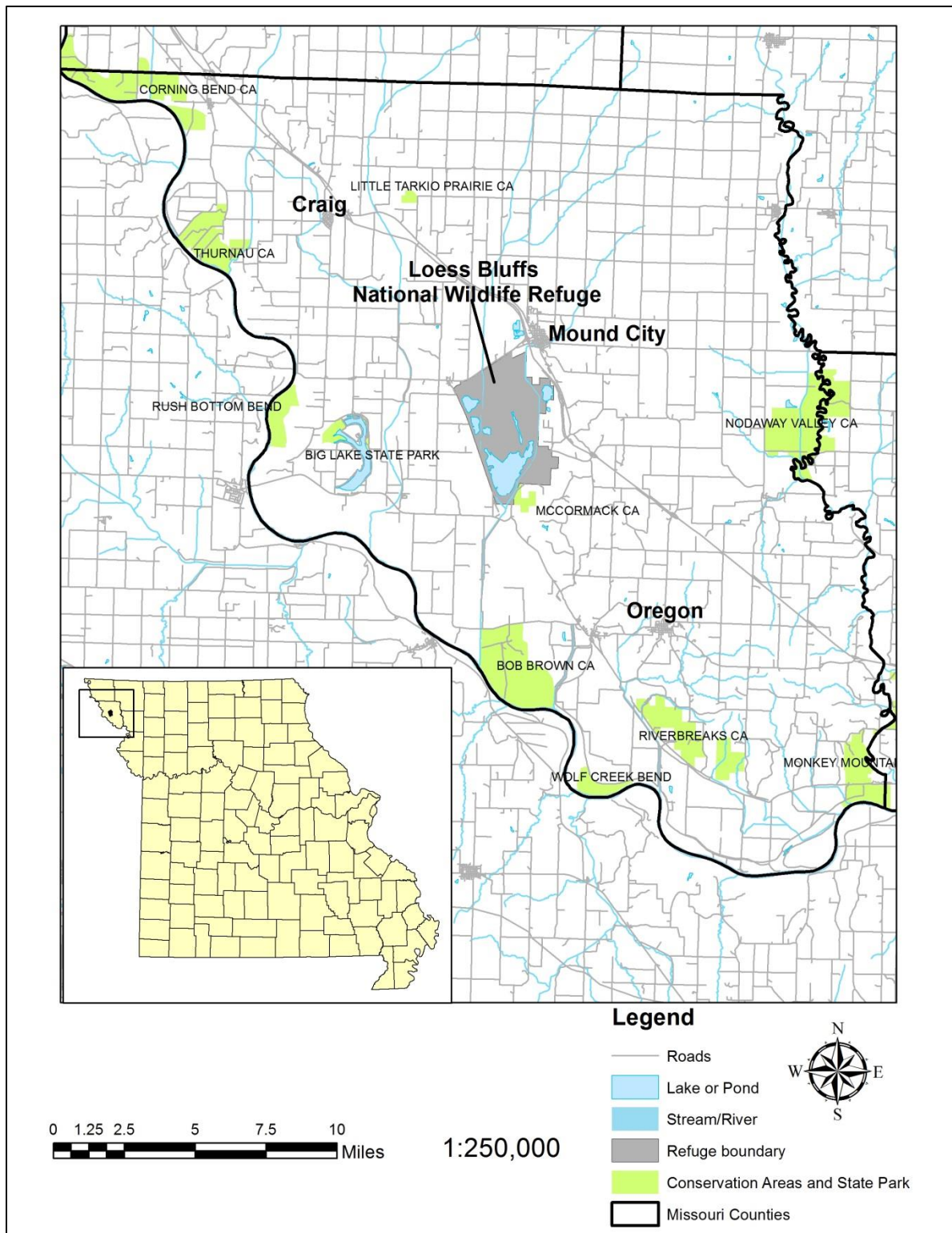


Figure 2.9. Missouri Department of Conservation- Conservation Areas and Missouri Department of Natural Resources- State Park proximity to LBNWR. Source: LBNWR_HMP_State_CAs&Parks.jpg created 5/4/2017 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

2.3 Historical Perspective of Ecological Landscape

Geologic Development

All of Holt County lies within the Western Glaciated Plains and Upper Missouri Big River divisions, also known as the Dissected Till Plains (Kramer 1993; Nigh and Schroeder 2002; Thom and Wilson 1980). These divisions are characterized by soils and topography that resulted from the influence of the Kansan stage of Pleistocene glaciation (Kramer 1993; Thom and Wilson 1980). Nigh and Schroeder (2002) further state that the Central Dissected Till Plains are characterized by moderately dissected glaciated plains that slope toward the Missouri and Mississippi Rivers. The topography of this region is younger than that of the rest of Missouri (Kramer 1993).

Soils of the Glaciated Plains are formed from glacial till, loess and alluvium. Pennsylvanian geology, including limestone, sandstone, thin-bedded shale and thin coal seams, underlines most the Glaciated Plains Natural Division. Only small, isolated outcrops along drainages reveal examples of strata that are buried under deep glacial till and loess soils (Kramer 1993). However, no known rock outcroppings exist on LBNWR. The Central Dissected Till Plains on LBNWR is further divided into the following subsections: Northwest Missouri River Alluvial Plain, Deep Loess Hills and Loess Hills subsections (Nigh and Schroeder 2002).

A total of 6,786 acres of the LBNWR are located in the Northwest Missouri River Alluvial Plain. Boundaries of the Northwest Missouri River Alluvial Plain include the river channel to the bluff line from the Iowa Border downstream to Mound City, Missouri. In the Missouri River Alluvial Plain, floodplain bedrock is usually over 30 feet below the surface (Nigh and Schroeder 2002).

A total of 629 acres of LBNWR contains Pleistocene loess which was deposited over glacial till and was formed over 4,000 years ago. According to Nigh and Schroeder (2002), the Deep Loess Subsection is distinguished by moderately thick to very thick loess soil (25-100 feet) over till and bedrock that has eroded into steep hills and narrow valleys with up to 250 feet of relief. The Loess Hills Subsection is distinguished by a thick loess mantle (10-25 feet) and loess soils. It is a hilly region characterized by broad, round ridges, moderate slopes, broad stream valleys, and a local relief of 100-150 feet. Bedrock and glacial till are exposed in deeper valleys. Bedrock in the Loess Hills of northwest Missouri is Pennsylvanian formations which are a series of cyclical shales, thin-bedded limestone, sandstones, and coals (Nigh and Schroeder 2002).

Pre-European Settlement

Northwest Missouri, where LBNWR is located, contains archeological evidence from the earliest suspected human presence in the Americas prior to 12,000 B.C., extending through the Paleo Indian, Archaic, Woodland, Mississippian, and historic Western cultures (Bell 2005). According to Kramer (1993), Sauk, Fox, Otoe, Ioway, Pottawattamie and Lakota Native American tribes thrived on the abundant game of the region. Kramer (1993) cites that white-tailed deer were abundant on the rolling prairies and flocks of wild turkey roamed through the tangled underbrush of the numerous oak groves. Prairie grouse and passenger pigeons were also commonly heard. Major drainages, including the Grand, Nodaway, Platte, Tarkio, One Hundred and Two, Nishnabotna, and Missouri rivers, provided enormous quantities of fish, necessary water, and routes of navigation (Kramer 1993).

In July 1804, Meriwether Lewis and William Clark followed the Missouri River bordering Holt and Atchison counties on their journey to the Pacific Ocean (Kramer 1993). Kramer (1993) cites that they described extensive bottoms interspersed with vines, willow islands and high, extensive prairies. Near the mouth of the Nishnabotna River (at the present day Atchison-Holt county line), the travelers found rich timber with small open prairies near the hills. Kramer (1993) also states that further north near McKissock Island (a few miles south of the Missouri-Iowa border); they describe a “ball (bald) pated prairie devoid of trees.” This range of bald hills paralleled the river and extended as far up and down the river as one could see. Little bottomland timber occurred here except for on islands and low wet points, which were covered with cottonwood, mulberry, sycamore and elm (Kramer 1993).

In the Missouri River floodplain, pre-settlement natural vegetation was largely wet mesic prairie and marshes, with narrow bands and isolated pockets of bottomland forest (Holbrook 1997; Kramer 1993; Nigh and Schroeder 2002). Over 50 percent of Holt County supported prairie vegetation, including tallgrass prairie with the steep loess bluffs exhibiting more xeric mixed-grass prairie vegetation (Holbrook 1997; Kramer 1993). Nigh and Schroeder (2002) further describe the Deep Loess Hills subsection as primarily prairie, including unique dry loess hill prairies and oak savanna. In the Loess Hills subsection, pre-settlement vegetation was mostly prairie with timber and brush in valleys and on steeper slopes (Nigh and Schroeder 2002). Woodlands were common along the smaller upland streams throughout Holt County (Holbrook 1997). Bottomland timber was largely composed of riverfront species including willow, cottonwood, silver maple, elm, hackberry, and ash (Nigh and Schroeder 2002). Oak savanna and woodland occupied steeper lands along valleys, and oak and mixed hardwood forest densely covered the rugged breaks along the Missouri River (Nigh and Schroeder 2002). General Land Office surveys from the 1830s-1840s suggest LBNWR was dominated by grassland and marshes on bottomlands with woodlands confined to certain areas including the Loess Hills (Figure 2.10). This diverse pattern of prairie and woodland was a major factor in the abundance of wildlife in pre-settlement Holt County (Holbrook 1997).

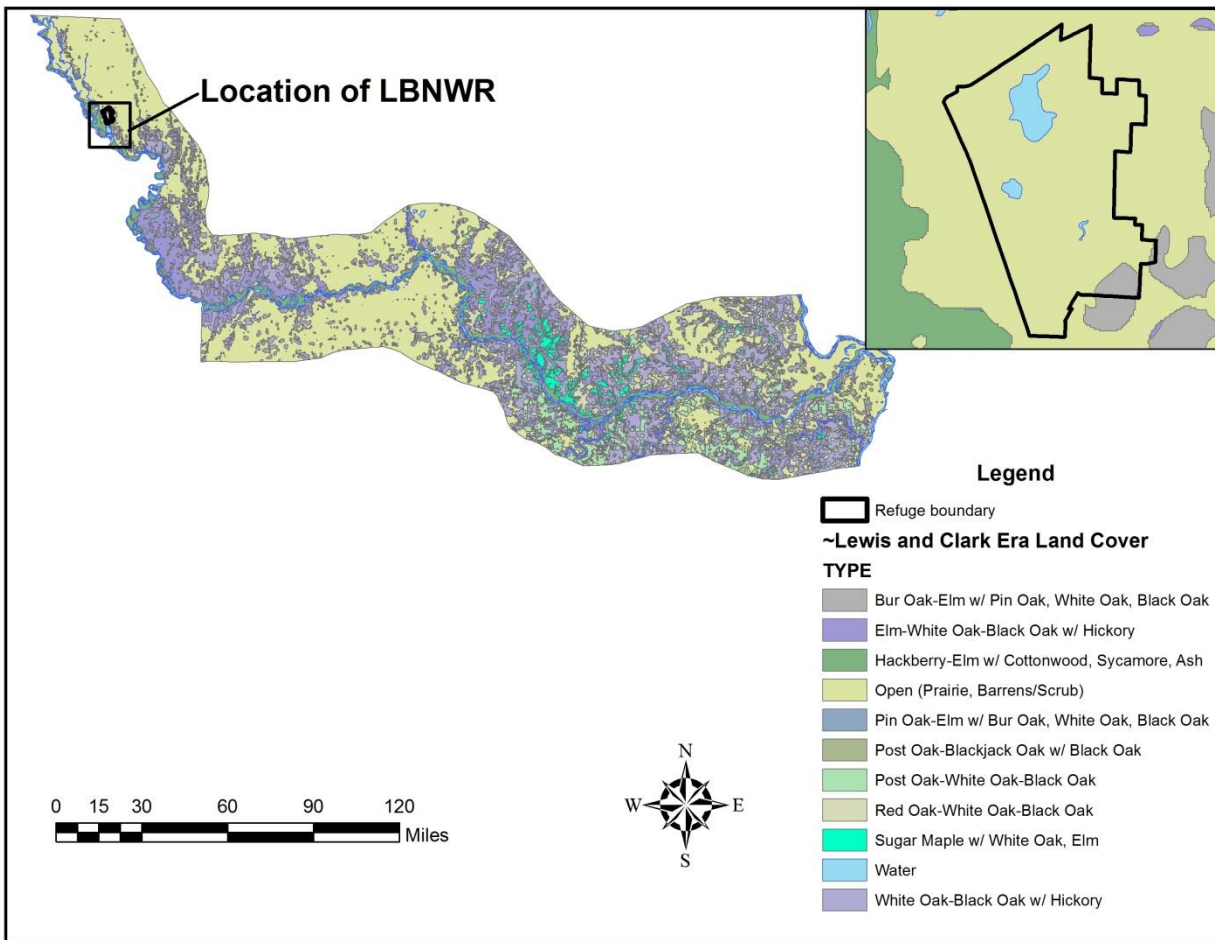


Figure 2.10. Historical land cover for lower Missouri River ecosystem and northwest Missouri and LBNWR. Source: HistoricalLC.jpg created 6/4/2015 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

The Missouri River formerly flowed in a braided channel with numerous islands, side chutes, and backwaters. Annual flooding created a complex and shifting mosaic of bottomland forest, marshes, wet prairies, and sandbars (Nigh and Schroeder 2002).

European Settlement

European settlement in northwest Missouri progressed with improved transportation, first in the form of steamboats and then railways. Americans used the Missouri River for transit, beginning in the early 1800's. Steamboats became common in the 1820's and peaked in the decades after the Civil War (Nigh and Schroeder 2002). Early American settlers from the eastern states of Kentucky, Tennessee, Georgia, Virginia, Ohio and Indiana were drawn to this rich land and began moving to the region in the early 1830's (Kramer 1993).

Early Americans hunted in the region, beginning in the 1820's, and began agricultural settlement in the 1830's and 1840's after the Platte Purchase was annexed to the state of Missouri (Nigh and Schroeder 2002). In the Loess Hills ecoregion, agricultural settlement

spread to northwestern Missouri by mid-1830. Settlements were established in a few places as river landings; however, in general, the alluvial lands were not widely cleared and farmed until after the adjacent bluff lands were utilized (Nigh and Schroeder 2002).

According to Kramer (1993), when the early settlers began to farm, they cultivated the woodland soils along the drainages first. The timber provided wood for shelter, fuel and tools. Also, water was more easily accessible. Though the less fertile timber soils were planted initially, settlers soon found that the deep, dark-colored prairie soils produced superior crops. This discovery spurred the intensive breaking of prairie sod which did not cease until nearly all land was converted (Kramer 1993). Holbrook (1997) states that the first crops planted were corn, wheat, barley, oats, alfalfa and hemp. Corn, soybeans and wheat soon became the major crops (Holbrook 1997). Farms were often commercial, with hemp and tobacco the chief cash crops in many areas, while the livestock industry of cattle, mules, and hogs was also important (Nigh and Schroeder 2002).

Holbrook (1997) cites that the hills adjacent to the Missouri River floodplain were well suited to fruit crops, and large acreages of apples, peaches, pears, and grapes were planted. By 1850, more than 82,000 acres (27% of the county) was used for crops (Holbrook 1997). There were more than 20,000 head of cattle, hogs, and sheep in the county (Holbrook 1997; Williams 1915). Thus, the population of the area quickly increased. By the Civil War, this was one of the foremost agricultural regions of Missouri, with one of the largest and densest rural populations. However, the Civil War caused great dislocations in the rural economy and the hemp industry virtually disappeared and tobacco very nearly so (Nigh and Schroeder 2002).

The coming of railroads aided the redevelopment of commercial agriculture; founded more on corn, hogs, cattle, and wheat (Nigh and Schroeder 2002). Railroads also opened up markets for timber, livestock, and farm products (Holbrook 1997). Soybeans were added in the twentieth century (Nigh and Schroeder 2002). Plows, reapers and fencing became readily available, enabling farmers to more aggressively convert the native prairies landscape to cropland and pasture (Kramer 1993). Mechanization and other innovations caused restriction of farming, and the steepest and most eroded lands were taken out of row crops (Nigh and Schroeder 2002). Artificial drainage of the Missouri River floodplain began in 1872, and in 1944 the Congressional Flood Act authorized the building of a system of levees along the river (Holbrook 1997). Channelization of the major riverways further increased farmable acreage and permanently altered the natural quality of most aquatic communities of the region (Kramer 1993).

The steep bluffs bordering the Missouri River floodplain in Atchison and Holt counties contain the largest amount of prairie remaining in the region (Kramer 1993). From a distance, these loess mounds have a very much denuded appearance, as if entirely devoid of vegetation (Bush 1895). As observed by Bush (1895), the south and west slopes are steep and precipitous, while the north and east sides are covered with a short thick growth of trees and shrubs near their bases. The well drained nature of loess, the steep topography and the exposures facing south and west all provide an arid environment on which drought tolerant vegetation evolved (Kramer, 1993). According to Kramer (1993) these bluff tops

contain Missouri's only mixed-grass prairie community, which includes at least 17 state listed plant and animal species.

Too steep to plow for cropland, the decline of the dry loess hill prairies is partially due to modern development—highway, power line and home construction (Kramer 1993). Severe erosion from overgrazing degraded many loess hills prairies and planted cool-season pastures have replaced native vegetation on several loess slopes. However, forest invasion is the major cause for the loss of prairie acreage. Kramer (1993) cites that modern-day woody invasion may have commenced with a weather trend toward a wetter climate that began before Lewis and Clark's expedition. A few hill prairies may be dry enough to resist forestation with the exclusion of fire, but without intensive intervention, loess hill prairies in Missouri are facing extinction (Kramer 1993).

Wildlife and Habitat Changes

Nearly the entire naturally occurring prairie and some of the woodland in Holt County is now used as cropland or for pasture, which is dominated by introduced grasses (Holbrook 1997). According to Holbrook (1997), scattered remnants of prairie are in old cemeteries and undisturbed fields and along the hills adjacent to the Missouri River floodplain. These remnant prairie areas are unique and contain several plant species that are rarely found in Missouri (Holbrook 1997). Pastures often have scattered, isolated savanna trees, with second growth forest confined to patches in the roughest land, especially in the breaks along the Missouri River (Nigh and Schroeder 2002). As cited by Nigh and Schroeder (2002), extensive draining, bank stabilization, and leveeing has drastically altered the hydrology of the region. Most of the wetlands have been drained and major bottomlands are now cropland. However, the number of wetlands in conservation ownership or protected by wetland reserve programs greatly increased after the Great Flood of 1993 (Nigh and Schroeder 2002).

The most common pre-settlement wildlife included bison (*Bison bison*), red wolf (*Canus rufus*), elk (*Cervus canadensis*), white-tailed deer and prairie chicken (*Tympanuchus cupido*) (Holbrook 1997). According to Holbrook (1997), destruction of the prairies has eliminated all but the white-tailed deer. Other wildlife species, such as coyotes (*Canus latrans*) and ring-necked pheasant (*Phasianus colchicus*), have adapted to the new land uses. Holt County remains a stopping area for an enormous number of migratory waterfowl and wading birds.

Hunting has become an important recreational activity in the county, with waterfowl, deer, pheasant and quail as the most sought-after game, along with turkey hunting in the wooded hills along the Missouri and Nodaway rivers (Holbrook 1997). Commercial and sport fishing for carp, channel catfish (*Ictalurus punctatus*) and buffalo (*Ictiobus spp.*) is also common in the Missouri River, while game fish such as largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*) and crappie (*Pomoxis spp.*) located in the area lakes and ponds along with some streams (Holbrook 1997).

Several wildlife species are presently being restored in Missouri, with some releases influencing the Holt County area (Holbrook 1997). According to Holbrook (1997), river

otters have been released in Platte County, along the Missouri River; due to their transient nature, they may become established in Holt County. The distribution of giant Canada goose (*Branta canadensis maxima*) of the eastern prairie population was expanded in Missouri, when young birds were relocated to Nodaway Lake in 1987 (Holbrook 1997).

2.4 Current Natural and Anthropogenic Disturbances

Natural disturbances in the Northwest Missouri Alluvial Plain include flooding, drought, freezing, and fire; while fire, grazing, and drought also helped to create and maintain the grassland dominated landscape of the Loess Hills ecoregion (Nigh and Schroeder 2002). Fire in prairie ecosystems is vital in killing shrubs and trees to allow fire-tolerant grassland species to thrive. Anthropogenic fire suppression has led to woodland expansion, which has developed an entire new mosaic of communities covering the Loess Hills, including woodlands and croplands in areas once dominated by prairie (Mutel 1989). Flooding in the Northwest Missouri Alluvial Plain helped to create a dynamic cycle of wetland destruction which resulted in a highly diverse ecosystem. Periodic events such as droughts and freezing temperatures played important roles in shaping the hydrology of the ecosystem (Nigh and Schroeder 2002). Much of the natural hydrological cycle has been altered due to agriculture and urban expansion.

Other anthropogenic disturbances include the introduction of invasive species and the impacts of agricultural use. Ravines in the bluff lands are often timbered in invasive species, such as elm and hackberry, while streams are suffering from siltation and agricultural pollutants (Nigh and Schroeder 2002). Plowing of slopes for cropland, degradation of soil-holding prairies by grazing cattle, and barring of soil through construction and recreational use has increased erosion of the Loess Hills, as well as increasing the speed at which precipitation runs off the hills into drainage, increasing the flood potential (Mutel 1989). In addition to plowing, overgrazing destroyed the native prairie grass. After 1840, overgrazing had the major effect of eliminating the native bluestem, which was replaced by introduced bluegrass (Schroeder 1981).

2.5 Current Refuge Conditions and Resources

Climate

The refuge is characterized by a continental climate, experiencing a wide range of temperatures throughout the year, with average winter lows of 15.9 °F and summer highs of 89.9 °F (Bell 2005). The average annual precipitation is 35.24 inches (Bell 2005). The average snowfall is 18.8 inches (Holbrook 1997). The average relative humidity is about 60 percent, with higher humidity at night (Holbrook 1997). The growing season in this area is around 200 days (Nigh and Schroeder 2002). Microclimatic variations are not significant in the Missouri River Alluvial Plain, while variations are significant between southwest-facing and northeast-facing slopes in the Deep Loess Hills subsection and local areas of higher relief in the Loess Hills subsection (Nigh and Schroeder 2002).

Soils

Soils in this regions are all very deep and were formed in alluvial sediments, with most upland soils being well to moderately well drained (Nigh and Schroeder 2002) (Figure 2.11). The Squaw and Davis Creek drainages consist of soils in the Marshal-Exira-Shelby soil series association, which are clay loam or silty clay loams (Heimann and Richards 2003; Holbrook 1997). Marshall, Exira, and Shelby soils are present on slopes greater than 7 percent, while minor soils in this association—Judson and Kendridge soil series- are present on slopes under 7 percent and in the floodplains areas (Heimann and Richards 2003; Holbrook 1997). Soils in these associations are used for crops including corn, soybeans, and winter wheat (Heimann and Richards 2003).

According to Holbrook (1997), the high floodplains along the Missouri River consists of soils in the Luton-Wabash-Blencoe association, which are nearly level, poorly drained and somewhat poorly drained, clayey soils that formed in alluvium. Floodplains along secondary streams of the Missouri River consist of soils in the Motark-Dupo-Dockery Association, which are nearly level, moderately well drained and somewhat poorly drained silty soils that formed in alluvium. Holbrook (1997) also cites that most areas of these associations are used for cultivated crops, such as corn, soybeans, and winter wheat, with grain sorghum and alfalfa sometimes being grown. The few scattered woodlands are dominated by cottonwood and other water-tolerant species that provide habitat for deer and other wildlife species, while spilled grain harvested fields also provides important feed for waterfowl during the fall migration, creating a suitable environment for hunting of deer and migratory waterfowl (Holbrook 1997).

The uplands and lower foot slopes adjacent to the Missouri River floodplain consist of soils in the Timula-Monona-Napier Association, which are very gently sloping to steep, well drained, silty soils that formed in loess and slope alluvium (Holbrook 1997). Holbrook (1997) states that most areas in this association are woodland with white oak, northern red oak, sugar maple, and shagbark hickory, which are used mainly for wildlife habitat and recreation, including fall hunting of deer and game birds. Some of the narrow ridgetops, valleys and side slopes are cultivated with corn, soybeans, alfalfa, grain sorghum, and winter wheat (Holbrook 1997).

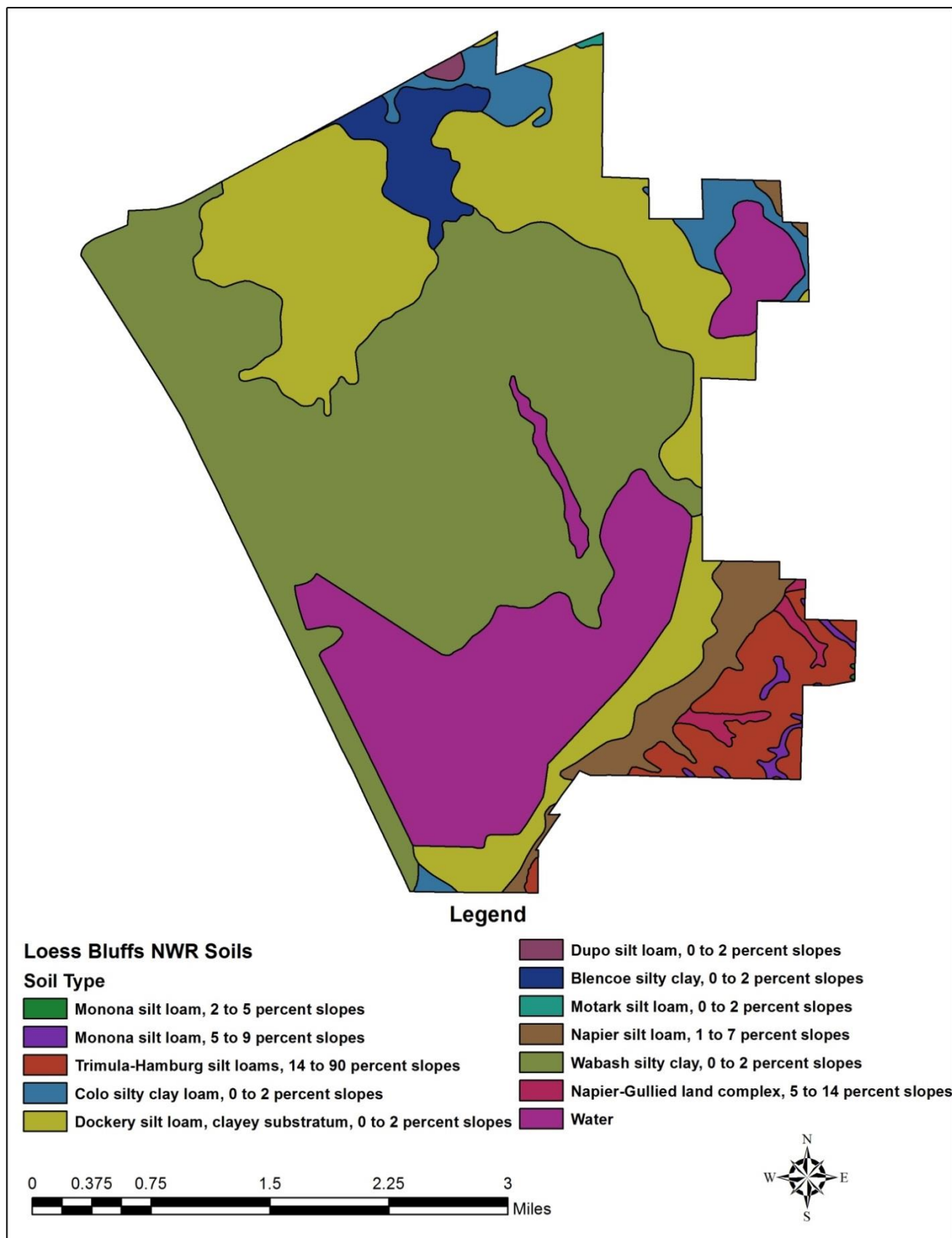


Figure 2.11. Soil types found within the boundary of Loess Bluffs NWR. Source: Soils.jpg created 6/5/2015 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

Topography

Between the Missouri and Nodaway rivers are narrow, gently sloping and moderately sloping summits with strongly sloping to very steep side slopes which are dissected by small drainage ways that flow toward larger streams (Holbrook 1997). In the southern part of the county, along these steep hills, limestone and shale formations are exposed on the lower parts of the hillslopes (Holbrook 1997). According to Holbrook (1997), steep hills rise abruptly, as much as 250 feet above the flood plain, with most summits in the county rising to elevations between 1,000 and 1,150 feet. A divide approximately 1,100 feet in elevation extends across the entire county from north to south (Holbrook 1997).

Topographic relief ranges from nearly level floodplains to dissected, sloping uplands with steep irregular loess mounds formed from wind-blown glacial outwash bordering the Missouri River floodplain in Atchison, Holt and Andrew counties (Kramer 1993). In the floodplain, topographic relief is usually less than 10 feet in any square mile, while relief in the Loess Hills ecoregion is 150 – 250 feet and declines with distance from the Missouri River with narrow ridges, steep slopes, and numerous short, steep drainages characterizing the landscape (Nigh and Schroeder 2002). Relief in the Squaw Creek and Davis Creek Basins is about 232 feet from the 1,096 upper basin divide to the 864 feet north refuge boundary (Heimann and Richards 2003).

Hydrology

Loess Bluffs NWR is directly influenced by a 60,000-acre upstream watershed, lying at the base of a highly erodible upland loess bluff hills (Heimann and Richards 2003) (Figure 2.12). About two-thirds of the uplands drain to the west directly into the Missouri River, while the eastern one-third of the uplands drains into the Nodaway River, a tributary of the Missouri River (Holbrook 1997). Other important Missouri River tributaries including Big Tarkio River, Little Tarkio Creek and Squaw Creek drain about 80 square miles of the uplands and then flow across the Missouri River flood plain in a southwesterly direction and empty into the Missouri River (Holbrook 1997). Specifically on the refuge, Squaw Creek drains about 63 square miles (approximately 45,000 acres) above Highway 59 and crosses under Interstate Highway 29 (Heimann and Richards 2003). At this point, the creek enters the floodplain and is confined between levees extending to the north boundary of the refuge (Heimann and Richards 2003). Davis Creek drains about 23 square miles (approximately 15,000 acres). The creek emerges from the hills at Mound City and directly enters the northeast corner of the refuge after passing under Interstate Highway 29. Three smaller creeks - Porter, Swope, and Blair - drain watersheds from the north and east that enter Loess Bluffs NWR. Though small, these creeks add another 9 square miles of drainage and runoff to the refuge, making the total upstream drainage area influencing the refuge approximately 95 square miles.

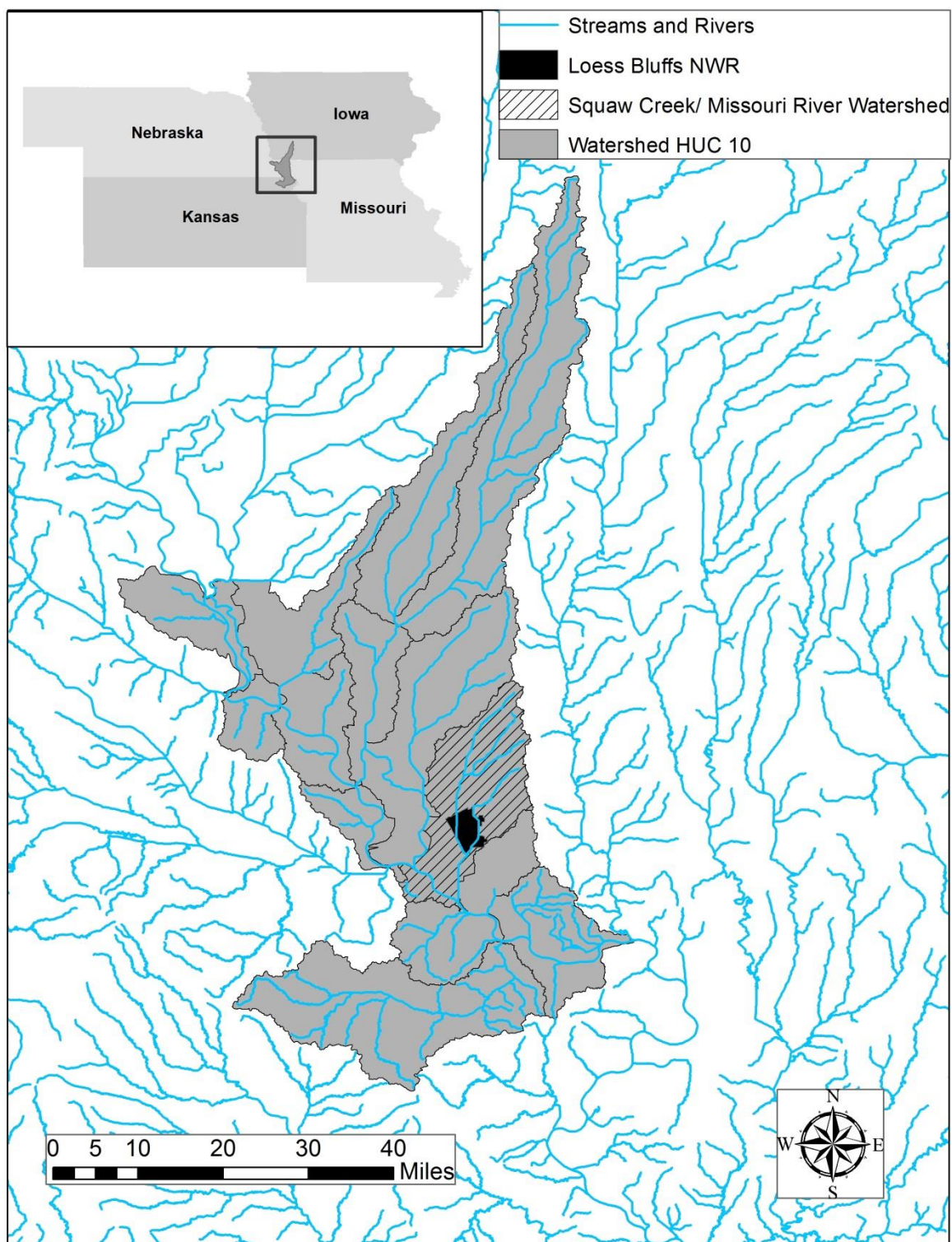


Figure 2.12. Watershed from National Hydrography Dataset for Loess Bluffs NWR and surrounding areas. Source: LBNWR_NHD.jpg created 6/18/2017 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

Flows from the Missouri River have limited and indirect influences on the refuge. This is particularly true during floods. As an example, during the 1993 flood, most of the damage the refuge sustained was a result of runoff from the upstream watershed rather than the Missouri River. However, because the river was in flood stage, the refuge was unable to discharge adequate amounts of water and runoff from the watershed backed up and flooded most of the refuge bottomland habitat. Missouri River discharge is now regulated by many large dams and reservoirs upstream on the Missouri and its tributaries, and the range in average monthly flows is much reduced, with most of the river floods now impeded by levees (Nigh and Schroeder 2002).

Water Quality

Extensive draining, bank stabilization, and leveeing have drastically altered the hydrology of the area. Loess hills streams carry very high suspended sediment loads derived from the subsection's easily eroded loess soils. Suspended sediment levels and ultimately sedimentation rates for deposits of silts and sand in the Mississippi River and its floodplain have increased following clearing of uplands for agriculture, construction of drainage and levee districts, increased diversion of water into the river, and slower flows and impounded conditions following construction of locks and dams. As a result, water quality has been seriously affected by agricultural land use and high turbidity (Nigh and Schroeder 2002).

Heimann and Richards (2003) reports trends in total sediment deposition and sedimentation rates in the wetlands of LBNWR. From 1937 to 1964, mean total sediment deposition in the wetlands of LBNWR was 1.26 feet, or 0.047 ft/yr., while the mean total sediment deposition for years 1964 to 2002 as reported from 2002 surveyed pools was 0.753 feet, or 0.020 ft/yr. When looking at 1937 to 2002, the total sediment volume deposited in the 2002 surveyed pool area was 9,900 acre-feet or 152 acre-ft/yr., also reported as about 10,300,000 tons of sediment 32.4 tons/acre/yr. (Heimann and Richards 2003).

Natural Community Types

Most of the 7,440 acres comprising the refuge are located along the eastern edge of the Missouri River floodplain in an historic wetland area. Based on 2007 Land Cover Land Use Data, habitat types include 823.8 acres of bottomland forest, 470.4 acres of bottomland mesic prairie, 1,079.7 acres of wet prairie, 376.6 acres of Loess Hills forest, 325 acres of agricultural field (to be converted), 300.3 acres of Loess Hills prairie, 3,641.3 acres of managed wetland, and 171.5 acres of wetland. Developed land including administrative areas, channelized ditches and roads accounts for 251.4 acres on the refuge.

The National Wildlife Refuge System adopted the National Vegetation Classification System (NVCS) which was developed by The Nature Conservancy and the Natural Heritage Network as a standard for classifying plant communities. The classification contains hierarchical levels of community specificity. The narrowest level within the classification is the Association. When possible, the global conservation status rankings can be indicated as referenced by NatureServe Explorer. Conservation status rankings indicate the degree of imperilment of a species of community on either a global, national, or state level. G1 rankings indicate a community that is most globally imperiled habitats, while G5 communities are considered globally stable. States also often rank these communities on a statewide scale. A table including the NVCS Associations found within the various broad scale habitats of the refuge will be included in Chapter 3 in relation to Biological Integrity, Diversity, and Environmental Health (BIDEH) criteria.

Wildlife

Loess Bluffs National Wildlife Refuge is home to 310 species of birds, including a large variety of waterfowl, with over 1,400,000 snow geese, 476 bald eagles, and 200,000 ducks seen during migration, as well as over 800 trumpeter swans recorded in 2015. The refuge also hosts a variety of other marsh birds, as well as an assortment of grassland and woodland birds. LBNWR is also home to other Missouri endangered species including: American bittern, northern harrier (*Circus cyaneus*), snowy egret (*Egretta thula*), peregrine falcon (*Falco peregrinus*), least tern (*Sternula antillarum*), and barn owl (*Tyto alba*).

The refuge also hosts a diverse amount of other vertebrates including 41 species of mammals and 37 species of reptiles and amphibians. Mammals found on the refuge include: white-tailed deer, gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), coyote, American mink (*Neovison vison*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*), longtail weasel (*Mustela frenata*), American badger (*Taxidea taxus*), river otter (*Lontra canadensis*), and rabbits, as well as several species of bats, rodents, and shrews. Amphibians and reptiles found at LBNWR include two species of salamander, four species of toads, five species of frogs, five

species of turtles, two lizard species, and 15 species of snakes. Notable reptiles include the Missouri endangered Blanding's turtle (*Emydoidea blandingii*) and prairie massasauga (*Sistrurus tergeminus tergeminus*). Fish resources are limited due to the lack of deep water. Invertebrate diversity is extensive, but poorly documented.

Invasive Species

The primary invasive species found at LBNWR, ranked based on degree of impact, include: reed canarygrass (*Phalaris arundinacea*), garlic mustard (*Alliaria petiolate*), oriental bittersweet (*Celastrus orbiculatus*), bush honeysuckle (*Lonicera* spp.), and Johnson grass (*Sorghum halepense*). Reed canarygrass is a highly invasive grass reaching 6 feet tall, which covers from 50-70% of the area, where present on LBNWR. The amount of reed canarygrass varies drastically with flooding at the refuge. Garlic mustard, along with bush honeysuckle, tends to invade forest and edge habitats and spreads rapidly. Oriental bittersweet, most likely originating at the early manager's house, is typically found smothering many herbaceous plants in wooded areas. Johnson grass tends to invade riverbanks and disturbed areas, including forest edges and fallow fields on the refuge. Other species of concern include invasive species such as Japanese hops (*Humulus japonicus*) and Sericea lespedeza (*Lespedeza cuneata*), along with aggressive native species such as black locust (*Robinia pseudo-acacia*). The management of invasive species is vital to appropriate habitat management at LBNWR, thus management strategies will be discussed and integrated into the HMP.

Research and Monitoring

Research and monitoring is a vital part of the functioning of LBNWR. Loess Bluffs participates in several surveys each year as part of ongoing research and monitoring efforts of the refuge. Staff conducts surveys of bald eagles from fall through spring migration, along with observations on breeding pairs and their young. As part of the Integrated Waterbird Management and Monitoring (IWMM) program, LBNWR completes regular waterfowl surveys, shorebird surveys, and marsh bird surveys. The refuge participates in the Christmas Bird Count and The Big Sit. In addition, LBNWR conducts waterbird nesting, white-tailed deer, muskrat house and beaver lodge counts, bat acoustic, Massasauga spring emergence, reptiles and amphibians (using cover boards and drift fences), and frog and toad breeding surveys. The refuge has participated in several collaborative projects conducted by USFWS, university faculty and/or students including the Reed Canary Grass Adaptive Management project, pollination ecology of American lotus project, a Massasauga spatial ecology project, and a Blanding's turtle spatial ecology project, among others. There is a need for further vegetation, invertebrate, and fish surveys on the refuge in order to fill gaps in data. All continued research and monitoring efforts and any new projects will be designed to reflect the habitat goals and objectives outlined in this HMP for the resources of concern.

2.6 Climate Change

Changes in the overall landscape, land use, and vegetative communities clearly had dramatic consequences for native flora and fauna. Climate change will only compound the challenges and threats described above. The climate of the Midwest has already changed measurably over the last half century (De Gaetano 2002; Kunkel et al. 1999). According to a scientific study by Wuebbles and Hayhoe (2004), average annual temperatures have risen, accompanied by a

number of major heat waves in the last few years. There have been fewer cold snaps, and ice and snow are melting sooner in the spring and arriving later in the fall. Heavy rains are occurring about twice as frequently as they did a century ago, increasing the risk of flooding (Wuebbles and Hayhoe 2004). In a recent paper by Martinuzzi et al. (2016) the refuge is predicted to experience increases in the frequency and intensity of extreme heat, fewer droughts, but no change in the incidence of false springs (defined as when leaf-out of plants is followed by a hard freeze). These climate alterations will impact a wide array of wildlife species and habitats, including those located on LBNWR.

Today, the continental population of breeding grassland birds continues to decline at a very high rate compared to other bird guilds of North America. Fifty-four percent of species showed a significant negative trend between 1966 and 2010 (Sauer et al. 2011). Fifty-seven percent of grassland bird species also show a medium-to-high vulnerability to climate change (NABCI 2010). This added pressure could result in more birds listed as Species of Conservation Concern. Higher temperatures predicted for the Great Plains (Ojima and Lockett 2002) could decrease productivity of many grasslands (NABCI 2010) due to changes in vegetation community and structure, loss of water sources, and decreased prey, among others.

Although wetlands are dynamic systems that fluctuate with changing weather, they also are very susceptible to climate change because of their shallow depths and high evapotranspiration rates (Johnson et al. 2010). Even slight temperature or precipitation changes could cause degradation or loss (NABCI 2010), likely causing shifts once more in the breeding range of waterfowl (Johnson et al. 2010; Johnson et al. 2005). Species such as black tern (*Chlidonias niger*), and Forster's tern (*Sterna forsteri*) may experience increased vulnerability due to breeding ground degradation (Marra et al. 2014). Forested habitats will also be subject to impacts from climate change. It is projected that rising air temperatures will supersede precipitation in some areas, leading to a substantial increase in evaporation, thus causing soil moisture deficit and drought-like conditions (Easterling and Karl 2001), or savannification of upland forested habitats. Many woodland species, such as yellow-bellied flycatchers (*Empidonax flaviventris*), wood thrush (*Hylocichla mustelina*), and worm-eating warblers (*Helminthos vermivorum*) may experience increased vulnerability due to habitat alterations (Marra et al. 2014).

Climate simulations are often used to make predictions regarding habitat alteration. Although these simulations provide information on possible future conditions, our management strategies need to remain flexible in order to accommodate a range of possible future conditions. Through the construction of this HMP, the possible future effects of climate change will be considered as habitat goals and objectives are set. The strategies chosen to implement these goals and objectives will incorporate adaptability in order to address the consequences of changing climate.

Chapter 3. Resources of Concern

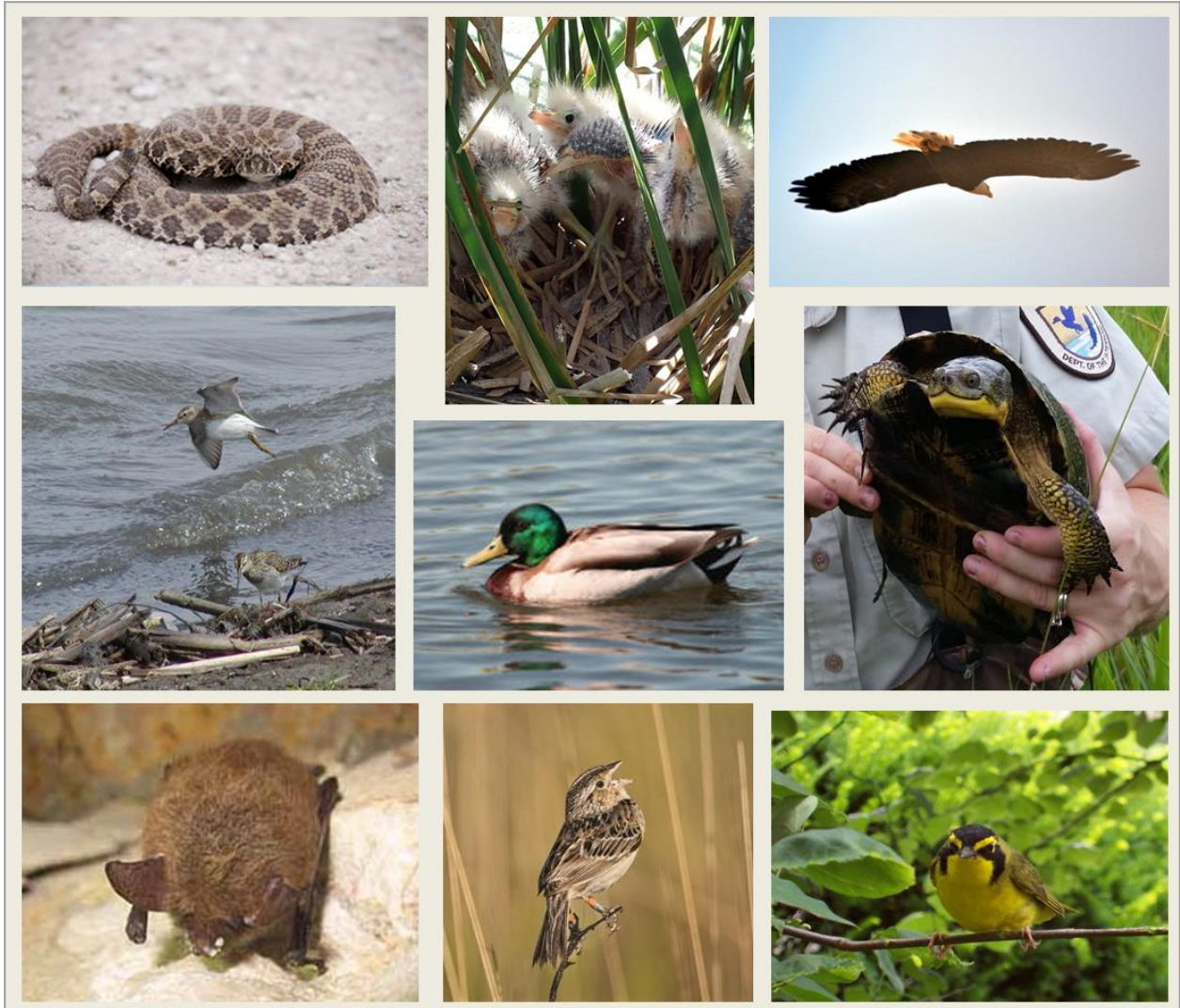


Image: Resources of concern including massasauga rattlesnake, least bittern, bald eagle, pectoral sandpiper, mallard, Blanding's turtle, northern long-eared bat, grasshopper sparrow, and Kentucky warbler.

Photo courtesy: USFWS staff.

3.1 Introduction

Resources of concern are the primary focus of this HMP and are central to the work of the NWRS. The USFWS is entrusted with conserving and protecting migratory birds, federally listed threatened and endangered species, inter-jurisdictional fishes, and certain marine mammals (i.e., “trust species”). Furthermore, each unit of the NWRS has one or more purposes for which it was established. The management direction of each refuge is driven by the refuge purpose(s) and statutory mandates, coupled with species and habitat priorities (a.k.a. resources of concern). Refuges also support other elements of biological diversity including invertebrates, rare plants, unique natural communities, and ecological processes that contribute to biological integrity and environmental health at the refuge, ecosystem, and broader scales.

The FWS’s HMP Policy (620 FW 1) defines “resources of concern” as:

All plant and/or animal species, species groups, or communities specifically identified in Refuge purpose(s), System mission, or international, national, regional, State, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are resources of concern on a refuge whose purpose is to protect “migrating waterfowl and shorebirds.” Federal or State threatened and endangered species on that same Refuge are also resources of concern under terms of the respective threatened and endangered species acts.

Given the multitude of purposes, mandates, policies, and plans that can apply to a refuge, it is necessary to explicitly identify resources of concern and identify those resources for which the refuge is best suited to focus its management activities. The process used by Loess Bluffs NWR to identify potential resources of concern, priority resources of concern, and priority habitat types is described below. Priority resources of concern and habitat types were then used to develop habitat goals, objectives, and strategies (Chapter 4, 5).

3.2 Comprehensive Resources of Concern

A comprehensive list of potential resources of concern for Loess Bluffs National Wildlife Refuge is found in Appendix B. The list was developed by consulting several plans and lists, including refuge species lists, national and regional priority documents, state fish and wildlife plans, and Federal and State endangered species lists. Generally, any species known to occur or that could reasonably occur on LBNWR and that is included in any of the resources consulted was added to the comprehensive list. Key ecosystems were added because they are important under the auspices of the Biological Integrity, Diversity, and Ecosystem Health policy (see section 3.3). The potential resources of concern include 189 birds, 49 mammals, 45 reptiles and amphibians, 45 fish, 28 gastropods, 11 insects, 22 plants, and 5 habitats. The final resources of concern were developed based on the priority species of greatest significance that were most likely to be impacted by management, as well as existing and future habitat at the refuge.

3.3 Biological Integrity, Diversity, and Environmental Health

The National Wildlife Refuge System Improvement Act of 1997 states that, in administering the System, the Service shall “ensure that the biological integrity, diversity, and environmental health of the System are maintained...” (601 FW 3; also known as the “Integrity Policy”). The Service defines these terms as follows:

<i>Biological Integrity</i>	Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities.
<i>Biological Diversity</i>	The variety of life and its processes, including the variety of living organisms, the genetic differences between them, and the communities and ecosystems in which they occur.
<i>Environmental Health</i>	Composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment.

Where possible, refuge management restores or mimics natural ecosystem processes or functions that support fish and wildlife and thereby maintain biological integrity, diversity, and environmental health (BIDEH). Table 3.1 includes all broad habitat types present on the refuge, their natural community descriptions, NVCS association classifications, as well as state and global conservation rankings. The natural community types are also portrayed in Figure 3.1. Table 3.2 includes the natural processes responsible for each habitat and the limiting factors and/or threat for each habitat. Assessing the types of habitats present on the refuge can provide guidance on what conditions constitute biological integrity, diversity and environmental health of those habitats; how those conditions are maintained; how and when it is appropriate to restore degraded conditions, and awareness of external threats to those habitats and ecosystems. Given the continually changing environmental conditions and landscape patterns of the past and present (e.g., rapid development, climate change, invasive species), relying on natural processes is not always feasible nor always the best management strategy for conserving wildlife resources. Uncertainty about the future requires Loess Bluffs NWR to manage within a natural range of variability rather than emulating an arbitrary point in time. Doing this maintains mechanisms that allow species, genetic strains, and natural communities to evolve with changing conditions, rather than trying to maintain stability or achieve the highest state of productivity each time we manage (i.e. hemi-marsh state of a wetland).

Table 3.1. BIDEH table highlighting the natural communities and NVCS associations located at LBNWR, with the habitat attributes and conservation rankings of each habitat.

Broad Habitat Type (Shorthand)	¹ General Natural Community Description	¹ Specific natural Community Description	^{2,3} NVCS Association Classification	^{2,3} Populations and Habitat Attributes	² Global Conservation Ranking	¹ MO State Rank
Grassland	Loess/Glacial Till Prairie	Dry Loess/Glacial Till Prairie	Loess Hills Little Bluestem Dry Prairie	Community is dominated by the bunchgrasses <i>Andropogon gerardii</i> , <i>Bouteloua curtipendula</i> , and <i>Schizachyrium scoparium</i> . <i>Bouteloua hirsute</i> , <i>Sporobolus cryptandrus</i> , <i>Dalea leporina</i> , <i>Dalea candida</i> , <i>Dalea enneandra</i> , <i>Astragalus lotiflorus</i> , and <i>Astragalus missouriensis</i> can be common.	G2	S2
		Dry-Mesic Loess/ Glacial Till Prairie				S1
		Mesic/ Wet- Mesic Bottomland Prairie	Central Wet- mesic Tallgrass Prairie CEGL002024	Extensive grassland; tree canopy of less than 10%; single layer of dominant graminoids intermixed with abundant forbs; tall grasses dominate, <i>Andropogon gerardii</i> and <i>Spartina pectinata</i> can exceed 2 m in height, <i>Panicum virgatum</i> greater than 1 m; other plants found in Missouri are <i>Juncus interior</i> , <i>Tripsacum dactyloides</i> , <i>Helianthus grosseserratus</i> , <i>Potentilla simplex</i> , <i>Eryngium yuccifolium</i> , and <i>Carex bicknellii</i> ; found on depressions of terraces and on floodplains of larger streams and rivers.	G2G3	S1
			Central Mesic Tallgrass Prairie CEGL002203	Trees are infrequent to absent. The height of the dominant plants ranges from 0.5-2.0 m. Cover is typically 85-95%. Forb species composition varies from site to site. <i>Andropogon gerardii</i> , <i>Symphyotrichum ericoides</i> , <i>Dalea candida</i> , <i>Eryngium yuccifolium</i> , <i>Helianthus pauciflorus</i> ssp. <i>pauciflorus</i> , <i>Liatris pycnostachya</i> , <i>Liatris spicata</i> , <i>Ratibida pinnata</i> , <i>Rosa carolina</i> , <i>Schizachyrium scoparium</i> , <i>Sporobolus heterolepis</i> , <i>Oligoneuron rigidum</i> , and <i>Sorghastrum nutans</i> are abundant throughout this community's range.	G3	S1
		Wet Bottomland Prairie	Central Cordgrass Wet Prairie CEGL002224	Dense layer of graminoids dominates; forbs and small trees or shrubs are also common. The vegetation is typically 1-2 m tall. <i>Calamagrostis canadensis</i> and <i>Spartina pectinata</i> are the most abundant species; common are <i>Carex lacustris</i> , <i>Carex aquatilis</i> , <i>Carex pellita</i> , and <i>Carex atherodes</i> ; found in lowland areas that are flooded in spring and saturated for much of the growing season.	G3	S1

Table 3.1. BIDEH table highlighting the natural communities and NVCS associations located at LBNWR, with the habitat attributes and conservation rankings of each habitat

Broad Habitat Type (Shorthand)	¹ General Natural Community Description	¹ Specific natural Community Description	^{2,3} NVCS Association Classification	^{2,3} Populations and Habitat Attributes	² Global Conservation Ranking	¹ MO State Rank
Wetland	Riverine Wetland	Marsh	Bulrush - Cattail - Burreed Shallow Marsh CEGL002026	Vegetation varies from zones dominated by tall emergents 1-2 m tall to those with hydrophytic annual and perennial forbs <1 m tall. In the tall emergent zone, <i>Schoenoplectus tabernaemontani</i> , <i>Schoenoplectus fluviatilis</i> , <i>Schoenoplectus acutus</i> , <i>Typha angustifolia</i> , and <i>Typha latifolia</i> may dominate, mixed with a variety of other herbaceous species.	G4G5	S2
			River Bulrush Marsh CEGL002221	Dominant species is <i>Schoenoplectus fluviatilis</i> . Other marsh associates include <i>Typha angustifolia</i> , <i>Typha latifolia</i> , <i>Schoenoplectus tabernaemontani</i> , and <i>Sparganium eurycarpum</i> .	G3G4	S2
			Midwest Mixed Emergent Deep Marsh CEGL002229	Community is dominated by a mosaic of emergents, submergents, and floating-leaved plants interspersed with areas of open water. Vegetation covers at least 3% of the surface. <i>Typha latifolia</i> , <i>Typha angustifolia</i> , and <i>Schoenoplectus acutus</i> dominate this dynamic ecosystem. Sedges are also common (e.g., <i>Carex lupuliformis</i>), and a diverse assemblage of grasses, floating-leaved aquatics, and submerged aquatics are present.	G4	S2
			Midwest Cattail Deep Marsh CEGL002233	Deepwater emergent marsh community is dominated by perennial, coarse-leaved graminoid vegetation. Stands may vary from a mosaic of emergents, submergents, and floating-leaved plants interspersed with areas of open water to dense stands of emergents; dominated by relatively pure stands of <i>Typha spp.</i> , either <i>Typha latifolia</i> or <i>Typha angustifolia</i> or both. Many associates could occur.	G5	S2
			Reed Canarygrass Eastern Marsh CEGL006044	Stands are dominated by <i>Phalaris arundinacea</i> , a 0.5- to 2-m tall perennial grass. Associates include <i>Verbesina alternifolia</i> , <i>Solidago rugosa</i> , <i>Boehmeria cylindrica</i> , and <i>Euthamia graminifolia</i> , along with exotic species such as <i>Glechoma hederacea</i> , <i>Coronilla varia</i> , <i>Rosa multiflora</i> , and <i>Elaeagnus umbellata</i> .	GNR	S2

Table 3.1. BIDEH table highlighting the natural communities and NCVS associations located at LBNWR, with the habitat attributes and conservation rankings of each habitat

Broad Habitat Type (Shorthand)	¹ General Natural Community Description	¹ Specific natural Community Description	^{2,3} NCVS Association Classification	^{2,3} Populations and Habitat Attributes	² Global Conservation Ranking	¹ MO State Rank
Wetland	Riverine Wetland	Shrub Swamp	Common Buttonbush/ Sedge Species Northern Shrubland CEGL002190	The shrub layer can vary from very open to closed (20-80%). <i>Cephalanthus occidentalis</i> typically comprises nearly 90% of the shrub layer in waters 1-2 m deep. Other shrubs include <i>Cornus sericea</i> , <i>Decodon verticillatus</i> , <i>Ilex verticillata</i> , <i>Rosa palustris</i> , and <i>Salix nigra</i> . Rooted or floating aquatics may dominate, including <i>Lemna minor</i> and <i>Nuphar advena</i> .	G4	S2
			Dogwood Floodplain Shrubland CEGL005220	Moderate to locally dense cold-deciduous shrubs 2-3 m tall. <i>Amorpha fruticosa</i> and <i>Cornus drummondii</i> dominate the stands, with scattered patches of <i>Cornus sericea</i> , <i>Salix exigua</i> and <i>Populus deltoides</i> saplings. Sedges, such as <i>Carex cristatella</i> , <i>Carex emoryi</i> , and <i>Carex pellita</i> , are found with mesophytic grasses, such as <i>Panicum virgatum</i> and <i>Andropogon gerardii</i> .	G4	S2
		Freshwater Aquatic Vegetation	Midwest Pondweed Submerged Aquatic Wetland CEGL002282	Open water marshes with emergent cover <25% and floating leaved aquatics >25%. Typical dominants include <i>Ceratophyllum demersum</i> , <i>Elodea canadensis</i> , <i>Lemna spp.</i> , <i>Myriophyllum sibiricum</i> , <i>Myriophyllum verticillatum</i> , <i>Potamogeton natans</i> , <i>Stuckenia pectinata</i> (= <i>Potamogeton pectinatus</i>), <i>Potamogeton richardsonii</i> , <i>Potamogeton zosteriformis</i> , <i>Ranunculus aquatilis</i> , <i>Utricularia macrorhiza</i> (= <i>Utricularia vulgaris</i>), and <i>Vallisneria americana</i> .	G5	S2
			American Lotus Aquatic Wetland CEGL004323	Floating-leaved aquatic plant species, such as <i>Nuphar advena</i> and <i>Nymphaea odorata</i> , may be present, as may emergent species such as <i>Schoenoplectus tabernaemontani</i> (= <i>Scirpus tabernaemontani</i>), <i>Pontederia cordata</i> , <i>Juncus effusus</i> , <i>Typha latifolia</i> , <i>Eichhornia crassipes</i> (alien), <i>Hydrocotyle spp.</i> , and floating aquatics, such as <i>Salvinia minima</i> , <i>Spirodela spp.</i> , <i>Lemna spp.</i> , and <i>Azolla caroliniana</i> . The hydrology of this association is highly variable; the hydrologic placement is debatable.	G4	S2

Table 3.1. BIDEH table highlighting the natural communities and NCVS associations located at LBNWR, with the habitat attributes and conservation rankings of each habitat

Broad Habitat Type (Shorthand)	¹ General Natural Community Description	¹ Specific natural Community Description	^{2,3} NCVS Association Classification	^{2,3} Populations and Habitat Attributes	² Global Conservation Ranking	¹ MO State Rank
Wetland	Riverine Wetland	Wet Shoreline Vegetation	Mixed Forbs Herbaceous Vegetation CEGL002430	Occur in shallow depressions that may flood for several weeks in the spring, but draw down by early summer. Species include <i>Bidens</i> spp., <i>Cyperus</i> spp., <i>Echinochloa crus-galli</i> , and <i>Polygonum</i> spp. In Missouri <i>Polygonum hydropiperoides</i> is common. Dominant perennials include <i>Typha latifolia</i> , <i>Typha angustifolia</i> , <i>Schoenoplectus tabernaemontani</i> (= <i>Scirpus tabernaemontani</i>), and <i>Polygonum amphibium</i> .	G4G5	S2
Forest	Loess/ Glacial Till Forest	Dry-Mesic/Mesic Loess/Glacial Till forest	White Oak-Hickory Forest CEGL002011	The most abundant tree species are <i>Quercus alba</i> , <i>Quercus rubra</i> , <i>Quercus velutina</i> , <i>Carya ovata</i> , <i>Carya cordiformis</i> , and <i>Tilia americana</i> . The shrubs in this community rarely exceed 2 m., including <i>Symphoricarpos orbiculatus</i> , <i>Amelanchier alnifolia</i> , <i>Cercis canadensis</i> , <i>Cornus drummondii</i> , and <i>Ribes</i> spp. Species typically in the herbaceous layer are <i>Aquilegia canadensis</i> , <i>Dicentra cucullaria</i> , <i>Laportea canadensis</i> , and <i>Verbena urticifolia</i> .	G3	S3
		Dry/Dry-Mesic Loess/Glacial Till woodland				
	Bottomland Forest/Woodland	Wet-Mesic Bottomland Forest & Wet Mesic Woodland	Silver Maple-Elm Forest CEGL002586	The canopy cover is more-or-less closed and dominated by <i>Acer saccharinum</i> , <i>Fraxinus pennsylvanica</i> , <i>Ulmus americana</i> , and <i>Populus deltoides</i> . Associated species include <i>Ulmus rubra</i> , <i>Acer negundo</i> , <i>Salix nigra</i> , <i>Celtis occidentalis</i> , and <i>Carya cordiformis</i> . The shrub and sapling layer is often open (<25% cover). Species that may be present include <i>Sambucus canadensis</i> , <i>Rubus occidentalis</i> , or <i>Lindera benzoin</i> . Woody and herbaceous vines; Herbaceous grasses, forbs, and ferns dominate the ground.	G4	S2S1
		Wet Bottomland Forest	Ash-Elm Seasonally Flooded Floodplain Forest CEGL007987	The canopy is moderately tall (to 70+ feet), closed, and layered with emergent tree species including <i>Fraxinus pennsylvanica</i> , <i>Ulmus americana</i> , <i>Quercus texana</i> , and <i>Gleditsia triacanthos</i> . Herbs and woody vines include <i>Bidens aristosa</i> , <i>Bignonia capreolata</i> , <i>Boehmeria cylindrica</i> , <i>Carex intumescens</i> , <i>Leersia virginica</i> , <i>Lycopus virginicus</i> , <i>Berchemiascandens</i> and <i>Toxicodendron radicans</i> .	G4	S3

¹ Nelson, PW. 2010. The terrestrial natural communities of Missouri. Jefferson City (MO): Missouri Department of Conservation.

² NCVS Association Classification: <http://explorer.natureserve.org/servlet/NatureServe>; ³ NCVS Association Classification: <http://usnvc.org/explore-classification/>

Global Rank (G):

G1: Critically Imperiled

G2: Imperiled

G3: Vulnerable

G4: Apparently Secure

G5: Secure

G#G#: Range Rank

GNR: Unranked

State Rank (S):

S1: Critically Imperiled

S2: Imperiled

S3: Vulnerable

S4: Apparently Secure

S5: Secure

S#S#: Range Rank

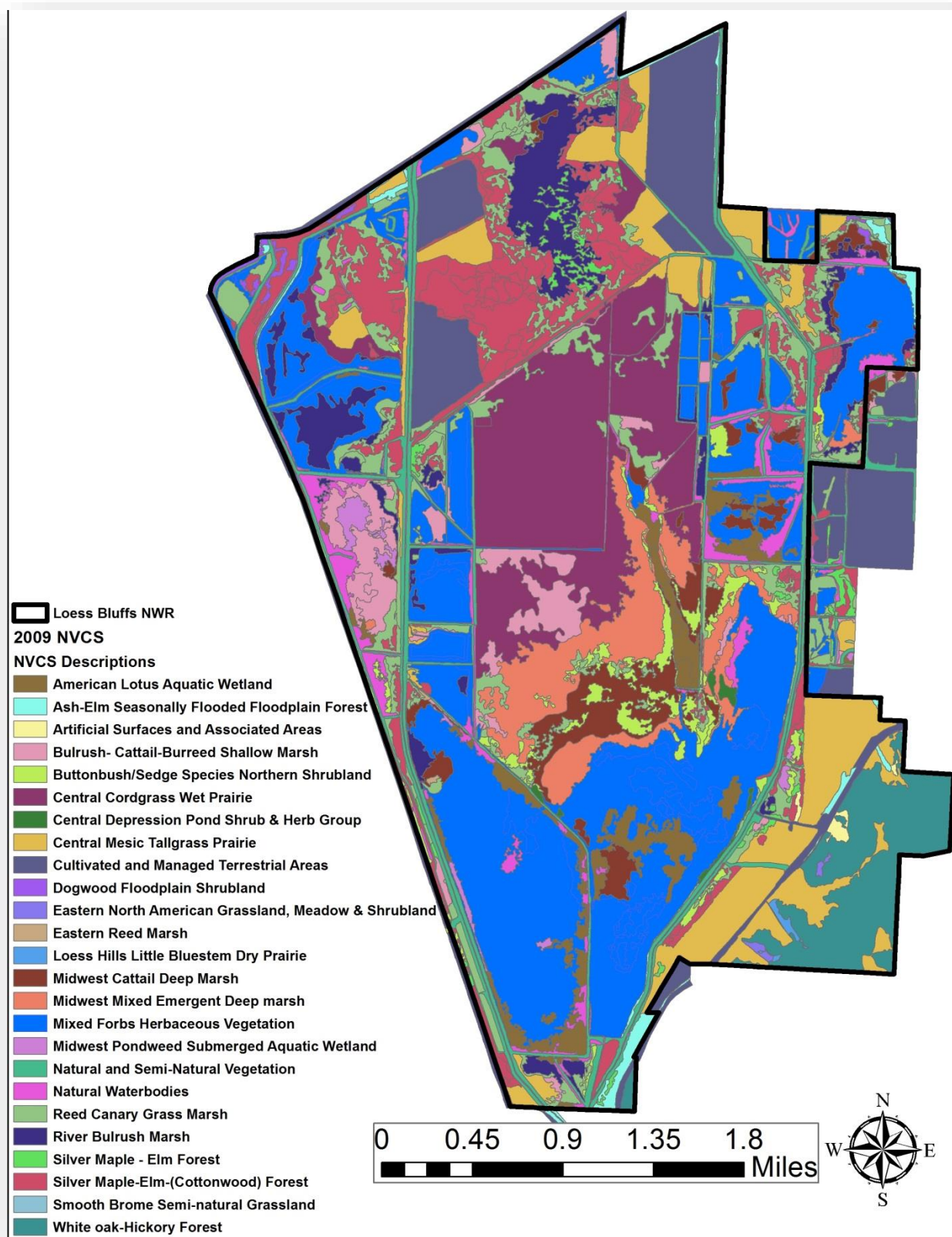


Figure 3.1. Natural Communities on Loess Bluffs National Wildlife Refuge based on [2009 National Vegetation Classification System data](#). Source: LBNWR_Natural_Communities.jpg created 7/18/2017 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

Table 3.2. BIDEH table highlighting the natural communities and NCVS associations located at LBNWR, along with associated natural processes and limiting factors/threats.

Broad Habitat Type (Shorthand)	¹ General Natural Community Description	¹ Specific natural Community Description	^{2,3} NCVS Association Classification	² Natural Processes Responsible For These Conditions	² Limiting Factors/Threats
Grassland	Loess/Glacial Till Prairie	Dry Loess/Glacial Till Prairie	Loess Hills Little Bluestem Dry Prairie CEGL002035	The soil is somewhat rapidly drained and very shallow (0-40 cm). This community is maintained by a combination of drought and fire.	This community has been eliminated in some places by overgrazing, or by quarrying of loess material for road construction. Many sites have been encroached on by woody vegetation.
		Dry-Mesic Loess/ Glacial Till Prairie			
		Wet-Mesic Bottomland Prairie	Central Wet-mesic Tallgrass Prairie CEGL002024	Soil is somewhat poorly drained and deep (100 cm or more). Fire plays a role in the maintenance of this wet- mesic prairie, with an average fire frequency of every two to five years.	This community has nearly been eliminated. Most areas have been converted to cropland. Lack of fire may permit increased dominance by woody species.
			Central Mesic Tallgrass Prairie CEGL002203	Soils are typically derived from deep (>100 cm) silty clay and silt loam glacial till or unaltered loess soil drainage is intermediate, and nutrient content is high. The pH ranges from slightly acidic to circumneutral. Topography varies from level to moderately sloping on uplands of glacial outwash and till plains.	Most former sites have been converted to cropland, pasture, or development. Others are succeeding to forest or woodland in the absence of fire.
		Wet Bottomland Prairie	Central Cordgrass Wet Prairie CEGL002224	Periodic prolonged flooding and fire prevents woody vegetation from dominating this community; soils are typically deep, fine-textured, poorly drained, and have high organic content; some sites have impermeable subsurface layer.	

Table 3.2. BIDEH table highlighting the natural communities and NCVS associations located at LBNWR, along with associated natural processes and limiting factors/threats.

Broad Habitat Type (Shorthand)	¹General Natural Community Description	¹Specific natural Community Description	^{2,3} NCVS Association Classification	²Natural Processes Responsible For These Conditions	²Limiting Factors/Threats
Wetland	Riverine Wetland	Marsh	Bulrush - Cattail - Burreed Shallow Marsh CEGL002026	Basin-like depressions, backwater areas of floodplains and shallow margins of lakes or ponds; soils that are saturated to inundated; standing water up to 15 cm in depth, throughout most of the growing season.	
			River Bulrush Marsh CEGL002221	Sites are subject to seasonal flooding that typically draws down by late summer.	In the northern tallgrass prairie these marshes can be heavily degraded due to heavy siltation, nutrient enrichment, and plowed floodplains.
			Midwest Mixed Emergent Deep Marsh CEGL002229	Found in glacial potholes, river valleys, ponds, and on lake plains; hydric soils and are flooded with water levels ranging from several centimeters to more than 1 m; soils are saturated, flooded, or ponded; develop anaerobic conditions.	
			Midwest Cattail Deep Marsh CEGL002233	Glacial potholes, river valleys, ponds, and on lakeplains; continuous inundation; water depth averages 0.3-0.6 m, to > 1 m for a significant part of the growing season.	Subject to many forms of human impact, particularly draining for farmland.
			Reed Canarygrass Eastern Marsh CEGL006044	Stands are found in both minerotrophic basin wetlands as well as rivershores.	It is native to the United States and Canada but is now more widely distributed and abundant because of local introductions; it can invade a variety of habitats.

Table 3.2. BIDEH table highlighting the natural communities and NCVS associations located at LBNWR, along with associated natural processes and limiting factors/threats.

Broad Habitat Type (Shorthand)	¹ General Natural Community Description	¹ Specific natural Community Description	^{2,3} NCVS Association Classification	² Natural Processes Responsible For These Conditions	² Limiting Factors/Threats
Wetland	Riverine Wetland	Shrub Swamp	Common Buttonbush/Sedge Species Northern Shrubland CEGL002190	Stands occupy shallow water depressions, oxbow ponds, and backwater sloughs of stream and river floodplains. Inundation is usually continuous throughout the year, but these sites can become dry in mid or late summer or during periods of prolonged drought.	
			Dogwood Floodplain Shrubland CEGL005220	It is found along high banks, raised islands, and terraces above the stream channel, which experience periodic flooding in late winter or spring. Soils are moderately well-drained and formed in alluvium.	
		Freshwater Aquatic Vegetation	Midwest Pondweed Submerged Aquatic Wetland CEGL002282	Major environmental controls on submerged aquatic vegetation are water depth (as it relates to light intensity), water chemistry, water movement, and nature of the substrate. Various combinations of these factors can interact in a variety of ways to influence the local composition of the community.	Alterations to water chemistry can affect species composition.
			American Lotus Aquatic Wetland CEGL004323	Stands are found in natural wetlands or artificial impoundments.	

Table 3.2. BIDEH table highlighting the natural communities and NCVS associations located at LBNWR, along with associated natural processes and limiting factors/threats.

Broad Habitat Type (Shorthand)	¹ General Natural Community Description	¹ Specific natural Community Description	^{2,3} NCVS Association Classification	² Natural Processes Responsible For These Conditions	² Limiting Factors/Threats
Wetland	Riverine Wetland	Wet Shoreline Vegetation	Mixed Forbs Herbaceous Vegetation CEGL002430	Repeated flooding may eliminate perennial species and favor annuals. Seedbanks are an important source of redevelopment. Seeds can remain viable 20-40 years after being drained or drying out.	During dry years, many stands may be plowed and farmed.
Forest	Loess/ Glacial Till Forest	Dry-Mesic/Mesic Loess/Glacial Till forest	White Oak-Hickory Forest CEGL002011	It is a dry-mesic deciduous forest community found on gentle to moderately steep slopes on uplands and on steep valley sides. The soils are moderately deep to deep and vary from silts to clays to loams. The parent material is glacial till, limestone, shale, or sandstone.	Many sites have been cleared or degraded by grazing.
		Dry/Dry-Mesic Loess/Glacial Till woodland			
	Bottomland Forest/Woodland	Wet-Mesic Bottomland Forest & Wet Mesic Woodland	Silver Maple-Elm Forest CEGL002586	The structure and composition of the type are influenced by the flooding regime, which is typically an annual flooding of relatively brief duration (several weeks), but may be absent in dry years or extensive during flash-flood years. Floods leave river-deposited debris on the forest floor, ice scars on trees, and abandoned channels that retain water at or above the level of the main river channel.	There has been significant conversion of stands to agriculture, hydrologic modifications due to river dams, etc., and siltation caused by modified flooding regimes.
		Wet Bottomland Forest	Ash-Elm Seasonally Flooded Floodplain Forest CEGL007987	Stands occur on medium to large, regularly flooded floodplains.	This community is located in beaver impacted areas. Both the change in hydrology and active removal of some species by beaver are evident. This community also occurs in anthropogenically impacted areas such as where roads have altered the local hydrology and in moist soil units developed by local hunters.

¹ Nelson PW. 2010. The terrestrial natural communities of Missouri. Jefferson City (MO): Missouri Department of Conservation.

² NCVS Association Classification: <http://explorer.natureserve.org/servlet/NatureServe>; ³ NCVS Association Classification: <http://usnvc.org/explore-classification/>

3.4 Priority Resources of Concern

The comprehensive list of potential resources of concern contains many species with a wide array of habitat needs and life history requirements. However, in order to best evaluate the effects of our management of habitats, as well as the species using those habitats, a lesser number of priority resources of concern are needed. Priority resources of concern are species or species groups that are representative of the spectrum of habitats found on the refuge and will serve as indicators during monitoring. These species are highly associated with conditions that represent the needs of larger groups of species or communities with similar requirements and respond to management similarly. Loess Bluffs National Wildlife Refuge has prioritized these species and their associated habitats (Section 3.5) to determine where we can make the greatest contribution to conservation efforts while taking into account three important considerations: 1) relevance to legal mandates, 2) management significance, and 3) ecological significance.

To guide in the selection of priority resources of concern, we used a series of filters and steps outlined in the Service's Identifying Refuge Resources of Concern and Management Priorities for Refuges: A Handbook (Paveglio and Taylor 2010). Species listed on the comprehensive list of resources of concern which are too rare to occur on the refuge were eliminated from the list, consisting primarily of accidental or unverified species. Each remaining species was assigned a plan inclusion ratio which represented the number of conservation plans the species was listed in compared to the number of plans the species was able to be included in. For instance, bird species were eligible for 14 plans, while amphibians and reptiles were only eligible for 5 plans. Thus, a bird species listed in 2 plans would have a plan ratio of 0.14, while a reptile listed in 2 plans would have a plan ratio of 0.4. All species, along with their plan ratio, were organized into 3 major habitat categories: grassland, forest, and wetland. Within these habitat types, species were sorted based on their plan inclusion ratio. Those with the highest plan inclusion ratios were included on lists for consideration as priority resources of concern.

We organized and hosted a meeting in order to determine priority resources of concern. Attendees for the meeting included individuals from U.S. Fish and Wildlife Service, Missouri Department of Conservation, and surrounding universities. The entire list can be found in Appendix D. During this meeting, we used a series of scoring filters in order to evaluate each resource. These filters included: conservation plan inclusion, ability of refuge to support species, abundance of species on refuge, species' response to habitat management, ability of species to represent larger group of species, and ability of species to represent on-refuge ecological processes and broader ecosystem processes. After determining a score for each filter, the species were ranked based on overall score. Those species that had above average scores were selected as priority resources of concern. These species, along with other associated species which benefit from the management of priority resources of concern, are found in Table 3.3.

Table 3.3. Table shows priority resources of concern and the associated species for each resource.

Priority Resource of Concern	Guild/Group of Species	Associated Species
Monarch Butterfly	Pollinators	Native bees, butterflies
Grasshopper Sparrow, Dickcissel, Short-eared Owl	Grassland Bird Species	Upland Sandpiper, Buff-breasted Sandpiper, Northern Harrier, Henslow's Sparrow, Bobolink, Sedge Wren, Eastern Meadowlark, Loggerhead Shrike, Bobwhite Quail, Wild Turkey
Prairie Massasauga	Other Grassland Species	Western Fox Snake, Great Plains Skink, Eastern Tiger Salamander, Great Plains Toad
Least Bittern Muskrat	Emergent Wetland Species	American Bittern, Blanding's Turtle, Yellow-headed Blackbird, Marsh Wren, King Rail, Virginia Rail, Yellow Rail, Common Gallinule, Black-crowned Night Heron, Green Heron, Great Blue Heron, Snowy Egret, Great Egret, Trumpeter Swan
Hudsonian Godwit Pectoral Sandpiper	Shorebirds	Marbled Godwit, Buff-breasted Sandpiper, Short-billed Dowitcher, Whimbrel, Semipalmated Sandpiper, Piping Plover, Wilson's Phalarope
Black Tern	Terns and Gulls (sandbar nesters and open water)	Least Tern, Common Tern
Mallard	Shallow Wetland Species (emergent vegetation/open water mosaic, moist soil units)	Blue-winged Teal, Wood Duck, King Rail, Black-crowned Night Heron, , Short-eared Owl, Yellow Rail
Snow Goose Trumpeter Swan	Open Water Species	Canvasback, Lesser Scaup, Black Tern, Common Tern, Canada Goose, Pied-billed Grebe
Bald Eagle	Wet Bottomland Forest Species	Red-headed Woodpecker, Red-shouldered Hawk, Prothonotary Warbler, Indiana Bat, Rusty Blackbird
Northern Long-eared Bat	Bottomland Forest and Loess/Glacial Till Forest Species	Silver-haired Bat, Indiana Bat, Swainson's Thrush, Hermit Thrush, Brown Thrasher, Prothonotary Warbler, Pine Warbler, Canada Warbler, Northern Flicker
Red-headed Woodpecker	Bottomland Forest Species	Northern Flicker, Northern Long-eared Bat, Silver-haired Bat, Indiana Bat
Wood Thrush	Bottomland Forest and Transitional Edge Species	Swainson's Thrush, Hermit Thrush, Brown Thrasher, Northern Long-eared Bat, Silver-haired Bat, Indiana Bat
Kentucky Warbler	Loess/Glacial Till Forest Species	Prothonotary Warbler, Pine Warbler, Canada Warbler, Northern Long-eared Bat, Indiana Bat

3.5 Priority Habitat Types and Associated Priority Resources of Concern

Habitat management most often focuses on restoring, managing, or maintaining habitats or certain habitat conditions to benefit a suite of focal species or a suite of plants and animals associated with a particular habitat. In addition to identifying priority resources of concern, we have identified the habitat requirements for each of the resources (Table 3.4). These requirements led to the identification of the high and low priority habitats to manage on the refuge (Table 3.5). Priority habitats are those broad habitats that the Priority Resources of Concern depend on throughout much of their life cycle, as well as those threatened and imperiled habitat types. The priority habitats of the refuge were identified based on information compiled (e.g., site capability, historic condition, current vegetation, conservation needs of wildlife associates). As part of that process, we identified any limiting factors that may affect the refuge's ability to maintain those habitats. Priority resources of concern as linked to each priority habitat type, along with key habitat requirements for those species and other benefiting species.

Since all management activities cannot feasibly be undertaken at the same time, we have prioritized habitats on the following ranking factors:

- Where management actions would provide the greatest conservation benefit to identified priority species,
- Current habitat conditions and the urgency of needs for active management, and
- Landscape level rankings for particular habitats.

Although a habitat may be ranked as "Priority 2", this should not be interpreted as meaning that the habitat type does not provide valuable habitat to a variety of species or contribute to the overall diversity, integrity, and health of the refuge. In some cases, habitats may not require active management by the refuge, or may represent an area where there is little management capability.

From selected priority habitats, we can develop measurable and achievable habitat goals and objectives for Loess Bluffs NWR which will benefit priority resources of concern. High and low priority habitat categories are primarily intended for long-term planning. The actual tracts of habitat that will be managed each year will be prioritized based on current resource conditions at each unit and logistical constraints such as available staff and equipment. These year-by-year factors will be addressed in the annual habitat work plans.

Table 3.4. Table shows the habitat requirements and habitat utilization for each priority resource of concern.

Focal Species	Habitat Type	Habitat Requirements	Utilization of Habitat	Associated Species
Monarch Butterfly	Loess/ Glacial Till Prairie Bottomland Prairie	Use open weedy areas, grasslands, and marshes; requires milkweed and flowering plants; herbicide use is detrimental to habitat ¹	Breeding and Migration	Native bees, butterflies, grassland bird species and other grassland species
Grasshopper Sparrow	Loess/ Glacial Till Prairie Bottomland Prairie	Breeds in dry fields with tall grass (30-120 cm); nest in ground depressions; prefers larger interior tracts of land >400 m from edge with limited shrub cover ^{2,3}	Breeding and Migration	Upland Sandpiper, Buff-breasted Sandpiper, Northern Harrier, Henslow's Sparrow, Bobolink, Sedge Wren, Eastern Meadowlark, Loggerhead Shrike, Prairie Massasauga, Monarch Butterfly
Dickcissel		Nests in grasslands habitats with dense (90-100% cover), moderate to tall vegetation (25-150 cm) and moderately deep litter (5-15 cm); >50% forb cover is needed for nesting and feeding ⁴	Breeding and Migration	
Prairie Massasauga	Bottomland Prairie	Uses a complex of interspersed relatively open habitat (most veg. cover <0.5m tall) with areas of greater cover (grass, shrub, or trees >0.5m tall), at least 50% of cover should be relatively open ⁵	Year Round	Western Fox Snake, Great Plains Skink, Eastern Tiger Salamander, Great Plains Toad, grassland bird species
Short-eared Owl	Bottomland Prairie	Generally uses large expanses (>50 ha) of open prairie for feeding; requires dense grasslands less than 30 cm high during winter ^{4,6}	Migration and Wintering	Upland Sandpiper, Buff-breasted Sandpiper, Northern Harrier, Henslow's Sparrow, Bobolink, Sedge Wren, Eastern Meadowlark, Loggerhead Shrike, Prairie Massasauga, Monarch Butterfly

Table 3.4. Table shows the habitat requirements and habitat utilization for each priority resource of concern.

Focal Species	Habitat Type	Habitat Requirements	Utilization of Habitat	Associated Species
Hudsonian Godwit Pectoral Sandpiper	Wet Shoreline Mud Flats	Forages on mudflats along the margins of marshes and flooded grasslands; Godwit may use water depths 5-20 cm; both use vegetation height 5-20 cm, and sparse to moderate vegetative cover ⁷	Migration	Marbled Godwit, Buff-breasted Sandpiper, Short-billed Dowitcher, Whimbrel, Semipalmated Sandpiper, Piping Plover, Wilson's Phalarope
Black Tern	Wet Shoreline Marsh	Forages over the surface of open water (0.5-1.5 m depth) with less dense emergent vegetation ⁸	Migration	Common Tern, Least Tern
Mallard		Forages in open to interspersed emergent cover; utilizes marshes, flooded basins, and flooded fields; water depths >40 cm. ⁹	Migration	Blue-winged Teal, Wood Duck, King Rail, Black-crowned Night Heron, Least Bittern, Short-eared Owl, Yellow Rail
Snow Goose Trumpeter Swan		Rests and forages in in shallow open water (<30 cm deep) away from shoreline vegetation ^{10, 11, 12}	Migration	Canvasback, Lesser Scaup, Black Tern, Common Tern, Canada Goose, Pied-billed Grebe
Least Bittern	Marsh	Breeds in shallow marshes (>30 cm in depth) with dense, tall emergent vegetation; nests near open water, on margins of vegetation; nests constructed on cattails and bulrush 8-96 cm above water ¹²	Breeding and Migration	American Bittern, Blanding's Turtle, Yellow-headed Blackbird, Marsh Wren, King Rail, Virginia Rail, Yellow Rail, Common Gallinule, Black-crowned Night Heron, Green Heron, Great Blue Heron, Snowy Egret, Great Egret, Trumpeter Swan
Muskrat		Live in marshes, creating its home out of vegetation in the water (depth 45-120 cm); feed on stems of cattail and bulrush and uses vegetation for mounds ¹³	Year Round	Blue-winged Teal, King Rail, Black-crowned Night Heron, Least Bittern, Short-eared Owl, Yellow Rail, Blanding's Turtle

Table 3.4. Table shows the habitat requirements and habitat utilization for each priority resource of concern.

Focal Species	Habitat Type	Habitat Requirements	Utilization of Habitat	Associated Species
Bald Eagle	Wet Bottomland Forest	Nests in mature, old-growth forests, open canopies 2km from bodies of water; roosts in deciduous trees at least 30-110 cm in DBH and 15-60 m in height ¹⁴	Migration and Nesting	Red-headed Woodpecker, Red-shouldered Hawk, Prothonotary Warbler, Indiana Bat, Rusty Blackbird
Red-headed Woodpecker	Bottomland Forest and Transitional Edge	Prefers deciduous woods with oaks that contain 3-10 m height snags and open understories; utilizes forest edges for breeding; uses cavities in dead trees or dead limbs of live trees for nesting ¹⁵	Breeding and Migration	Northern Flicker, Northern Long-eared Bat, Silver-haired Bat, Indiana Bat
Wood Thrush		Breeds in the interior and edges of deciduous forests with trees >16 m in height, high variety of species (maple, oaks, sweet gum), moderate sub-canopy, open forest floor ¹⁶	Breeding	Swainson's Thrush, Hermit Thrush, Brown Thrasher, Northern Long-eared Bat, Silver-haired Bat, Indiana Bat
Northern Long-eared Bat	Bottomland Forest Loess/Glacial Till Forest	Feed in understory of forested areas with about 55% canopy cover; nest in cavities of dead trees; roosts in trees with >7.5 cm DBH ¹⁷	Breeding and Migration	Silver-haired Bat, Indiana Bat, Swainson's Thrush, Hermit Thrush, Brown Thrasher, Prothonotary Warbler, Pine Warbler, Canada Warbler, Northern Flicker
Kentucky Warbler	Bottomland Forest Loess/Glacial Till Forest	Can occupy expanses of bottomland deciduous forest from 2.4 ha-500 ha with dense understory, usually maples ¹⁸	Breeding and Migration	Prothonotary Warbler, Pine Warbler, Canada Warbler, Northern Long-eared Bat, Indiana Bat

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Table 3.5. Table lists the priority 1 and 2 habitat types on the refuge, along with reasons for these rankings and any limiting factors that affect management.

Habitat Type	Reasons for Priority Ranking	Limiting Factors/Threats
Priority 1 Habitats		
Marsh/ Wet Shoreline	Important habitat for nesting marsh birds, as well as migrating waterfowl, waterbirds, and shorebirds. Habitat for valuable amphibian and reptile resources. As the largest habitat type on the refuge, it provides the greatest opportunity for management results with a positive, measurable impact on designated resources of concern.	Disking and draining; altered hydrology; invasive species
Bottomland Prairie	Important habitat for a variety of grassland species (birds, reptiles, mammals). Also, an important remnant of native prairie which is a valuable State resource.	Succession; requires mechanical treatments; invasive species
Loess/Glacial Till Prairie	Important habitat for a variety of grassland species (birds, reptiles, mammals). Also, an important remnant of native prairie which is a valuable state resource.	Succession; requires mechanical treatments; invasive species
Priority 2 Habitats		
Bottomland Forest	Habitat for several breeding and migratory species. Knowledge of forest resources is limited, which makes management actions difficult to determine and monitor.	Hydrological impacts; invasive species; aggressive native species
Loess/Glacial Till Forest	Habitat for several breeding and migratory species. Knowledge of forest resources is limited, which makes management actions difficult to determine and monitor.	Invasive species; aggressive native species

3.6 Conflicting Habitat Needs

Given the diversity of goals, purposes, mandates, and conservation priorities for the NWRS, it is not uncommon to have conflicting management priorities at a refuge. Balancing the types and proportion of habitats (and their management) requires special consideration and a process for determining the best course of action. Loess Bluffs NWR contains habitat and management decisions that require such consideration.

During a typical spring season, water levels inundate moist-soil/ wetland units. Water levels are manipulated during the summer growing season to drawdown these areas in order to stimulate plant growth of species which produce a high yield of seeds that can be used as forage during the fall season for migrating waterfowl. The reduction in open water habitat mimics the inundation and subsequent drying up of wetland habitat that was present before the river levees were constructed. Water level drawdowns are also necessary to manage vegetation so it provides high quality habitat for migrating waterfowl, shorebirds, wading and other bird species. On the other hand, drawing these areas down reduces habitat for amphibians and reptiles (frogs, toads, turtles, snakes) that are utilizing the available open water, wetland habitat for breeding, nesting, or foraging. The reduction in open water habitat also makes aquatic habitat-dependent species more vulnerable to predation. When completing these management actions, it is important to consider all species that use the habitat in order to implement strategies at the most suitable times and in the most appropriate manner.

Moist-soil units are a critical focus for Loess Bluffs National Wildlife Refuge. The focus of management efforts is to continually reset plant community succession, to allow regeneration of pioneering species which provide a seed crop that is beneficial to migrating waterfowl. Without active management, perennial species with less valuable seed production would become more prevalent. When these perennial species are non-native exotic species, management actions need to be taken. However, some of the perennial species that become more prevalent are native species. A conflicting habitat need is the tradeoff between an early successional community that benefits waterfowl and a mid-successional community comprised of native species that have less value to waterfowl, but nevertheless benefit species which require more well-developed vegetation. Thus, it is often the preferred management action to strive for a hemi-marsh condition that comprises a mixture of open water environment and emergent vegetation. Generally, the emergent vegetation types desired are cattail, river bulrush, and arrowhead, as those are used by nesting marsh birds. The exact spatial arrangement and percentages of these plant species on which management actions are based is often dictated by soil moisture conditions, current weather patterns, and species present during the season in question.

3.7 Adaptive Management

The priority resources of concern and their respective habitat attributes were used to develop specific habitat objectives. Refuge habitat management objectives must be achievable. Many factors, such as the lack of resources, existing habitat conditions, species response to habitat manipulations, climatic changes, or invasive species, may reduce or eliminate the ability of the refuge to achieve objectives. Although these limiting factors were considered during the development of management objectives, conditions are likely to change over the next 15 years and beyond. Adaptive management involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself (Williams et al. 2009). It is described as a series of 9 steps: involving stakeholder involvement, management objectives, management alternatives, predictive models, monitoring plans, decision making, monitoring responses to management, assessment, and adjustment to management actions (Williams et al. 2009). This will allow refuge staff to participate in structured decision making while acknowledging uncertainty in ecological functions and how they respond to management actions in an effort to take action to pursue desired outcomes. In addition, the refuge will be required to establish and maintain a monitoring program to ensure that changing conditions can be detected and responded to adequately and efficiently. The monitoring program will be developed in accordance with 701 FW 2 as a step down plan. Currently (as of 2016) the refuge is involved in Region 3, Forest Invasive Adaptive Management (FIAM) program with protocol and reports found on the [ServCat project page](#).

Chapter 4. Habitat Goals and Objectives



Image. Smartweed and millet from a moist soil unit. Photo courtesy of USFWS staff.

4.1 Background

Loess Bluffs National Wildlife Refuge is centered on priority native habitat types and its management is aligned with the Refuge/District purpose, the USFWS Biological Integrity, Diversity and Environmental Health Policy, and the NWRS mission. Because the LBNWR CCP wildlife and habitat goals and objectives were not specific enough for the purposes of an HMP and many were outdated, we modified the CCP goals and objectives for the HMP, focusing and refining the broad vision provided in the refuge CCP. Goals for LBNWR CCP were broken down into the following broad categories: habitat, wildlife and people (goals 1-3). Objectives for LBNWR CCP were taken from the habitat and wildlife sections and then modified into goals for the HMP. Table 4.1 documents the differences and rationale between CCP objectives and HMP goals. Each HMP habitat goal includes qualitative statements expressing ecological values to strive for, while working towards achieving the Service's vision and refuge purpose. Objectives were developed based on S.M.A.R.T. (specific, measurable, achievable, results-oriented, time fixed) standards. These goals and objectives are arranged based on major habitat type designations using 2009 GIS data which will guide management actions (Figure 4.1).

Table 4.1. Differences and rationale between Loess Bluffs NWR CCP objectives and the HMP objectives.

CCP Objective	Change between CCP and HMP	Rationale
1.7 Objective: Croplands and Old Fields: Implement a long range plan to convert 279 acres of the 579 existing cropland acres and 59 acres of existing old field to mesic bottomland prairie and Loess Hill prairie. The reduction will be accomplished by 2015 through attrition of current cooperators.	Removed from management goals and objectives.	Agricultural fields are no longer managed primarily for supplemental food. Farming was discontinued in 2015 and the refuge is in the process of restoring to wet-mesic bottomland prairie
1.8. Objective: Exotic, Invasive, and Nuisance Species: Control and reduce the presence of exotic, invasive, and nuisance species of plants and animals on the Refuge. Non-native species will not exceed 2003 density or distribution levels.	Removed from management goals and objectives. Invasive species management is incorporated in objectives and strategies by habitat type. For example see HMP Objective 5.1.	Invasive and nuisance species vary by habitat type in order to meet objectives and reduce redundancy this objective was removed. Invasive species treatment was addressed either in habitat specific objectives and/or strategies.
1.9 Objective: Land Acquisition: Working with willing sellers, acquire up to 400 acres in fee title of existing and restorable wetlands within the authorized Refuge boundaries	Removed from goals and objectives.	This will be addressed in a land acquisition plan that should be completed by 2019.
1.11 Objective: Wildlife Management District: Develop, improve, and maintain native riparian, wetland, and grassland habitats consistent with the existing dominant vegetative structure (non-agricultural crop), contributing to soil and water conservation within the Management District and also benefitting a broad spectrum of both game and non-game migratory birds and other resident wildlife species.	Removed from goals and objectives.	Habitat management in the Wildlife Management District will be broken down and addressed by major habitat types which are listed in the HMP (Tables 3.2 - 3.5).

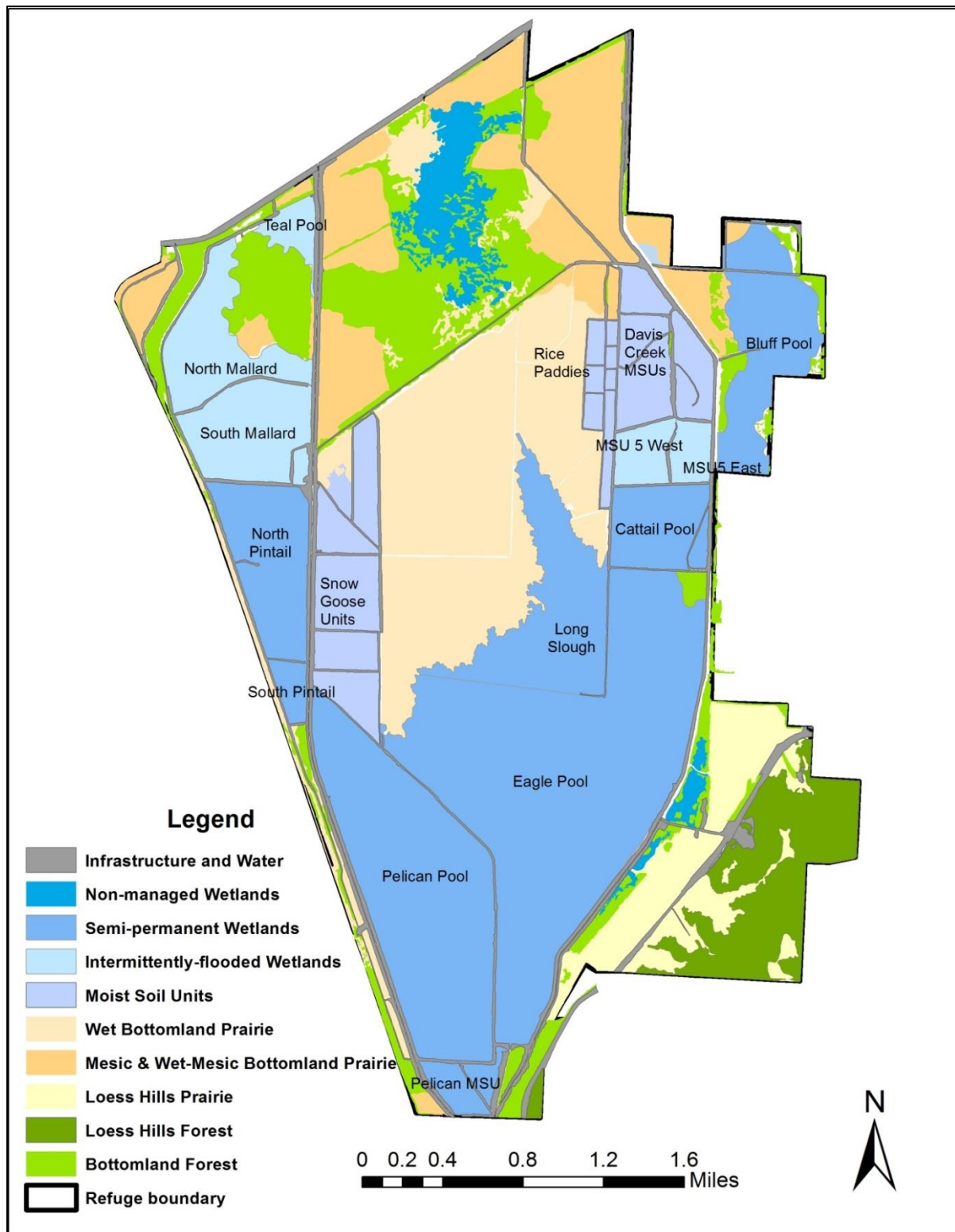


Figure 4.1. Management units used for goals and objectives on the HMP for the Loess Bluffs NWR. Source: LBNWR GIS 2009 Landover data; Management_Types.jpg created 7/24/2017 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

4.2 Habitat Goals and Objectives

Goal 1

All Wetlands: Provide a complex of managed wetlands for waterbirds and other wetland dependent species on 3,812.8 acres that support the population goals and objectives established in the North American Waterfowl Management Plan, the Upper Mississippi and Great Lakes Joint Venture Plans, and the MDC Comprehensive Wildlife Strategy.

Objective 1.1

Manage water levels in 80% of total acreage of wetlands to maintain full pool (~852-854 MSL) during fall, winter, and early spring migration for resting and roosting migratory waterfowl such as mallards (*Anas platyrhynchos*), snow geese (*Anser caerulescens*), trumpeter swans (*Cygnus buccinator*), and other associated species in order to achieve 5 million duck energy days (DEDs) and/ or duck use days (DUDs) over yearly fall/spring migration. Other species that benefit from this management action include least bitterns (*Ixobrychus exilis*), muskrats (*Ondatra zibethicus*), pied-billed grebes (*Podilymbus podiceps*) and Blanding's turtle. Provide nesting habitat for least bitterns (range of 6-126 nests) and other associated marsh bird species. Maintain presence of Blanding's turtles in refuge wetlands.

Rationale Statement:

The refuge is an important stopover location during spring and fall migration for marsh birds, waterbirds, and waterfowl. Water depths between 20 and 40 cm provide optimum foraging depths for mallards and trumpeter swans during migration, while these depths also provide adequate nesting habitat for pied-billed grebes (Muller and Storer 1999). The benefits of these water levels for mallards and trumpeter swans extend to other associated species such as blue-winged teal, wood ducks, canvasbacks, pied-billed grebes, and Canada geese, among others. Least bitterns benefit from these water levels (>30 cm) during breeding season due to the positive correlation between water depths and emergent vegetation (Nelson 2003). The number of least bittern nests can vary greatly year to year. In 2001, 126 nests were observed compared to 6 nests in 2002 (Nelson 2003). Muskrats can also use water depths above 45 cm to create their lodges (Allen and Hoffman 1984). During lodge construction, muskrats eat-out areas creating a patch mosaic of wetland vegetation, which is beneficial for nesting marsh birds. Blanding's turtles also benefit from open water areas that can be used for foraging (Lehnhoff 2004). Blanding's turtles are listed as State Endangered throughout much of their range in the United States, thus the monitoring of this species is vital to the mission of the refuge. According to Meyer et al. (2017) less than 20 individual Blanding's turtles have been documented since they were first observed in 1984 on LBNWR. The refuge plans to maintain presence of Blanding's turtles in managed wetlands. LBNWR will continue to partner with local universities and graduate students to assess habitat use, breeding and potential population estimates for Blanding's turtle.

Goal 2

Semi-permanent Wetlands: Manage 2,601.9 acres of open marsh habitat comprised of a mixture of desirable submergent, floating, and emergent vegetation to support migratory birds and other wetland-associated wildlife species.

Objective 2.1

Provide for a long-term average of 50% open water, 50% vegetation mosaic habitat in Eagle, Pelican, North Pintail, South Pintail, Bluff, Cattail Pools, as well as Long Slough and Cattail Triangle with the use of fire, mechanical, or chemical treatment to control American lotus, river bulrush, and cattail when vegetative surface area coverage exceeds 80 percent. This will maintain open water habitat for the following species: black tern, mallard, snow goose, trumpeter swan, pied-billed grebe, least bittern, muskrat, Blanding's turtle, and other associated species.

Rationale Statement:

Many waterfowl, waterbirds, and marsh birds require a mixture of vegetative cover and open water for foraging, breeding, and nest construction. Mallards, pied-billed grebes, and black terns forage in open water areas among less dense emergent vegetation (Soulliere et al. 2007). Trumpeter swans forage in sites far from shoreline vegetation with higher macrophyte and tuber density (Mitchell and Eichholz 2010; Squires 1991). Least bitterns use the margins of emergent vegetation and are often found near areas of open water, thus requiring a patch mosaic of vegetation and water (Nelson 2003). Blanding's turtles utilize dense vegetation for cover, while moving through open water areas to reach other foraging locations and potential nesting sites (Lehnhoff 2004). To ensure an appropriate spatial distribution of vegetation amongst open water, different treatments may need to be used. Mechanical treatments, such as disking and mowing, can be used to control cattail, river bulrush, and American lotus when water levels are lowered sufficiently for a prolonged period of time (Nelms et al. 2007; Sojda and Solberg 1993). The use of fire to control cattail and river bulrush may be effective, if it can be performed when water levels are low and then utilize high water the following season to reduce regeneration of plants. However, the use of fire on American lotus may only be effective if water levels can be kept low during the following season (Nelms et al. 2007).

Objective 2.2

Maintain a minimum of 25 percent of total acreage as interior, isolated cattail stands to provide nesting habitat on the periphery of vegetation within 10 meters of open water for species such as least bittern and associated species such as yellow-headed blackbird (*Xanthocephalus xanthocephalus*), and marsh wren (*Cistothorus palustris*).

Rationale Statement:

Least bitterns nest sites are generally located on the periphery of vegetation, less than 10 meters from open water, in an area which consists of cattail interspersed with few arrowhead and/or American lotus (Fredrickson 1991; Nelson 2003). Predominant vegetation tends to be dense in order to guard from predation (Nelson 2003). Nest site characteristics typically include the use of robust emergent vegetation patches, typically cattail, interspersed with water at depths of greater than 30 cm (Griffin 2007; Nelson 2003). It is important to balance the water regime needs of waterfowl with the need for cattail habitat, as high water years may lead to lowered cattail and arrowhead regeneration (Griffin 2007). Associated species like marsh wrens and yellow-headed blackbirds will also benefit from isolated patches of cattail stands, as these birds tend to nest in dense vegetation (Gutzwiller and Anderson 1987).

Objective 2.3

Maintain minimum winter water depths between 30 and 45 cm on the interior of Eagle, Pelican, North Pintail, South Pintail, Bluff, Cattail Pools for muskrat survival (with a minimum of 0.28 ± 0.16 muskrat houses/acre based on the long term average of unpublished refuge data) to assure open water areas (muskrat eat-out areas) will be available for roosting and resting waterfowl, while also maintaining minimum summer water depths of at least 30 cm in order to provide nesting habitat for least bitterns and other marsh birds.

Rationale Statement:

Musk rats prefer water depths between 30 and 45 cm for lodge construction and are more sensitive to low water levels during winter, as this may lead to the water column freezing and elimination of food resources (Allen and Hoffman 1984). The eat-out areas created by muskrats when they build a lodge can serve as open water habitat for roosting and resting waterfowl, such as snow geese, trumpeter swans, mallards, and other associated species. These eat-out areas also help to create a patch mosaic of wetland vegetation, which is beneficial for nesting marsh birds. When the habitat is created, these marsh birds (least bitterns and associated species) require water depths of at least 30 cm in order to ensure the appropriate vegetation is present for nesting substrates (Griffin 2007; Nelson 2003).

Goal 3

Intermittently-flooded Wetlands: Annually manage 493.5 acres of intermittently-flooded (transition between semi-permanent or seasonally flooded) wetlands to provide habitat for waterfowl, waterbirds, and shorebirds.

Objective 3.1

Maintain spring water levels in a minimum of 20 percent of total acreage of Teal Pool, North Mallard, South Mallard, MSU 5 E and W, for mallards, snow geese, trumpeter swans and other associated species. Providing a minimum of 845,000 DED which is based on intensively managed moist soil areas with 8,562 duck use days per acre as described by Nelms et al. (2007). Implement mechanical and/or chemical manipulation on at least 50 percent of the total remaining acreage to encourage moist soil plant growth (e.g., millet, smartweed, yellow nut sedge, toothcup, etc.), if needed, for waterfowl and shorebird food sources.

Rationale Statement:

Maintaining spring water levels is important to provide habitat for wetland dependent species, such as waterbirds and waterfowl. Moist soil plant production is important to provide a food source for migrating waterfowl and shorebirds. Millet (*Echinochloa crusgalli*) is an excellent seed producer during the first growing season after soil disturbance and also provides a moderate substrate for invertebrates. The best production of millet occurs when the soil is disturbed late in the previous growing season; a good technique consists of disking in late summer or early fall followed by shallow flooding to provide shorebird habitat (Nelms et al. 2007). Smartweeds (*Polygonum* spp.) are good seed producers and provide an excellent substrate for invertebrates. Early drawdowns and soil disturbance can increase smartweed production in the following growing season (Nelms et al. 2007). Yellow nutsedge (*Cyperus esculentus*) produces underground tuberous rhizomes which are of great value as waterfowl food and shallow disking early in the growing season often results in greater stem densities (Nelms et al. 2007). Toothcup

(*Ammania coccinea*) is an early successional species that germinates late in the growing season, serving as a valuable source of seeds for late season migratory birds. Periodic mechanical disturbances and summer drawdowns can be used to enhance occurrence and seed production (Nelms et al. 2007).

Objective 3.2

Implement late fall/early winter flooding to achieve full pool (~852-854 MSL) in a minimum of 80 percent of total acreage of intermittently-flooded wetlands to provide habitat for migratory waterfowl, shorebirds, and aquatic vertebrates such as Blanding's turtles. This will also provide nesting habitat for marsh birds including, but not limited to, least bitterns, pied-billed grebes, common gallinules (*Gallinula chloropus*), and other associated species.

Rationale Statement:

Waterfowl species such as mallards, blue-winged teal (*Anas discors*), and other associated species typically require water depths of at least 25 cm (Muller and Storer 1999). Shorebird species benefit from flooding in pools given flooding kills the wet meadow plants, allowing midges to rapidly colonize the detritus, and ultimately providing food sources for shorebird migration (Eldridge 1992). Blanding's turtles tend to prefer moderate water levels along the edges of marsh units (Lehnhoff 2004). Least bitterns require water levels of at least 30 cm for nesting (Nelson 2003). Pied-billed grebes and common gallinules also require water levels of at least 25 cm for nest construction (Muller and Storer 1999).

Goal 4

Moist Soil Units: Annually manage 595.3 acres of moist soil units to provide habitat for waterfowl, waterbirds, and shorebirds including, but not limited to, mallards, snow geese, trumpeter swans, Hudsonian godwits (*Limosa haemastica*), pectoral sandpipers (*Calidris melanotos*), and other associated species.

Objective 4.1

Implement annual water manipulation in Davis Creek Moist Soil Units 1, 2, and 3, Rice Paddies, and all Snow Goose Pools (A-E) to maintain water on less than 10 percent of total acreage during the summer to encourage growth of moist soil plants to provide food for waterfowl species, along with creating mudflat and shallow water habitat for shorebirds.

Rationale Statement:

Proper moist soil management includes the drawdown of water to promote germination of native plants on exposed mudflats and the subsequent re-flooding of the same areas (Nelms et al. 2007). Specific moist soil management is determined by timing of drawdowns, with slow drawdowns producing a greater diversity of plants (Nelms et al. 2007). Moist soil vegetation is critical for providing a food source for migratory waterfowl. These plant species help to provide consistent production of foods across years with varying water availability, low management costs, high tolerance to diverse environmental conditions, and low deterioration rate of seeds after flooding (Laubhan 1992). Shorebirds are drawn to areas that contain a combination of open mudflat and shallow water (2 to 5 cm) and very little vegetation with high invertebrate abundance (Eldridge 1992). Slow drawdowns of water on moist soil units encourage midge larvae and bloodworms to emerge after over-wintering and provide food for migratory shorebirds (Eldridge 1992).

Objective 4.2

Maintain early successional stage, reduce undesirable plants, encourage preferred moist soil seed producing plants, and create additional shoreline and mudflat habitat in all Moist Soil Units on an annual basis.

Rationale Statement:

Vegetation within moist soil units can shift rapidly to a monoculture of robust plants if water regimes remain constant on an annual basis, in areas that are flooded at high levels, or as a result of cessation of disturbance. Disturbance will destroy monocultures and set back succession. Vegetation structure can be modified with machinery to provide good interspersed (Nelms et al. 2007). Mechanical manipulation can help to expose the seedbank, allowing for desirable species regeneration. Since mechanical manipulation usually requires drawdown of water levels, this technique also helps to produce shoreline and mudflat habitat that can be utilized by shorebirds (Fredrickson 1991).

Goal 5

Wet Bottomland Prairie: Annually manage a minimum of 500 acres of the total area of wet prairie habitat (1,079.7 acres) for the benefit of grassland species such as grasshopper sparrow (*Ammodramus savannarum*), dickcissel (*Spiza americana*), prairie massasauga (*Sistrurus tergeminus tergeminus*), short-eared owls (*Asio flammeus*), and other associated species.

Objective 5.1

Develop and maintain a diverse mosaic of natural vegetative cover (<50% reed canarygrass, >40% forbs and sedges, >40% tall grasses) to support a variety of grassland species including dickcissels (≥ 0.426 birds/acre) and grasshopper sparrows (≥ 0.054 bird/acre).

Rationale Statement:

Grassland-dependent birds adapted to the microhabitats resulting from frequent disturbance in the tallgrass prairies. Grassland species are best supported with diverse vegetative cover which varies in height and species composition in order to provide the most available nesting, breeding, and foraging habitat. For example, grasshopper sparrows and dickcissels prefer tall grasses up to 125 cm in height (Dechant et al. 2002; Holmes and Miller 2010). Dickcissels also require a significant amount of forb cover for nesting and feeding (Dechant et al. 2002). Ripper and Duke (2017) observed ≥ 0.054 grasshopper sparrows/acre and ≥ 0.426 dickcissels/acre across all (85) properties surveyed in Missouri grasslands from 2013 – 2016 using line transects and distance sampling. Short-eared owls tend to require dense grasslands with short grasses, often less than 30 cm (Weller et al. 1955). Prairie massasaugas require a complex habitat of relatively open habitat with areas of greater cover (Johnson et al. 2000). Depending on floodplain elevation and soil drainage, wet bottomland prairie vegetation ranges from a strong grass-dominated system with extensive stands of prairie cordgrass (*Spartina pectinate*) or bluejoint grass (*Calamagrostis canadensis*) and scattered forbs to patchy marshes and sedge meadows (Nelson 2010). Fire and grazing, along with a highly variable climate, shaped and maintained the pre-settlement tallgrass prairie (Anderson 1990). Frequent fires set back encroaching woody vegetation. Fire can also function to remove the dead vegetation and release tied-up nutrients, stimulating dormant plants to sprout and grow. Currently LBNWR uses a 2-5 year burning rotation in the spring in the wet

bottomland prairie. Historically, bison trampled young woody seedlings while grazing on tender grass shoots of newly burned areas, allowing forb species to flourish. Grazing in a prairie ecosystem functions to encourage new plant growth. This can work in conjunction with fire to ensure a high quality vegetative environment for grassland species. This interaction between fire and grazing created a shifting mosaic of microhabitats for grassland birds and other wildlife, prairie invertebrates, and prairie vegetation (Schroeder 1981). In addition to fire and grazing, flooding increasingly becomes a major disturbance process with its accompanying hydrological functions. Variations in flood frequency, duration, and intensity create diverse vegetation patterns (Nelson 2010). Loess Bluffs NWR is a representative site for this state-listed habitat (Nelson 2010).

Goal 6

Wet-Mesic/Mesic Prairie: Annually manage a minimum of 375 acres of the total area of wet mesic prairie habitat (795.4 acres) to provide quality nesting cover for migratory birds including, but not limited to, dickcissels, grasshopper sparrows, short-eared owls, mallards, and other associated species.

Objective 6.1

To achieve and maintain a diverse mosaic of vegetative cover (<50% reed canarygrass, >40% forbs and sedges, >40% tall grasses), with a focus to rejuvenate prairie cordgrass (*Spartina pectinata*) habitat (>10% of the total area), to support a variety of grassland species including dickcissels (≥ 0.426 birds/acre) and grasshopper sparrows (≥ 0.054 bird/acre).

Rationale Statement:

Grassland-dependent birds adapted to the microhabitats resulting from frequent disturbance in the tallgrass prairies. Grassland species are best supported with diverse vegetative cover which varies in height and species composition in order to provide nesting, breeding, and foraging habitat for resources of concern including dickcissels, grasshopper sparrows, short-eared owls, mallards, and other associated species. Ripper and Duke (2017) observed ≥ 0.054 grasshopper sparrows/acre and ≥ 0.426 dickcissels/acre across all (85) properties surveyed in Missouri grasslands from 2013 – 2016 using line transects and distance sampling. Fire and grazing, along with a highly variable climate, shaped and maintained the pre-settlement tallgrass prairie (Anderson 1990). This interaction between fire and grazing created a shifting mosaic of microhabitats for grassland birds and other wildlife, prairie invertebrates, and prairie vegetation (Schroeder 1981). In addition to fire and grazing, flooding, and its accompanying hydrological fluctuations, is a major disturbance process. Variations in flood frequency, duration, and intensity create diverse vegetation patterns (Nelson 2010). According to Nelson (2010) dominant plants of the wet-mesic bottomland prairie are big bluestem (*Andropogon gerardi*), prairie cordgrass, bluejoint, switch grass (*Panicum virgatum*) and mixed sedges (*Carex* species) along with various forbs. This remnant natural prairie habitat provides the necessary habitat for prairie massasauga rattlesnakes, among other resources of concern. It requires regular disturbance in order to maintain its biological integrity. Regular disturbance in wet-mesic bottomland prairie in Missouri included fire, flooding (frequency, duration and intensity) and herbivory by bison, elk, deer and insects (Nelson 2010). These disturbances along with chemical treatments will also help to reduce reed canarygrass throughout the wet-mesic/mesic prairie. Currently LBNWR uses a 2-5 year burning rotation in the spring in the wet-mesic bottomland prairie.

Goal 7

Loess Hills Prairie: Annually manage a minimum of 150 acres of Loess Hill prairie habitat (300.3 acres) to provide quality nesting cover for grassland bird species, such as grasshopper sparrows, dickcissels, pollinators such as monarch butterflies (*Danaus plexippus*) and other associated species.

Objective 7.1

Maintain, enhance, and/or restore grasslands to a mixture of warm and cool season native grasses to maximize native vegetation (90% cover) for cover-dependent species such as dickcissels, minimize fragmentation for interior grassland species (patches >400 m from non-prairie edge) such as grasshopper sparrows, and maximize minimum patch size for area-dependent species. Annually treat a minimum of 150 acres through prescribed fire along with enhancing a minimum of 10 acres per year by planting native forbs or through mechanical/ chemical treatment.

Rationale Statement:

Loess Hills upland prairies are typically dominated by mid-height grasses with little bluestem being the most abundant and side-oats grama acting as a codominant species. Short grasses, such as hairy grama and buffalograss, also occur on the hill prairies (Mutel 1989). A rich diversity of drought-tolerant forbs also contributes to the diversity of plant species on Loess Hill prairies (Mutel 1989). A variety of wildflower species are also present in the Loess Hills prairies including silverleaf psoralea (*Pediomelum argophyllum*), soapweed yucca (*Yucca glauca*), and skeleton plant (*Lygodesmia juncea*), which are state listed species of conservation concern. Grasshopper sparrows and dickcissels utilize this habitat for its dense cover (Delany et al. 2013). Monarch butterflies benefit most from areas containing milkweed, while other pollinator populations will increase with the presence of diverse vegetative communities.

Goal 8

Loess Hills Forest: Annually manage a minimum of 75 acres of the total area of Loess Hills forest habitat (376.6 acres) for the benefit of focal species such as Kentucky warblers (*Oporornis formosus*), northern long-eared bats (*Myotis septentrionalis*), wood thrushes (*Hylocichla mustelina*) and other associated species.

Objective 8.1

Determine species composition, stand quality and age within the woodland units in order to develop a stand-based forest management program within 10 years of the approval of HMP in order to reach desired stand conditions recommended for dry-mesic forest (Loess Hills) characteristics (Table 4.1). Reduce invasive species and aggressive natives to <50% of the total area such as garlic mustard (*Alliaria petiolata*), honey locust (*Gleditsia triacanthos*), black locust (*Robinia pseudo-acacia*), ironwood, Autumn olive (*Elaeagnus umbellata*), bush honeysuckle (*Lonicera maackii*), and other species to promote red oak (*Quercus rubra*) regeneration, canopy and understory species diversity as outlined in Table 4.1.

Rationale Statement:

At the moment, a thorough forest resources inventory for the Loess Hills area of the refuge has not been completed. In order to adequately determine the most appropriate management

strategies, it is necessary to have a record of species composition, stand structure, stand quality, snag density and age within the woodland areas. A thorough inventory will include a determination of occupancy by northern long-eared bats. Northern long-eared bats need about 55% canopy cover and roost in trees with >7.5 cm DBH; thus, the forest inventory will be looking specifically at these characteristics (USFWS 2014). There is also the potential for this area to provide habitat for Indiana bats (*Myotis sodalis*), which is also a federally-endangered species; thus, any future management actions should not threaten the long-term suitability of this habitat. Any major habitat modification will be done in consultation with USFWS Ecological Services with an Intra-Service Section 7. Loess Hills forests also host Kentucky warblers, that require large expanses of forest (2.4 ha-500 ha) with dense understories (McShea et al. 1995). Therefore, the forest inventory will help to determine if this area of the refuge provides suitable habitat and the potential for improved management for Kentucky warblers. Wood thrushes prefer trees >16 m in height with a high variety of species (Evans et al. 2011). The forest resource inventory will inform refuge staff of forest composition and stand quality along with guide management for wood thrush.

Management of aggressive native deciduous tree species such as black locust, sugar maple, and ironwood through hack and squirt methods can be effective on trees larger than 4" diameter breast height. Invasive species such as Autumn olive and bush honeysuckle may respond to control by burning or chemical methods. These species all act as nuisance species by preventing understory regeneration, specifically the regeneration of species like red oak. These species also spread prolifically through an area, lowering species diversity in forest canopy and understory layers (MDC 2015). All resources of concern and associated species for this area require moderately dense canopy cover to dense understory cover; these resources can benefit from increased species diversity within forest stands as a means of providing diverse habitats.

Goal 9

Bottomland Forest: Annually manage a minimum of 165 acres of the total area of bottomland forest habitat (823.8 acres) to provide optimum nesting, resting, and foraging habitat during breeding and migration periods for species of concern such as bald eagle (*Haliaeetus leucocephalus*), red-headed woodpecker (*Melanerpes erythrocephalus*), wood thrush, northern long-eared bat, Kentucky warbler, Monarch butterflies, and other associated species.

Objective 9.1

Determine species composition, stand quality and age within the woodland units in order to develop a stand-based forest management program within 10 years of the approval of HMP in order to reach desired stand conditions recommended for bottomland forest characteristics (Table 4.2). Reduce invasive species and aggressive natives to <50% of the total area such as garlic mustard (*Alliaria petiolata*), honey locust (*Gleditsia triacanthos*), black locust (*Robinia pseudo-acacia*), reed canarygrass and other species to in order to achieve a diverse canopy and understory composition, as outlined in Table 4.2.

Rationale Statement:

At the moment, a thorough forest resources inventory for the bottomland forest area of the refuge has not been completed. In order to adequately determine the most appropriate management strategies, it is necessary to have a record of species composition, stand quality and age within the woodland areas. A thorough inventory will also allow for the determination of suitable northern long-eared bat habitat, which includes old-growth trees with cavities or crevices, as well as dead or dying trees. Northern long-eared bats also look for about 55% canopy cover and roost in trees with >7.5 cm DBH; thus, the forest inventory will be looking specifically at these characteristics (USFWS 2014). There is also the potential of this area to provide habitat for Indiana bats, which are an endangered species; thus, any future management actions should not threaten the suitability of this habitat. Loess Hills forests also host Kentucky warblers, which require large expanses of forest (2.4 ha-500 ha) with dense understories; therefore, the forest inventory will help to determine if this area of the refuge can be improved by management and provide suitable Kentucky warbler nesting habitat (McShea et al. 1995). Bottomland forests are also home to bald eagles, red-headed woodpeckers, and wood thrushes. Bald eagles prefer old growth trees with open canopies of trees at least 30-110 cm in diameter and 15-60 m in height (Buehler 2000). Since, 1998 two active bald eagle nests have been present on LBNWR. The refuge would like to maintain a minimum of two bald eagle nests in bottomland forest habitat. Red-headed woodpeckers prefer forest stands with 3-10 m snags, as well as cavities in dead or dying trees (Conner et al. 1994). Wood thrushes prefer trees >16 m in height with a high variety of species (Evans et al. 2011). The forest resource inventory will inform refuge staff of forest composition, stand quality, and stand age. This information can then be combined with knowledge of suitable habitat for resources of concern in order to develop suitable management actions and population goals for wildlife.

Low intensity fires can be an important technique for reducing undesirable and overbearing understory plants. By thinning the understory, it will allow forest canopy species regeneration. Low intensity fires are necessary to not damage existing desirable tree species (MacCleery 1994). Resources of concern and their associated species can benefit from increased species diversity and unevenness of stand conditions. Resources such as bald eagles and wood thrushes prefer trees over 16 m in height, while resources such as red-headed woodpeckers can benefit from the presence of 3-10 m high snags (Buehler 2000; Conner et al. 1994; Evans et al. 2011). The use of low intensity fire can help to increase the diversity of stand age composition by allowing for regeneration; this action will also increase forest species diversity which will benefit all resources of concern and associated species.

Table 4.2. Desired stand conditions for Loess Hills forest.

Forest Variables	Desired Stand Condition	Conditions That May Warrant Management
Primary Management Factors		
Overstory Canopy Cover ³	<80%	>80%
Average Canopy Height ³	15-30 m/ 60-100 ft	<12 m/ 50 ft or >40 m/ 130 ft
Average Tree DBH ³	0.75 m/ 2.5 ft	<0.5 m/ 1.5 ft
Secondary Management Factors		
Emergent Trees ¹	2 per acre	<1 per acre
Understory Cover ²	50-80%	>85%
Regeneration ¹	10% of area	<5% of area
Coarse Woody Debris ¹ (> 0.3 m/ 10 inch diameter)	2 trees per acre	<1 tree per acre
Small Cavities ¹ (<0.3m/ 10 inch diameter)	8 per acre	<5 per acre
Den Trees/ Large Cavities ¹ (>0.3 m/ 10 inch diameter)	4 per acre	<2 per acre
Standing Dead/ Stressed Trees ¹ (>0.5m/ 18 inch diameter)	3 per acre	<1 per acre
Desired Mast Species ^{1,2}	Oaks, Hickory, Walnut, Hackberry, Ash	Dogwoods, Paw Paw, Black Locust, Berries, and other soft mast species

Sources:

1. Missouri Department of Conservation (MDC). 2015 draft. Missouri Sustainable Forest Management Guidelines. Jefferson City (MO): Missouri Department of Conservation.
2. Raeker G, Fleming J, Morris M, Moser K, Treiman T. 2010. Missouri's forest resource assessment and strategy: seeking a sustainable future for Missouri's forest. Columbia (MO): Missouri Department of Conservation; Newtown Square (PA): U.S. Department of Agriculture Forest Service, Northern Research Station.
3. Loess Bluffs NWR Habitat Management Plan Resources of Concern Table 3.4

Table 4.3. Desired stand conditions for bottomland forests in Missouri Alluvial Plain.

Forest Variables	Desired Stand Condition	Conditions That May Warrant Management
Primary Management Factors		
Overstory Canopy Cover ³	60-70%	>80%
Average Canopy Height ³	20-30 m/ 65-100 ft	<15 m/ 50 ft or >40 m/ 130 ft
Average Tree DBH ³	0.75 m/ 2.5 ft	<0.5 m/ 1.5 ft
Secondary Management Factors		
Emergent Trees ¹	2-4 per acre	<1 per acre
Understory Cover ²	50-75%	>75%
Regeneration ¹	15% of area	<10% of area
Coarse Woody Debris ¹ (> 0.3 m/ 10 inch diameter)	2 trees per acre	<1 tree per acre
Small Cavities ¹ (<0.3m/ 10 inch diameter)	8 per acre	<5 per acre
Den Trees/ Large Cavities ¹ (>0.3 m/ 10 inch diameter)	4 per acre	<2 per acre
Standing Dead/ Stressed Trees ¹ (>0.5m/ 18 inch diameter)	3 per acre	<1 per acre
Desired Mast Species ^{1,2}	Oaks, Hickory, Walnut, Hackberry, Ash	Dogwoods, Black Locust, Berries, and other soft mast species

Sources:

1. Missouri Department of Conservation (MDC). 2015 draft. Missouri Sustainable Forest Management Guidelines. Jefferson City (MO): Missouri Department of Conservation.
2. Raeker G, Fleming J, Morris M, Moser K, Treiman T. 2010. Missouri's forest resource assessment and strategy: seeking a sustainable future for Missouri's forest. Columbia (MO): Missouri Department of Conservation; Newtown Square (PA): U.S. Department of Agriculture Forest Service, Northern Research Station.
3. Loess Bluffs NWR Habitat Management Plan Resources of Concern Table 3.4

Goal 10

Watershed Improvement: Reduce sedimentation from soil erosion and improve water quality on Loess Bluffs NWR from private lands in the 60,000 acre upstream watershed using conservation practices fostering improved soil and water uses.

Objective 10.1

Within the first 5 years of the approval of the HMP work with USDA Natural Resource Conservation Service (NRCS), Holt County Soil and Water Conservation District and/ or Partners for Fish Wildlife to form a water quality partnership working with private land owners aimed at addressing water quality degradation, insufficient water, and soil erosion.

Rationale Statement:

Increased sedimentation and poor water quality are factors that can severely impair the critical habitats and the wildlife that use those habitats on the refuge. Reducing sedimentation and improving water quality is essential to ensuring good ecosystem health within the refuge. Previous surveys conducted in 1937, 1964, and 2002 completed by USFWS and/or the USGS showed a mean total sediment deposition of 0.047 ft/yr and a mean volume of 152 acre-ft/yr. Some areas of LBNWR have exceeded 8 ft of sediment deposition in over 65 years (Heimann and Richards 2003). The primary contributor to wetland sedimentation is Squaw and Davis Creek basins along with periodic flooding from the Missouri River. Predominant land use within the watershed outside the refuge is agriculture which contributes to the sediment load of Davis and Squaw creeks. Any information gathered in relation to sedimentation and water quality will be used to help guide management actions aimed at improving wetland management (i.e., water control structure installation, levee repair, and water depth calculations across units compared to bird use days), monitoring, and reducing sedimentation on LBNWR. If such actions are successful, wetland habitats on LBNWR will continue to be productive and resilient for use by waterfowl, shorebirds and other wetland dependent species.

Goal 11

Wildlife Disease: Annually reduce the effects and occurrence of waterfowl die-offs in refuge wetland habitat. Reduce the spread of wildlife diseases including but not limited to avian cholera, avian botulism, avian influenza and snake fungal disease.

Objective 11.1

Keep wildlife disease outbreaks as small as possible (collect carcasses of animals ≥ 5 per species or total of multiple species as recommended by [USGS](#)). Minimize disease transmission between subpopulations and refuge habitat types for example between refuge wetland pools and subpopulations of prairie massasauga rattlesnakes like the railroad and main wet prairie.

Rationale Statement:

Submission and diagnosis of avian disease cases is extremely important in identifying the causes of mortality in our wild bird populations ([USGS](#)). This information helps us to: a) determine the impacts mortality events have on avian populations, b) identify hotspots of disease on the landscape, c) develop management strategies to lessen the impacts of disease, and d) provide early warning for agents that may cause disease in livestock or humans ([USGS](#)). Monitoring of waterfowl concentration for indication of disease and stress will be completed and

recommendations made by the USGS National Wildlife Health Center will be implemented if the situation warrants. When waterfowl concentration exceeds objective levels to the extent the welfare of the waterfowl is at risk, such as in the control of disease outbreaks, disturbance measure that result in concentration reductions will be implemented. Other wildlife diseases can have detrimental effects on populations especially in regard to resources of concern like the prairie massasauga rattlesnake. Snake fungal disease (SFD) has been emerging in certain populations of wild snakes in the eastern and Midwestern United States (USGS 2013). Laboratory analyses have demonstrated that the fungus *Ophidiomyces ophiodiicola* is consistently associated with SFD, but often, additional fungi are isolated from affected snakes (USGS 2013). Multiple species of snakes have been diagnosed with SFD including northern water snake (*Nerodia sipedon*), eastern racer (*Coluber constrictor*), rat snake (*Pantherophis obsoletus* species complex), timber rattlesnake (*Crotalus horridus*), massasauga (*Sistrurus catenatus*), pygmy rattlesnake (*Sistrurus miliarius*), and milk snake (*Lampropeltis triangulum*) (USGS 2013). Symptoms of SFD were noted at LBNWR as early as 2011 with positive confirmation in prairie massasauga rattlesnakes and associated species in 2016 (Welchert et al. 2017). Further monitoring of SFD is needed to identify the extent of occurrence and the potential effect on snake populations on LBNWR including prairie massasaugas and other associated species.

Chapter 5. Management Strategies and Prescriptions



Image. Eagle Pool radial gates and outflow structure. Photo courtesy of USFWS staff.

5.1 Development of Management Strategies and Prescriptions

This chapter outlines management strategies and prescriptions to address the habitat management goals and objectives outlined under Chapter 4. Management strategies identify the tools and techniques (e.g. mowing, water-level manipulation, chemical application, etc.) used to achieve the habitat objectives. Prescriptions provide the details behind the specific means by which the strategies will be implemented (e.g. timing, frequency, duration, and location). A review of available literature related to potential strategies and prescriptions was completed. The identified treatments were selected in consultation with other refuge biologists, managers, and practitioners to ensure their effectiveness. Many environmental factors including wildlife populations, weather, seasonal variations, and habitat conditions affect the selected prescriptions and their ability to achieve objectives from year to year. As such, many of the details of prescriptions will be identified in Annual Habitat Work Plans. Prescriptions outlined herein are discussed on a conceptual level.

The natural world contains a myriad of extremely complex and dynamic systems. Despite the extensive planning efforts undertaken within this Habitat Management Plan, there will undoubtedly be additional need to address physical, ecological, social, political, and financial factors that influence biodiversity and its conservation. Strategies listed under each objective specify the activities that will be pursued to realize an objective. The strategies may be refined or amended as specific tasks are completed or new research and information come to light.

The work outlined within this habitat management plan is intended to be feasible, yet extensive, given the available workload of refuge staff and community support. Addition of biological technicians and other staff may help in achieving these management objectives over the next several years. The management prescriptions outlined here represents a comprehensive effort to guide management over the next five years. However, it is impossible to predict the full suite of management strategies and prescriptions required over this period. Some additional strategies may need to be added, while others listed here may not be used.

5.2 Management Strategies and Prescriptions by Habitat Objective

Objective 1.1

Strategy 1.1.1: Begin incrementally recharging pools in late summer/early fall in order to provide habitat for early migratory species including, but not limited to, pectoral sandpipers, Hudsonian godwits, blue-winged teal, and other associated species.

- *It is important to provide habitat for early migratory species. Blue-winged teal typically begin fall migration between late August and late September. During migration, they will forage in shallow waters (under 20 cm) for food (Gammonley 1995). Pectoral sandpipers and Hudsonian godwits will forage on the margins of wetland pools where midge larvae start to emerge (Eldridge 1992). Progression of recharge will occur based on location of water control structures and water manipulation capabilities, typically beginning in Moist Soil Unit 1 and Snow Goose Pool B. Specific timing of recharge will coincide with early migration periods.*

Strategy 1.1.2: Continue to recharge pools in order to achieve full pool level by peak fall migration activity (around November 15).

- *Southward migration extends from August through December depending on species, weather patterns, food availability, and other factors (Anderson and Davis 2013). Thus, in order to provide habitat for the vast array of migratory waterbirds, waterfowl, and shorebirds, it is necessary to achieve full pool by peak fall migration.*

Strategy 1.1.3: Monitor waterfowl and shorebird populations according to the Integrated Waterbird Management & Monitoring (IWMM) protocol, along with habitat use in all wetland habitats in order to determine effectiveness of habitat management.

- *Monitoring of arrivals and concentration build-ups with the specific intent to witness and record annual peak numbers and date of occurrence of special interest species. To accomplish this task, bird counts will be conducted on a regular weekly basis in all wetland habitats throughout the entire migratory period in order to determine status of the populations and habitat utilization. IWMM protocol will be used to survey birds, vegetation, structure, water levels and management actions.*

Strategy 1.1.4: Monitor marsh and water bird nesting to determine habitat use and effects of management on habitat.

- *Marsh bird nesting surveys will be conducted during breeding season on all flooded wetlands with suitable vegetation to document nesting habitat utilization of all relevant marsh bird species including, but not limited to, least bitterns, pied-billed grebes, and common gallinules. Primary focus will be on nesting least bitterns which are listed as resource of concern for the HMP.*

Strategy 1.1.5: Continue to partner with local universities such as Missouri Western State University and Northwest Missouri State University and graduate students to monitor Blanding's turtles movements (a minimum of 5 years in a 15 year period) to determine habitat use, breeding and nesting locations, and the effects of management on population. Assess the feasibility of coming up with a population model.

- *A current study regarding movements of Blanding's turtles on the refuge is in progress. The male and female turtles that reside on the refuge are equipped with VHF transmitters that allow refuge staff to locate turtles and determine habitat preferences. Combined with GIS technology, to determine information relating to habitat and breeding ecology along with water management effects on Blanding's turtles, while also attempting to document more turtles on the refuge.*

Objective 2.1

Strategy 2.1.1: Annual vegetation monitoring using IWMM protocol to assess status of problem vegetation.

- *Status of problem vegetation (American lotus, river bulrush, and cattail) will be assessed each season. If cover begins to exceed 80% in one pool, soil conditions and surrounding vegetation will be assessed to determine specific management actions.*

Strategy 2.1.2: Use mechanical, chemical, fire or other appropriate tools to manage or eradicate invasive and exotic species in these pools to minimize or remove the impact to waterfowl and waterbird habitat.

- *Generally, problem vegetation can be addressed using a form of mechanical manipulation when water levels are low. Often sustained low water levels can be used in combination with disking to eradicate or significantly reduce problem vegetation (Nelms et al. 2007). Chemical methods may also be effective if soil moisture conditions are appropriate. Fire will typically only be used when water level drawdowns can be sustained for a significant period of time, mostly only along the edges of wetland pools. Aerial application of appropriate herbicides may be used to control undesirable plant species in areas that are too large or inaccessible to conventional means for instance flooded wetlands.*

Strategy 2.1.3: Document the utilization of different habitats by resources of concern to better predict effects of future natural and induced habitat changes on populations.

- *Waterfowl, waterbird, and shorebird surveys using IWMM protocol will be performed on a weekly basis during migratory periods. This will provide information relating to habitat utilization and can help to inform management practices for the following season. IWMM protocol will be used to survey birds, vegetation, structure, water levels and management actions.*

Strategy 2.1.4: Partner with local universities (Northwest Missouri State University and Missouri Western State University) to obtain snow goose and trumpeter swan neck collar readings during the spring and fall migrations (at least once a week during peak times) to assist in determining the status and the movement of these populations.

- *Loess Bluffs NWR typically harbors an average peak population of 1 million snow geese annually since 2008. According to the Artic Goose Habitat Working Group, this is beyond the carrying capacity for the wintering habitat. Thus, studies have been initiated to determine the status and the movement of this population in order to assist in snow geese reduction (Batt 1997). Information on trumpeter swan bands will be sent to the Bird Banding Laboratory at Patuxent Wildlife Research Center to help in population number estimates and migration studies.*

Objective 2.2

Strategy 2.2.1: Utilize an alternating summer drawdown schedule for Eagle, Pelican, North Pintail, South Pintail, Bluff, Cattail pools, as well as Long Slough to ensure each pool is drawn down for an average of 3 out of 10 years (Figure 4.1). This will encourage cattail stand growth, as well as create wet shoreline and mudflats for shorebird habitat.

- *Cattails require mudflats and/or shallow water for germination and soils must remain exposed for best establishment. Thus, short duration drawdowns, followed by later flooding will help cattail propagation. On the other hand, cattails can be managed through 2-3 consecutive years of drought (Nelms et al. 2007). Specific drawdown schedule will consider the vegetative structure of each pool, looking to optimize a 50/50 mosaic of open water and emergent vegetation. If the levels of vegetative cover begin to exceed that which is desirable (80%) or the species composition becomes monotypic, sustained drawdown of that area will be implemented in the upcoming season when possible in order to allow for vegetation management.*

Strategy 2.2.2: Shallowly flood pools to encourage cattail regeneration once cattail growth has begun.

- *A shallow flood (about 10 cm) may help to encourage cattail regeneration since this may leave a significant expanse of unflooded, saturated soils nearby where cattail germination can flourish. If this level of water is maintained for a significant amount of time, cattail growth will be optimal (Sojda and Solberg 1993).*

Objective 2.3

Strategy 2.3.1: Routinely check and record water staff gauge levels using the Water Level Monitoring map in the Collector (ArcGIS Online, Environmental Systems Research Institute, Redlands, CA) or similar platform for all pools to ensure water level is appropriate, recharging pools when necessary to maintain minimum water depths.

- *All wetland pools have water staff gauges which can be monitored in order to determine water depth. Bathymetry data for all pools has either been compiled or will be completed during the first two years of HMP approval. These data can be used in combination with water staff gauge readings to determine water depths over the entire area of a pool. This information will allow for water manipulation at the pool level to achieve sufficient water depths for resources of concern.*

Strategy 2.3.2: Monitor marsh and water bird nesting to determine habitat use and effects of management on habitat.

- *Marsh bird nesting surveys will be conducted during breeding season on all pools to document nesting habitat use of all relevant marsh bird species including, but not limited to, least bitterns, pied-billed grebes, and common gallinules. Primary focus will be on nesting least bitterns which are listed as resource of concern for the HMP.*

Strategy 2.3.3: Monitor muskrat population and location of muskrat eat-out areas to determine general information regarding population density (with a minimum of 0.28 ± 0.16 muskrat houses/acre based on the long term average of unpublished refuge data) and response to habitat management

- *Musk rats function as valuable components of the wetland ecosystem, creating open areas within vegetation which can be utilized by marsh birds. These areas also help to maintain a 50/50 ratio of open water and emergent vegetation. It is important to monitor muskrat populations to ensure that population numbers do not increase beyond the capacity of the wetland to sustain emergent vegetation growth (Allen and Hoffman 1984). Muskrat population densities will be allowed to cycle naturally or will be controlled using water management i.e. drawdowns when emergent vegetation is <25%.*

Objective 3.1

Strategy 3.1.1: In order to provide aquatic habitat for wetland dependent species, recharging of some pools may be necessary. This recharging will not exceed full pool levels.

- *By providing spring water levels over an extended amount of area, it ensures that we will provide a sufficient variety of habitats which waterfowl like mallards, wading birds like herons and egrets, and shorebird populations require for foraging.*

Strategy 3.1.2: Routinely check water staff gauges for all pools to ensure water level is appropriate, recharging pools when necessary to maintain minimum water depths.

- *All wetland pools have water staff gauges that should be monitored in order to determine water depth. Bathymetry data for all pools has either been compiled or will be completed by 2020. These data can be used in combination with water staff gauge reading to determine water depths over the entire area of a pool. This information will allow for water manipulation at the pool level to achieve sufficient water depths for resources of concern.*

Strategy 3.1.3: Document the use of different habitats by indicator species to better predict effects of future natural and induced habitat changes on populations.

- *Waterfowl, waterbird, and shorebird surveys using IWMM protocol will be performed on a weekly basis during migratory periods. This will provide information relating to habitat utilization and can help to inform management practices for the following season. IWMM protocol will be used to survey birds, vegetation, structure, water levels and management actions.*

Strategy 3.1.5: Partner with local universities (Northwest Missouri State University and Missouri Western State University) to obtain snow goose and trumpeter swan neck collar readings during the spring and fall migrations (at least once a week during peak times) to assist in determining the status and the movement of these populations.

- *Loess Bluffs NWR typically harbors an average peak population of 1 million snow geese annually since 2008. According to the Artic Goose Habitat Working Group, this is beyond the carrying capacity for the wintering habitat. Thus, studies have been initiated to determine the status and the movement of this population in order to assist in snow geese reduction (Batt 1997). Information on trumpeter swan bands will be sent to the Bird Banding*

Laboratory at Patuxent Wildlife Research Center to help in population number estimates and migration studies.

Objective 3.2

Strategy 3.2.1: Use water control structures to channel water from Davis Creek and/or Squaw Creek into designated pools until pools achieve their desired water depths.

- *These water control structures allow the release of water from Davis Creek and/or Squaw Creek into pools that are designated to maintain full pool during the winter. Water depths of pools will be determined by utilizing a combination of data from water staff gauges and bathymetry data.*

Strategy 3.2.2: Routinely check and record water staff gauge levels for all pools to ensure water level is appropriate, recharging pools when necessary to maintain minimum water depths.

- *All wetland pools have water staff gauges which can be monitored in order to determine water depth. Bathymetry data for all pools has either been compiled or will be completed during the upcoming season. These data can be used in combination with water staff gauge reading to determine water depths over the entire area of a pool. This information will allow for water manipulation at the pool level to achieve sufficient water depths for resources of concern.*

Strategy 3.2.3: Monitor marsh and water bird nesting to determine habitat utilization and effects of management on habitat.

- *Marsh bird nesting surveys will be conducted during breeding season on all pools to document nesting habitat utilization of all relevant marsh bird species including, but not limited to, least bitterns, pied-billed grebes, and common gallinules. Primary focus will be on nesting least bitterns which are listed as resource of concern for the HMP.*

Objective 4.1

Strategy 4.1.1: Annually flood designated impoundments to a depth of 45 cm or less during the period of November through March to ensure available habitat for waterfowl within the moist soil management units.

- *During fall migration, it is important to maintain sufficient habitat for all waterfowl. Water control structures will be used to flood units to the appropriate levels as determined by water staff gauges and bathymetry data. This depth will allow waterfowl to forage for food resources within the moist soil units (Fredrickson 1991).*

Strategy 4.1.2: On a rotational basis, shallow flood (< 25 cm in depth) a minimum of 5 percent of total moist soil management units for teal and other early migrants from August to October each year.

- *To accommodate early migrants, a shallow flood will be utilized within units which have the most desirable conditions for the year (food resources, soil moisture regime, vegetative cover). These depths work to make seed and other food available to waterfowl, while also leaving mudflat habitat for shorebirds (Baldassarre and Bolen 2006; Gammonley 1995).*

Strategy 4.1.3: Annually perform early (April 1-May 15) and late (May 15-June 15) season drawdowns (Eldridge 1992; Fredrickson 1991 which may vary depending on bird use and change in yearly weather patterns) within designated moist soil areas (Figure 4.1) to encourage the production of annual beneficial moist soil plants in the production of 5 million DEDs and/ or DUDs objective as a combined effort across all refuge wetland types, while also allowing for continuous availability of invertebrates and to extend the availability of habitat throughout the migratory period for shorebirds.

- *Early spring drawdowns increase the availability of seeds and invertebrates for waterbirds, while late spring drawdowns can be beneficial for shorebirds (Baldassarre and Bolen 2006; Eldridge 1992). Germination of each species of moist soil plants is dependent on certain environmental conditions, including soil temperature and moisture; thus, timing of drawdowns in specific pools should depend on current and desired vegetative conditions (Fredrickson 1991). Management actions and drawdowns at minimum will be recorded in IWMM habitat management database and refuge's Annual Habitat Work Plan.*

Strategy 4.1.4: Document the utilization of different habitats by resources of concern to better predict effects of future natural and induced habitat changes on populations.

- *Waterfowl, waterbird, and shorebird surveys using IWMM protocol will be performed on a weekly basis during migratory periods. This will provide information relating to habitat utilization and can help to inform management practices for the following season. IWMM protocol will be used to survey birds, vegetation, structure, water levels and management actions.*

Strategy 4.1.5: Continue to monitor and treat nuisance animal species within the moist soil units following guidance outlined in the Loess Bluffs Nuisance Species Plan and subsequent Environmental Assessment.

- *This will allow staff to better manage water levels in the moist soil units and prevent water from standing during growing season or treatment windows.*

Objective 4.2

Strategy 4.2.1: During the period of May through September each year, use mechanical, fire, hydrological, or chemical treatments on a 2 to 5-year rotation or as vegetation response dictates from IWMM vegetation surveys to reduce undesirable plant communities such as cocklebur, river bulrush, reed canary grass, and spikerush to levels that do not negatively impact seed production of moist soil habitats.

- *When water can be sufficiently drawdown on moist soil units, it makes it possible to employ management techniques for undesirable plant communities. Cocklebur and spikerush can be managed by using disking followed by irrigation in order to eliminate or greatly reduce germination. Herbicide in combination with higher water levels can effective in managing reed canary grass and river bulrush. The specific technique utilized will be based on the predominant problem vegetation, other prevailing vegetation, soil moisture conditions, and climate patterns (Nelms et al. 2007).*

Objective 5.1

Strategy 5.1.1: Work with local cooperators to apply grazing of cattle or other grazers (high intensity, short duration) on wet prairie locations on the refuge and help create the desired vegetative mosaic including but not limited to a natural vegetative cover (<50% reed canarygrass, >40% forbs and sedges, >40% tall grasses).

- *In order to incorporate a grazing program, it will be necessary to complete a Compatibility Determination, as well as consult upcoming haying and grazing guidance in relation to the Monarch and Pollinator project. Once this has been completed, the ideal grazing program would occur during all months of the year in order to elicit the most beneficial biological effects for the entire ecosystem. Grazing would help to reduce percentages of cool season grasses, while allowing food sources to maintain a balanced energy budget. However, prescribed grazing will not be implemented on the main portion of the bottomland wet prairie which includes LBNWR burn units 6 (A & B), 8, 9, 14, 15, 25 and 32 (Figure 5.1) until information has been collected via an Adaptive Management (AM) framework and/ or experimental design to indicate that grazing impacts to microhabitats do not pose a risk to the massasauga population at LBNWR. Initial experimental stages of the AM grazing project will focus on lower quality sites (Burn Units: 10, 21, Davis Creek MSU 4, and Bluff Pool A and B) until the potential impacts from grazing have been evaluated before applying grazing to the main portion of the wet bottomland prairie. To increase robustness of the AM or research project, reducing the uncertainty associated with grazing impacts to soil compaction and crayfish burrow density would be the initial focus along with biomass and/ or percent coverage reduction of RCG.*

Strategy 5.1.2: Use a 2-5 year rotational burning program in the wet prairie to reduce exotic invasive species and woody encroachment, while promoting native grass and forb production and reducing soil disturbance and negative impacts on grassland species.

- *Fire can be utilized as a pre-treatment management tool to reduce biomass over an area which can then undergo grazing or mechanical manipulation. Prescribed burns would be utilized over sections of the entire area when vegetation begins to approach monotypic cover. By performing smaller prescribed fires in a rotational pattern, a more diverse vegetative mosaic can be created.*

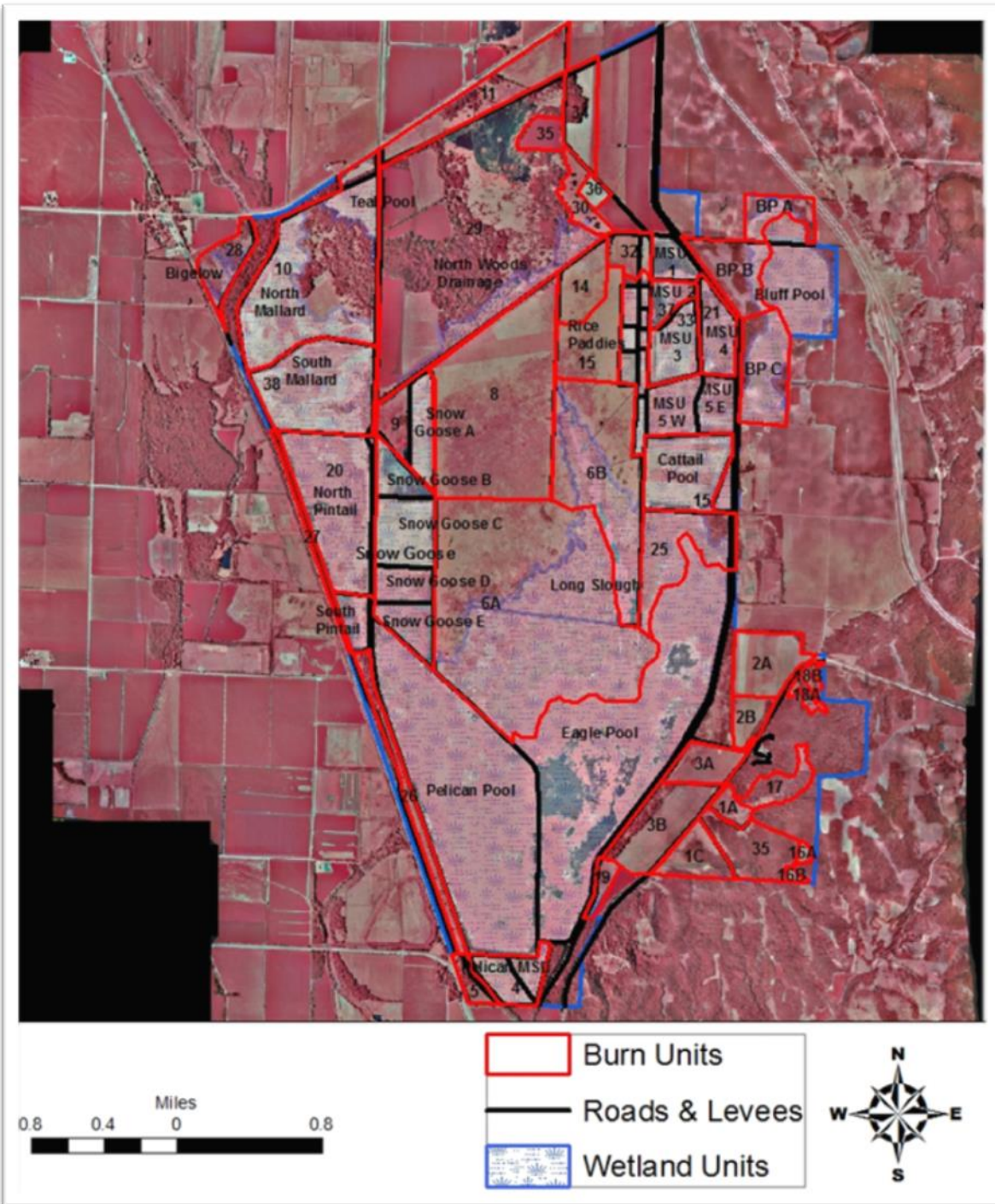


Figure 5.1. Burn Units on Loess Bluffs National Wildlife Refuge. Source: BurnUnits.jpg created 6/21/2016 by Darrin Welchert, Wildlife Biologist and located S:\Wildlife Biologist\Plans\Squaw Creek HMP\HMP Maps.

Strategy 5.1.3: Maintain current disked fire breaks for management of wet prairie area.

- To aid in the implementation of a prescribed fire regime, it is necessary to maintain all current disked fire breaks to assist refuge staff in the completion of this objective.

Strategy 5.1.4: Maintain full-time prescribed fire specialist to implement and to advance the prescribed fire program.

- *In order to adequately implement a prescribe fire program, it is necessary to maintain a full-time prescribed fire specialist in order to compile and execute fire plans appropriately.*

Strategy 5.1.5: Incorporate chemical and mechanical manipulation in combination with grazing and burning to promote native grass and forb production and creating habitat for grassland species.

- *In order to promote vegetative diversity, it is necessary to supplement ongoing management strategies with control strategies for invasive and aggressive native vegetation. Herbicides may be used when necessary, along with limited mechanical treatments (disking and mowing). Mechanical treatments will be used only during time periods (October 1 through March 30) and in areas that will not have adverse long-term impacts on prairie massasauga rattlesnakes.*

Strategy 5.1.6: Monitor consequences of burning and other disturbance methods on the wet bottomland prairie vegetative communities using 25 m belt transect protocol modified from Native Prairie Adaptive Management program, wildlife species, and invasive species, including the utilization of grassland bird surveys using transects and protocol developed by Missouri River Bird Observatory.

- *Seasonal vegetation monitoring will be utilized to determine if the grazing and prescribed fire programs are effective at promoting native grass and forb diversity. Invasive species will be monitored in order to implement effective control methods. Grassland bird surveys will be conducted during the late spring and summer to determine habitat utilization by species such as grasshopper sparrows (≥ 0.054 bird/acre), dickcissels (≥ 0.426 birds/acre), and other associated species (Ripper and Duke 2017).*

Objective 6.1

Strategy 6.1.1: Work with local cooperators to apply grazing of cattle or other grazers (high intensity, short duration) on wet prairie locations on the refuge to help create the desired vegetative mosaic.

- *In order to incorporate a grazing program, it will be necessary to complete a Compatibility Determination, as well as consult upcoming haying and grazing guidance in relation to the Monarch and Pollinator project. Once this has been completed, the ideal grazing program would occur during all months of the year in order to elicit the most beneficial biological effects for the entire ecosystem. Grazing would help to reduce percentages of cool season grasses, while allowing food sources to maintain a balanced energy budget. If grazing is implemented in the wet-mesic/ mesic prairie especially in areas that contain concentrations of massasauga rattlesnakes the same experimental design and/ or AM framework used in the wet bottomland prairie will be used for this management technique in the wet-mesic/ mesic prairie.*

Strategy 6.1.2: Use rotational burning (2-5 year rotation) on the wet prairies to reduce exotic invasive species and woody encroachment, while promoting native grass and forb production and reducing soil disturbance and negative impacts on grassland species.

- *Fire is a pre-treatment management tool used to reduce biomass over an area which can then undergo grazing or mechanical manipulation. Prescribed burns would be applied over sections of an entire unit when vegetation begins to approach monotypic cover. By applying smaller prescribed fires in a rotational pattern, a more diverse vegetative mosaic can be created.*

Strategy 6.1.3: Maintain current disked fire breaks for management of wet-mesic prairie area

- *To aid in the implementation of a prescribed fire regime, it is necessary to maintain all current disked fire breaks to assist refuge staff in the completion of this objective.*

Strategy 6.1.4: Maintain full-time prescribed fire specialist to implement management treatments.

- *In order to adequately implement a prescribe fire program, it is necessary to maintain a full-time prescribed fire specialist in order to compile and execute fire plans appropriately.*

Strategy 6.1.5: Incorporate chemical and mechanical manipulation in combination with grazing and burning to promote native grass and forb production and creating habitat for grassland species.

- *In order to promote vegetative diversity, it is necessary to supplement ongoing management strategies with control strategies for invasive and aggressive native vegetation. Herbicides may be used when necessary, along with disking and mowing.*

Strategy 6.1.6: Plant native forbs in converted grassland areas in order to enhance grassland vegetative community composition, using on refuge seeds and other local sources.

- *With the assistance of volunteers, refuge staff will collect seeds of native forbs in existing refuge prairies to be used in converted grassland areas. In addition to collection of native forbs seeds, wildflower seeds such as Pale Purple Coneflower, Heath Aster, and Rigid Goldenrod will be collected from existing refuge prairies to be used in converted grassland areas. When necessary, local ecotypes will be used to promote native plant propagation.*

Strategy 6.1.7: Monitor consequences of burning and other disturbance methods on the wet-mesic/mesic bottomland prairie vegetative communities using 25 m belt transect protocol modified from Native Prairie Adaptive Management program, wildlife species, and invasive species, including the use of grassland bird surveys using transects and protocol developed by Missouri River Bird Observatory.

- *Seasonal vegetation monitoring will be utilized to determine if the grazing and prescribed fire programs are effective at promoting native grass and forb diversity. Invasive species will be monitored in order to implement effective control methods. Grassland bird surveys will be conducted during the late spring and summer to determine habitat utilization by species such as grasshopper sparrows (≥ 0.054 bird/acre), dickcissels (≥ 0.426 birds/acre), and other associated species (Ripper and Duke 2017).*

Objective 7.1

Strategy 7.1.1: Continue to restore and/ or enhance a minimum of 10 acres per year native warm season grasses and forbs in the loess bluff hills by planting native forbs such as *Liatris spp.*, pale purple coneflowers, rattlesnake master, wild indigo, and lead plants, using local ecotype seeds when available.

- *With the assistance of volunteers, refuge staff will collect native forbs from existing refuge areas and plant these within areas of the Loess Hills that could benefit from greater species diversity.*

Strategy 7.1.2: Control invading tree species and brush on steep slopes by hand-cutting and utilize chemical applications on invading plant species such as rough-leaved dogwood, honey locust, tree of heaven, and Illinois garlic mustard.

- *With the assistance of volunteers, refuge staff will implement mechanical and chemical control of invading plant species. This control method will provide open areas that can be utilized for native grasses and forbs habitat.*

Strategy 7.1.3: Maintain a full-time prescribed fire specialist to implement management actions.

- *In order to effectively and safely apply prescribe fire for management purposes, it is necessary to maintain a full-timer prescribed fire specialist in order to compile and execute fire plans appropriately.*

Strategy 7.1.4: Apply seasonal rotational prescribed burns on a 2-5 rotation in the spring or fall for all upland grassland areas to reduce exotic invasive species and woody encroachment, promote native grass and forb production leaving a minimum of 50 percent of grassland for nesting and winter cover each year.

- *Prescribed burns will be applied when vegetative cover is dominated (>50%) by exotic invasive species or aggressive natives. Specific areas will be determined based on the need to maintain continuous habitat for grassland species.*

Strategy 7.1.5: Monitor consequences of burning and other disturbance methods on the Loess Hills prairie vegetative communities using 25 m belt transect protocol modified from Native Prairie Adaptive Management program, wildlife species, and invasive species, including the utilization of grassland bird surveys using transects and protocol developed by Missouri River Bird Observatory.

- *Seasonal vegetation monitoring will be utilized to determine if the management actions are effective at promoting native grass and forb diversity. Invasive species will be monitored in order to implement effective control methods. Grassland bird surveys will be conducted during the late spring and summer to determine habitat utilization by species such as grasshopper sparrows (≥ 0.054 bird/acre), dickcissels (≥ 0.426 birds/acre), and other associated species (Ripper and Duke 2017).*

Objective 8.1

Strategy 8.1.1: Utilize state and federal funds to hire personnel to conduct a robust inventory of all forest resources.

- *It would prove difficult for current refuge staff to complete a robust forest inventory; therefore, staff will seek state and/or federal funds to bring in a dedicated individual to complete inventory. This forest inventory will include characteristics such as tree species, tree height, tree diameter at breast height, tree canopy class, tree health, overstory height and closure, understory height and closure, understory species, and other notable features. Loess Hills forest inventory was started in 2016 and is anticipated to be completed in 2018.*

Strategy 8.1.2: Use results of forest resource inventory to divide forested areas into forest stand units to determine specific management actions to reach desired stand conditions as indicated in Table 4.1.

- *The forest inventory will yield results relating to species composition, stand quality, and stand age. These characteristics will be used to divide forest area into management units based on shared forest attributes, along with soil conditions. A management plan for each unit will be developed and implemented. It is expected that the development of a management plan for this area will occur in the next 5-10 years and will be implemented accordingly.*

Strategy 8.1.3: Continue using Forest Invasive Adaptive Management (FIAM) project protocol to prioritize invasive species treatment areas in forested habitats.

- *FIAM was developed to provide refuge biologists and managers with a framework for tackling invasive plants in a way that is cost-effective and compatible with policy (Booker et al. 2017). FIAM formalizes a step-by-step process for 1) mapping invasive species distributions, 2) prioritizing the location of management actions, 3) treating the invasives, and 4) evaluating the effectiveness of the treatments (Booker et al. 2017).*

Strategy 8.1.4: Once every 5 years use acoustic monitoring to assess forest bat communities for occupancy within Loess Hills forest habitat. Emphasis of survey efforts will be placed upon occupancy of federally listed species including Indiana and northern long-eared bats. This project will provide information on the geographic distribution, habitat use (when combined with forest inventory and FIAM data) and species occurrence trends of not only common but species of conservation concern on LBNWR.

- *The current passive acoustic monitoring program for bats on the refuge is designed to identify bat species present and general locations of those species. This information will help to identify bat species of concern and allow refuge staff to guide management actions to provide suitable habitat for these species. This monitoring program will continue (done once every 5 years) as a means of identifying bat occupancy, as well as a means of determining the effect of management action on species present.*

Strategy 8.1.5: Use a combination of mechanical, hand-cutting techniques, and chemical applications on fire-tolerant species such as black or honey locust, hackberry, bush honeysuckle, smooth sumac and dogwood and invasive herbaceous vegetation like garlic mustard.

- *It is necessary to address the proliferation of these undesirable species (black or honey locust, hackberry, bush honeysuckle, dogwood, etc.) especially when the understory is*

≥85% and invasive herbaceous vegetation (garlic mustard) ≥50% in forested areas due to their negative impact on desirable species (oak, hickory, etc.) regeneration. While useful with some understory species, many deciduous trees and shrubs will re-sprout in response to fire; thus, other methods are required. A combination of hand-cutting, “hack and squirt”, and soil treatment can be used to assist in removal of these species from areas where they have become prolific (Clubine 2009). The use of mechanical treatments such as chopping, mowing, or mulching reduce above-ground vegetation and help to prepare the seedbed and reduce competing vegetation for desirable species regeneration. Chemical treatments treatment should consider soil characteristics, weather conditions, time of year, and vegetation (MDC 2015).

Strategy 8.1.6: In consultation with Ecological Services, implement a 3-year low intensity burn rotation to control exotic species and other aggressive native species and to promote red oak regeneration.

- *Fire can be effective in the reduction of exotic species such as bush honeysuckle, making it more responsive to chemical treatments (Clubine 2009). The reduction of other aggressive native species, such as pawpaw and ironwood or American hophornbeam (*Ostrya virginiana*) can be accomplished through the use of fire (MDC 2015). Low intensity fire can eliminate understory species, while not harming desirable canopy species. Prescribed burning can be used to reduce the depth of the forest floor and expose the soil, improving seedbed germination of naturally dispersed seeds. Fire can often be used to initiate regeneration of oaks and hickories (MDC 2015).*

Strategy 8.1.7: Continue partner with Missouri Department of Conservation to monitor forest pest species including but not limited to gypsy moth and emerald ash borer every 3-5 years.

- *It is necessary to identify the type of pest that is present, the life stage of the pest, and how much damage has occurred (Perry and Randall 2000). Common pests in Missouri include, but are not limited to, the following: gypsy moth, emerald ash borer, thousand cankers disease of walnut, and red oak borer (Missouri Invasive Forest Pest Council 2015). It will be important to determine the level at which damage is unacceptable and outline a management strategy when that level has been reached. Management strategies will be determined and implemented through consultations with other Missouri agencies including Missouri Department of Conservation, Missouri Department of Agriculture, and other professionals. As part of current pest management, refuge staff works with Missouri Department of Conservation to set gypsy moth traps every 3-5 years and will continue to do so. Any additional management strategies will be implemented as the need arises.*

Objective 9.1

Strategy 9.1.1: Utilize state and federal funds to hire personnel to conduct a robust inventory of all forest resources.

- *It would prove difficult for current refuge staff to complete a robust forest inventory; therefore, staff will seek state and/or federal funds to bring in a dedicated individual to complete inventory. This forest inventory will include characteristics such as tree species, tree height, tree diameter at breast height, tree canopy class, tree health, overstory height*

and closure, understory height and closure, understory species, and other notable features. Forest Inventory in the bottomland forest is expected to be started in 2018 and completed by 2021.

Strategy 9.1.2: Use results of forest resource inventory to divide forested areas into forest stand units to determine specific management actions to reach desired stand conditions as indicated in Table 4.2.

- *The forest inventory will yield results relating to species composition, stand quality, and stand age. These characteristics will be used to divide forest area into management units based on shared forest attributes, along with soil conditions. A management plan for each unit will be developed and implemented. It is expected that the development of a management plan for this area will occur in the next 5-10 years and will be implemented accordingly.*

Strategy 9.1.3: In 2018, start using Forest Invasive Adaptive Management (FIAM) project protocol to prioritize invasive species treatment areas in bottomland forest habitat.

- *FIAM was developed to provide refuge biologists and managers with a framework for tackling invasive plants in a way that is cost-effective and compatible with policy (Booker et al. 2017). FIAM formalizes a step-by-step process for 1) mapping invasive species distributions, 2) prioritizing the location of management actions, 3) treating the invasives, and 4) evaluating the effectiveness of the treatments (Booker et al. 2017).*

Strategy 9.1.4: Once every 5 years use acoustic monitoring to assess forest bat communities for occupancy within bottomland forest habitat. Emphasis of survey efforts will be placed upon occupancy of federally listed species including Indiana and northern long-eared bats. This project will provide information on the geographic distribution, habitat use (when combined with forest inventory and FIAM data) and species occurrence trends of not only common but species of conservation concern on LBNWR.

- *The current passive acoustic monitoring program for bats on the refuge is designed to identify bat species present and general locations of those species. This information will help to identify bat species of concern and allow refuge staff to guide management actions to provide suitable habitat for these species. This monitoring program will continue (done once every 5 years) as a means of identifying bat occupancy, as well as a means of determining the effect of management action on species present.*

Strategy 9.1.5: Conduct hydrological assessment of forested areas in order to determine appropriate species composition.

- *A proper hydrological assessment of forested areas will help to determine locations of suitable soil moisture conditions for planting of desirable native species such as bur oak, shagbark hickory, ash, hackberry, red oak, pin oak, and walnut. These tree species all require specific soil types of soil moisture regimes; thus, it is necessary to understand the water inputs which affect the bottomland forest areas of the refuge and the elevation changes within this area to determine appropriate planting locations. Once these variables have been determined, refuge staff can consult with other professionals (Missouri Department of Conservation, local universities) to determine methods of diversifying forest composition. Use potential climate change projections similar to those developed by U.S. Department of Agriculture Forest Service's Forecasts of Climate-*

Associated Shifts in Tree Species ([ForeCASTS](#)) in order select species based on water and temperature tolerances.

Strategy 9.1.6: In consultation with Ecological Services, implement burning, spraying, flooding, and mechanical disturbance regimen to eradicate invasive species populations (i.e. garlic mustard, Japanese hops, reed canarygrass) in order to allow for growth of native understory plants in forest restoration locations.

- *Garlic mustard is extremely invasive due to its prolific seed production and its ability to out-compete native vegetation by spreading quickly and producing a chemical that inhibits other plant growth. If garlic mustard is found, it helps to minimize soil disturbance in order to prevent its spread. Garlic mustard can be managed through cutting or chemical control methods, which should be continued annually until the seed bank is exhausted (MDC 2015). It can also be control using prescribed fire in the fall (late October/ early November). Japanese hops grow rapidly and van eventually form a blanket of vegetation four feet thick, smothers existing native vegetation. Manual removal can be effective in early spring, while herbicide should be used in areas with heavier infestation. Mowing and cutting can also be effective. Usually, three consecutive years of control efforts will exhaust the seed bank (MDC 2015). Reed canarygrass can aggressively replace native species as a result of its hardiness and rapid growth. Herbicide in combination with higher water levels can effective in managing reed canary grass (Nelms et al. 2007).*

Strategy 9.1.7: Determine high elevation areas in bottomland forest in order to establish seedlings of native species including, but not limited to, bur oak, shagbark hickory, ash, hackberry, red oak, pin oak, and walnut.

- *In order to establish vertical stratification within the bottomland forest environment, it is necessary to determine areas of higher elevations. These areas will have a smaller soil moisture content which will allow different species to subsist. If areas of higher elevation are not found, it would be possible to locate areas where higher elevation can be artificially created through movement of sediment from other areas on the refuge. Ultimately, soil moisture content should dictate tree species planted.*

Strategy 9.1.8: Continue partnering with Missouri Department of Conservation to monitor forest pest species including but not limited to gypsy moth and emerald ash borer every 3-5 years.

- *It is necessary to identify the type of pest that is present, the life stage of the pest, and how much damage has occurred (Perry and Randall 2000). Common pests in Missouri include, but are not limited to, the following: gypsy moth, emerald ash borer, thousand cankers disease of walnut, and red oak borer (Missouri Invasive Forest Pest Council 2015). It will be important to determine the level at which damage is unacceptable and outline a management strategy when that level has been reached. Management strategies will be determined and implemented through consultations with other Missouri agencies including Missouri Department of Conservation, Missouri Department of Agriculture, and other professionals. As part of current pest management, refuge staff works with Missouri Department of Conservation to set gypsy moth traps every 3-5 years and will continue to do so. Any additional management strategies will be implemented as the need arises.*

Objective 10.1

Strategy 10.1: Within the first 5 years of the approval of the HMP, partner with NRCS, Holt County Soil and Water Conservation District and/ or Partners for Fish Wildlife to form a water quality partnership working with private land owners aimed at addressing water quality degradation, insufficient water, and soil erosion.

- *A number of conservation practices may be deployed on private land to help improve water quality and decrease erosion/ sedimentation. These include but are not limited to the following: conservation cover, conservation crop rotation, contour buffers strips, cover crops, drainage water management, terrace, grassed waterways and water control structures*

Strategy 10.1.2: Monitor and maintain automated water gauges (pressure transducers, bubblers and/ or radar units) located on Squaw and Davis creeks in order to determine daily stream depth, which can in turn measures water flow and use when coupled with refuge bathymetry data and appropriate rating curves for discharge.

- *In 2010, Region 3 Division of Biological Resources now the Division of Natural Resources and Conservation Planning (DNR-CP) Branch of Water Resources staff installed 2 water monitoring stations (one on Davis and Squaw creeks). Both of these stations are equipped with GOES data loggers and transducers that measure streamflow and water temperature. These data loggers record readings every 15 minutes, which allows for the determination of a daily average stream depth along with determination of flood risks. When coupled with bathymetric maps showing elevation and volume of wetland units, it will be possible to determine stream discharge. This will allow LBNWR to predict vegetative response and work to reduce sedimentation within wetland units.*

Strategy 10.1.3: Partner with federal, state, local, university, and/or non-profit organizations (e.g., USGS or NRCS) to monitor water quality and sedimentation in Squaw Creek and Davis Creek through the determination of standards including, but not limited to, pH, dissolved oxygen, nitrates, specific conductivity, turbidity and salinity.

- *LBNWR currently works with Region 3 DNR-CP to determine stream discharge from Squaw Creek and Davis Creek. Refuge staff will also work to develop partnerships with local organizations including, but not limited to, Missouri Stream Team, Missouri Master Naturalists, Friends of LBNWR, USGS, NRCS, Missouri Department of Conservation, and local universities. Water quality monitoring will ideally occur on a monthly basis; however, as refuge staff establishes a reliable system, monitoring will occur on a bi-monthly basis. Refuge staff will also work to secure funding to improve existing water monitoring stations to incorporate technology for monitoring of all possible water quality standards, while other factors will continue to be measured by staff and/or volunteers. Introduction of technology will allow for more consistent monitoring of water quality standards. When monitoring water quality, refuge staff will be looking for baseline values and any patterns of change in those values. According to the EPA Water Quality Standards, the following ranges are ideal for freshwater habitats*

(<https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table#table>): pH (6.5-9.0); dissolved oxygen (5-7 mg/L) and nitrates (10mg/L) (EPA 1986; 2017). It is recommended that suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent (EPA 2017).

Strategy 10.1.4: Within 2 years of approval of the HMP, use current and future bathymetric data using a combination of techniques including, but not limited to, LiDAR and Real Time Kinetic (RTK) Surveys to determine changes in sedimentation rates within LBNWR wetland units.

- *LBNWR has an ongoing project using RTK Surveys to collect Universal Transverse Mercator coordinates and elevation data on wetland units. Products produced from this project include bathymetric maps of wetland units showing elevation and volume that will serve as a continuation of the 2002 USGS topographic survey and as a baseline for future bathymetry. LBNWR staff gauge, streamflow, and bathymetric data will be used to calculate yearly water use. The RTK Surveys will ideally be completed every 10 years in order to determine any changes in sedimentation. This information will be used to help guide current management actions aimed at improving wetland management (i.e. water control structure installation, levee repair, and water depth calculations across units compared to bird use days), monitoring and reducing sedimentation on LBNWR. If such actions are successful, wetland habitats on LBNWR will continue to be productive and resilient for use by waterfowl, shorebirds and other wetland dependent species.*

Objective 11.1

Strategy 11.1.1: Maintain a high level of disease monitoring of waterfowl during the spring and fall migrations and readiness to deal with a major disease outbreak.

- *Using Diagnostic case submission guidelines by [USGS](#) and USFWS Region 3 quick response of wildlife morbidity mortality events the LBNWR by monitoring waterfowl concentrations for indication of disease and stress. Recommendations made by USGS National Wildlife Health Center will be implemented if the situation warrants. The refuge will strive to keep wildlife disease outbreaks as small as possible (collect carcasses of animals ≥ 5 per species or total of multiple species as recommended by [USGS](#)). When waterfowl concentration exceeds objective levels to the extent the welfare of the waterfowl is at risk, such as in the control of disease outbreaks, disturbance measure that result in concentration reductions will be implemented.*

Strategy 11.1.2: Continue to annually partner with Missouri Department of Conservation and local universities to monitor for the presence and extent of occurrence of snake fungal disease (SFD) in prairie massasauga rattlesnakes and other associated species on LBNWR.

- *A better understanding, including documentation of disease, provides managers with necessary tools for future planning. Continued monitoring of SFD in prairie massasaugas is needed to thoroughly assess the spatial extent, percent of the population infected, effect on population dynamics/ structure and other associated species infected.*

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Appendix A – Resource of Concern Selection Committee

Name	Job Title	Affiliation
Lindsey Landowski	Refuge Manager	USFWS, Loess Bluffs NWR
Darrin Welchert	Wildlife Biologist	USFWS, Loess Bluffs NWR
Corey Kudrna	Wildlife Refuge Specialist	USFWS, Loess Bluffs NWR
Trisha Crabill	Fish and Wildlife Biologist	USFWS, Ecological Services
Thomas Bell	Refuge/ Complex Manager	USFWS, Big Muddy NWR
Steve Buback	Natural History Biologist	Missouri Department of Conservation
Jim Pierson	Private Land Conservationist	Missouri Department of Conservation
Craig Crisler	Wildlife Management Biologist	Missouri Department of Conservation
Mary Nemecek	Conservation Coordinator	Burroughs Audobon Society
Ron Bell	Retired Refuge Manager/ Treasurer	Midland Empire Audobon Society
Mark Robbins	Collection Manager	Kansas University/ Museum
Dr. Mark Mills	Biology Associate Professor	Missouri Western State University
Dr. Jay McGhee	Natural Sciences Professor	Northwestern Missouri State University
Lonnie Messbarger	Forester	Missouri Department of Conservation

Appendix B

Common name Scientific Name	Threatened and Endangered		State Lists		Fish and Wildlife Service Lists					LCC	PIF	BCR	UMRGLRJV Bird Lists				ABC Watch List		Other Species Lists		
	R3 T&E Species	MO T&E Species	MO SWAP SGCN 2013	MO Natural Heritage List	Nat'l List, 2008	BCR 22, 2008	Region 3, 2012	Focal Species	Conservation Priority List, 2012	Surrogate Species, 2014	Priority PIF 32	UMRGLR JV BCR 22 All Birds	Waterbirds	Shorebirds	Landbirds	Waterfowl	Red	Yellow	Interjurisdictional Fish 2009	PARC	Xerces
Bald Eagle <i>Haliaeetus leucocephalus</i>			X	X	X	X	X	X	X		X										
Golden Eagle <i>Aquila chrysaetos</i>																					
Northern Harrier <i>Circus cyaneus</i>		E	X						X		X										
Osprey <i>Pandion haliaetus</i>			X																		
Red-shouldered Hawk <i>Buteo lineatus</i>										X											
Swainson's Hawk <i>Buteo swainsoni</i>			X		X		X		X						X						
American Black Duck <i>Anas rubripes</i>								X				X				X					
American Wigeon <i>Anas americana</i>												X				X					
Atlantic Brant <i>Branta b. bernicla</i>																X					
Black Scoter <i>Melanitta nigra</i>																X					
Blue-winged Teal <i>Anas discors</i>										X		X				X					

	Threatened and Endangered		State Lists		Fish and Wildlife Service Lists					LCC	PIF	BCR	UMRGLRJV Bird Lists				ABC Watch List		Other Species Lists		
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Bufflehead <i>Bucephala albeola</i>																X					
Canada Goose <i>Branta canadensis</i>									X			X				X					
Canvasback <i>Aythya valisineria</i>												X				X					
Cinnamon Teal <i>Anas cyanoptera</i>																					
Common Goldeneye <i>Bucephala clangula</i>												X				X					
Common Merganser <i>Mergus merganser</i>																X					
Gadwall <i>Anas strepera</i>																X					
Greater Scaup <i>Aythya marila</i>								X								X					
Greater White-fronted Goose <i>Anser albifrons</i>																					
Green-winged Teal <i>Anas crecca</i>																X					
Hooded Merganser <i>Lophodytes cucullatus</i>																X					

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Lesser Scaup <i>Aythya affinis</i>								X		X		X				X					
Long-tailed Duck <i>Clangula hyemalis</i>																X					
Mallard <i>Anas platyrhynchos</i>									X	X		X				X					
Mute swan <i>Cygnus olor</i>																X					
Northern Pintail <i>Anas acuta</i>								X				X				X					
Northern Shoveler <i>Anas clypeata</i>																X					
Red-breasted Merganser <i>Mergus serrator</i>																X					
Redhead <i>Aythya americana</i>												X				X					
Ring-necked Duck <i>Aythya collaris</i>																X					
Ross's Goose <i>Chen rossii</i>																X					
Ruddy Duck <i>Oxyura jamaicensis</i>																X					

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Snow Goose <i>Chen caerulescens</i>									X							X					
Surf Scoter <i>Melanitta perspicillata</i>																X					
Trumpeter Swan <i>Cygnus buccinator</i>			X													X		X			
Tundra Swan <i>Cygnus columbianus</i>												X				X					
White-winged Scoter <i>Melanitta fusca</i>																X					
Wood Duck <i>Aix sponsa</i>									X	X		X				X					
Chimney Swift <i>Chaetura pelagica</i>											X	X			X						
American Bittern <i>Botaurus lentiginosus</i>		E	X			X	X					X	X								
Black-crowned Night-heron <i>Nycticorax nycticorax</i>			X	X		X	X		X			X	X								
Cattle Egret <i>eubulcus ibis</i>													X								
Great Blue Heron <i>Ardea herodias</i>													X								

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Great Egret <i>Ardea alba</i>			X										X								
Green Heron <i>Butorides virescens</i>													X								
Least Bittern <i>Ixobrychus exilis</i>			X	X		X	X					X	X								
Little Blue Heron <i>Egretta caerulea</i>			X										X								
Snowy Egret <i>Egretta thula</i>		E	X										X								
Yellow-crowned Night-heron <i>Nyctanassa violacea</i>												X	X								
Whip-poor-will <i>Caprimulgus vociferus</i>						X	X		X			X			X						
Dickcissel <i>Spiza americana</i>					X	X	X		X		X	X			X						
Painted Bunting <i>Passerina ciris</i>			X				X	X										X			
Black Vulture <i>Coragyps atratus</i>			X																		
Brown Creeper <i>Certhia americana</i>			X																		

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American Golden Plover <i>Pluvialis dominica</i>												X		X							
Black-bellied Plover <i>Pluvialis squatarola</i>														X							
Killdeer <i>Charadrius vociferus</i>												X		X							
Piping Plover (Great Plains pop.) <i>Charadrius melodus</i>	T						E		X	X	X										
Semipalmated Plover <i>Charadrius semipalmatus</i>														X				X			
Snowy Plover <i>Charadrius alexandrinus</i>																					
Mourning Dove <i>Zenaida macroura</i>																					
American Crow <i>Corvus brachyrhynchos</i>																					
Black-billed Cuckoo <i>Coccyzus erythrophthalmus</i>						X	X		X												
American Tree Sparrow <i>Spizella arborea</i>											X										
Baird's Sparrow <i>Ammodramus bairdii</i>					X		X								X		X				

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Chestnut-collared Longspur <i>Calcarius ornatus</i>							X								X			x			
Field Sparrow <i>Spizella pusilla</i>						X	X		X		X										
Grasshopper Sparrow <i>Ammodramus savannarum</i>						X	X	X	X		X				X						
Harris's Sparrow <i>Zonotrichia querula</i>											X										
Henslow's Sparrow <i>Ammodramus henslowii</i>					X	X	X	X	X	X	X	X			X		X				
Lark Bunting <i>Calamospiza melanocorys</i>															X						
Le Conte's Sparrow <i>Ammodramus leconteii</i>							X			X								X			
Nelson's Sharp-tailed Sparrow <i>Ammodramus nelsoni</i>					X		X								X			X			
Smith's Longspur <i>Calcarius pictus</i>					X	X	X											X			
Peregrine Falcon <i>Falco peregrinus</i>		E	X		X	X	X														
Prairie Falcon <i>Falco mexicanus</i>																					

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Pine Siskin <i>Spinus pinus</i>			X																		
Common Loon <i>Gavia immer</i>										X			X								
Sandhill Crane <i>Grus canadensis</i>			X	X									X								
Whooping Cran <i>Grus americana</i>	E						X					X	X				X				
Baltimore Oriole <i>Icterus galbula</i>											x										
Bobolink <i>Dolichonyx orizivorus</i>							X	X	X	X	X										
Eastern Meadowlark <i>Sturnella magna</i>									X	X		X			X						
Orchard Oriole <i>Icterus spurius</i>							X		X		X										
Rusty Blackbird <i>Euphagus carolinus</i>					X	X	X	X	X			X						X			
Western Meadowlark <i>Sturnella neglecta</i>									X												
Yellow-headed Blackbird <i>Xanthocephalus xanthocephalus</i>			X	X																	

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Loggerhead Shrike <i>Lanius ludovicianus</i>			X	X	X	X	X		X		X										
Black Tern <i>Chlidonias niger</i>			X			X	X	X		X		X	X								
Bonaparte's Gull <i>Larus philadelphia</i>													X								
Caspian Tern <i>Sterna caspia</i>													X								
Common Tern <i>Sterna hirundo</i>						X	X	X		X		X	X								
Forster's Tern <i>Sterna forsteri</i>									X				X								
Franklin's Gull <i>Leucophaeus pipixcan</i>													X								
Glaucous Gull <i>Larus hyperboreus</i>													X								
Great Black-backed Gull <i>Larus marinus</i>													X								
Herring Gull <i>Larus argentatus</i>													X								
Iceland Gull <i>Larus glaucoides glaucoides</i>													X								

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Least Tern, Interior <i>Sternula antillarum</i>	E	E	X				E		X		X	X	X				X				
Lesser Black-backed Gull <i>Larus fuscus</i>													X								
Little Gull <i>Hydrocoloeus minutus</i>													X								
Parasitic Jaeger <i>Stercorarius parasiticus</i>													X								
Ring-billed Gull <i>Larus delawarensis</i>													X								
Sabine's Gull <i>Xema sabini</i>													X								
Thayer's Gull <i>Larus glaucoides thayeri</i>													X					X			
Brown Thrasher <i>Toxostoma rufum</i>							X			X	X										
Sprague's Pipit <i>Anthus spragueii</i>	C				X			X							X						
Northern Bobwhite <i>Colinus virginianus</i>											X										
Bay-breasted Warbler <i>Setophaga castanea</i>												X									

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Black-throated Green Warbler <i>Setophaga virens</i>			X																		
Blue-winged Warbler <i>Vermivora cyanoptera</i>					X	X	X		X			X			X			X			
Canada Warbler <i>Cardellina canadensis</i>					X		X			X		X			X			X			
Cape May Warbler <i>Setophaga tigrina</i>												X			X						
Cerulean Warbler <i>Setophaga cerulea</i>			X		X	X	X	X			X	X			X			X			
Chestnut-sided Warbler <i>Setophaga pensylvanica</i>			X																		
Golden-winged warbler <i>Vermivora chrysoptera</i>					X		X	X		X		X			X		X				
Kentucky Warbler <i>Geothlypis formosus</i>	E				X	X	X		X			X			X		X				
Louisiana Waterthrush <i>Parkesia motacilla</i>							X		X			X			X						
Pine Warbler <i>Setophaga pinus</i>										X											
Prairie Warbler <i>Setophaga discolor</i>							X											X			

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Prothonotary Warbler <i>Prothonotary citrea</i>					X	X	X		X		X	X			X			X			
Worm-eating Warbler <i>Helmitheros vermivorum</i>							X					X									
American White Pelican <i>Pelecanus erythrorhynchos</i>													X								
Double-crested Cormorant <i>Phalacrocorax auritus</i>													XX								
Greater Prairie-Chicken <i>Tympanuchus cupido</i>		E	X								X	X			X		X				
Ring-necked Pheasant <i>Phasianus colchicus</i>																					
Wild Turkey <i>Meleagris gallopavo</i>																					
Northern Flicker <i>Colaptes auratus</i>						X	X		X	X											
Red-headed Woodpecker <i>Melanerpes erythrocephalus</i>					X	X	X		X		X	X			X			X			
Eared Grebe <i>Podiceps nigricollis</i>													X								
Horned Grebe <i>Podiceps auritus</i>						X	X						X								

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Pied-billed Grebe <i>Podilymbus podiceps</i>						X	X					X	X								
Red-necked Grebe <i>Podiceps grisegena</i>													X								
Western Grebe <i>Aechmophorus occidentalis</i>													X								
American Coot <i>Fulica americana</i>													X								
Common Gallinule <i>Gallinula galeata</i>				X																	
Common Moorhen <i>Gallinula chloropus</i>			X						X				X								
King Rail <i>Rallus elegans</i>		E	X	X			X	X	X			X	X					X			
Sora <i>Porzana carolina</i>			X									X	X								
Virginia Rail <i>Rallus limicola</i>			X										X								
Yellow Rail <i>Coturnicops noveboracensis</i>			X	X	X		X	X				X	X				X				
American Avocet <i>Recurvirostra americana</i>														X							

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American Woodcock <i>Scolopax minor</i>								X		X		X		X	X						
Baird's Sandpiper <i>Calidris bairdii</i>														X							
Black-necked Stilt <i>Himantopus mexicanus</i>														X							
Buff-breasted Sandpiper <i>Tryngites subruficollis</i>					X	X	X	X	X			X		X			X				
Dunlin <i>Calidris alpina</i>								X				X		X							
Greater Yellowlegs <i>Tringa melanoleuca</i>									X					X							
Hudsonian Godwit <i>Limosa haemastica</i>					X	X	X	X	X			X		X				X			
Least Sandpiper <i>Calidris minutilla</i>														X							
Lesser Yellowlegs <i>Tringa flavipes</i>					X		X							X							
Long-billed Curlew <i>Numenius americanus</i>								X										X			
Long-billed Dowitcher <i>Limnodromus scolopaceus</i>														X							

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Marbled Godwit <i>Limosa fedoa</i>					X	X	X	X	X			X		X				X			
Pectoral Sandpiper <i>Calidris melanotos</i>														X			X				
Red Knot (roselaari ssp.) <i>Calidris canutus</i>	T					X	X	X				X		X				X			
Red Knot (rufa ssp.) <i>Calidris canutus</i>	T				X	X	X	X				X		X				X			
Red-necked Phalarope <i>Phalaropus lobatus</i>														X							
Ruddy Turnstone <i>Arenaria interpres</i>												X		X							
Sanderling <i>Calidris alba</i>												X		X				X			
Semipalmated Sandpiper <i>Calidris pusilla</i>					X		X	X						X							
Short-billed Dowitcher <i>Limnodromus griseus</i>					X	X	X		X			X		X							
Solitary Sandpiper <i>Tringa solitaria</i>					X	X	X					X		X							
Spotted Sandpiper <i>Actitis macularius</i>														X							

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Stilt Sandpiper <i>Calidris himantopus</i>									X					X				X			
Upland Sandpiper <i>Bartramia longicauda</i>					X	X	X	X	X	X		X		X	X						
Western Sandpiper <i>Calidris mauri</i>														X				X			
Whimbrel <i>Numenius phaeopus</i>					X	X	X		X			X		X							
White-rumped Sandpiper <i>Calidris fuscicollis</i>														X				X			
Willet <i>Tringa semipalmata</i>														X							
Wilson's Phalarope <i>Phalaropus tricolor</i>									X			X		X							
Wilson's Snipe <i>Gallinago delicata</i>												X		X							
Burrowing Owl <i>Athene cunicularia</i>			X					X													
Long-eared Owl <i>Asio otus</i>			X						X		X										
Short-eared Owl <i>Asio flammeus</i>			X		X	X	X		X		X	X			X						

	Threatened and Endangered		State Lists		Fish and Wildlife Service Lists					LCC	PIF	BCR	UMRGLRJV Bird Lists				ABC Watch List		Other Species Lists		
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<i>Bewick's Wren (bewickii ssp.)</i> <i>Thryomanes bewickii</i>						X	X		X												
Marsh Wren <i>Cistothorus palustris</i>			X	X			X														
Sedge Wren <i>Cistothorus platensis</i>							X														
Veery <i>Catharus fuscescens</i>												X			X						
Wood Thrush <i>Hylocichla mustelina</i>					X	X	X	X	X	X		X			X		X				
Acadian Flycatcher <i>Empidonax virescens</i>						X	X		X												
Eastern Kingbird <i>Tyrannus tyrannus</i>											X										
Eastern Phoebe <i>Sayornis phoebe</i>											X										
Least Flycatcher <i>Empidonax minimus</i>			X																		
Olive-sided Flycatcher <i>Contopus cooperi</i>					X		X					X			X			X			
Willow Flycatcher <i>Empidonax traillii</i>					X		X					X			X			X			

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Barn Owl <i>Tyto alba</i>			X	X					X												
Bell's Vireo <i>Vireo bellii</i>					X	X	X		X		X	X			X		X				
Lake sturgeon <i>Acipenser fulvescens</i>		E	X						X	X											
Pallid Sturgeon <i>Scaphirhynchus albus</i>	E	E	X	X					X										X		
Shovelnose Sturgeon <i>Scaphirhynchus platyrhynchus</i>									X										X		
American Eel <i>Anguilla rostrata</i>			X																X		
Bigmouth buffalo <i>Ictiobus cyprinellus</i>																			X		
Blue Sucker <i>Cycleptus elongatus</i>									X										X		
River carpsucker <i>Carpionodes carpio</i>																			X		
Shorthead Redhorse <i>Moxostoma macrolepidotum</i>																			X		
Smallmouth buffalo <i>Ictiobus bubalus</i>																			X		

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White Sucker <i>Catostomus commersoni</i>																			X		
Black crappie <i>Pomoxis nigromaculatus</i>																			X		
Bluegill <i>Lepomis macrochirus</i>																			X		
Largemouth bass <i>Micropterus salmoides</i>																			X		
White crappie <i>Pomoxis annularis</i>																			X		
Gizzard shad <i>Dorosoma cepedianum</i>																			X		
Skipjack herring <i>Alosa chrysochloris</i>			X	X															X		
Brassy Minnow <i>Hybognathus hankinsoni</i>			X																X		
Common carp <i>Cyprinus carpio</i>																			X		
Flathead chub <i>Platygobio gracilis</i>		E	X	X															X		
Freshwater drum <i>Aplodinotus grunniens</i>																			X		

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Goldfish <i>Carassius auratus</i>																					
Grass carp <i>Ctenopharyngodon idella</i>																			X		
Plains Minnow <i>Hybognathus placitus</i>			X	X					X										X		
River Shiner <i>Notropis blennius</i>																			X		
Silverband shiner <i>Notropis shumardi</i>																			X		
Sturgeon Chub <i>Macrhybopsis gelida</i>			X	X					X										X		
Western Silvery Minnow <i>Hybognathus argyritis</i>			X	X					X										X		
Northern Plains Killifish <i>Fundulus kansae</i>			X																		
Goldeye <i>Hiodon alosoides</i>																			X		
Black bullhead <i>Ameiurus melas</i>																			X		
Blue catfish <i>Ictalurus furcatus</i>																			X		

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Blue catfish <i>Ictalurus furcatus</i>																			X		
Channel catfish <i>Ictalurus punctatus</i>																			X		
Flathead catfish <i>Pylodictis olivaris</i>																			X		
Longnose gar <i>Lepisosteus osseus</i>																			X		
Shortnose gar <i>Lepisosteus platostomus</i>																			X		
White bass <i>Morone chrysops</i>																			X		
Sauger <i>Stizostedion canadense</i>																			X		
Walleye <i>Sander vitreus</i>										X									X		
Chestnut Lamprey <i>Ichthyomyzon castaneus</i>																			X		
Mosquitofish <i>Gambusia affinis</i>																					
Paddlefish <i>Polyodon spathula</i>									X	X									X		

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Bullfrog <i>Lithobates catesbeiana</i>																					
Cope's Gray Treefrog <i>Hyla chrysoscelis</i>																					
Blanchard's Cricket Frog <i>Acris blanchardi</i>																				X	
Northern Leopard Frog <i>Lithobates pipiens</i>			X	X																	
Plain's Leopard Frog <i>Lithobates blairi</i>																					
Boreal Chorus Frog <i>Pseudacris maculata</i>																					
American Toad <i>Anaxyrus americanus</i>																					
Western Narrowmouth Toad <i>Gastrophryne olivacea</i>																					
Great Plains Toad <i>Anaxyrus cognatus</i>			X	X																	
Plains Spadefoot Toad <i>Spea bombifrons</i>																					
Woodhouse's Toad <i>Anaxyrus woodhousii</i>																					

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Eastern Tiger Salamander <i>Ambystoma tigrinum</i>			X	X																	
Smallmouth salamander <i>Ambystoma texanum</i>																					
Common Five-lined Skink <i>Plestiodon fasciatus</i>																					
Great Plains Skink <i>Plestiodon obsoletus</i>				X																X	
Northern Prairie Skink <i>Plestiodon septentrionalis septentrionalis</i>			X	X																X	
Six-lined Racerunner <i>Aspidoscelis sexlineata</i>																					
Slender Glass Lizard <i>Ophisaurus attenuatus</i>																					
Eastern Yellow-bellied Racer <i>Coluber c. flaviventrus</i>																					
Diamond-backed Watersnake <i>Nerodia rhombifer</i>																					
Eastern Gartersnake <i>Thamnophis sirtalis sirtalis</i>																					
Eastern Hog-nosed Snake <i>Heterodon platirhinos</i>																					

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Bullsnake <i>Pituophis catenifer sayi</i>																					
Graham's Crayfish Snake <i>Regina grahamii</i>																					
Lined Snake <i>Tropidoclonion lineatum</i>																					
Red Milksnake <i>Lampropeltis triangulum</i>																					
Northern Watersnake <i>Nerodia sipedon sipedon</i>																					
Plains Gartersnake <i>Thamnophis radix</i>																					
Prairie Ring-necked Snake <i>Diadophis punctatus arnyi</i>																					
Speckled Kingsnake <i>Lampropeltis holbrooki</i>																					
Western Ratsnake <i>Pantherophis obsoletus</i>																					
Texas Brownsnake <i>Storeria dekayi texana</i>																					
Western Foxsnake <i>Pantherophis ramspotti</i>				X																	

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Praire Massasauga <i>Sistrurus tergeminus tergeminus</i>		E	X	X																	
Western Ribbonsnake <i>Thamnophis proximus</i>																					
Western Wormsnake <i>Carphophis vermis</i>																				X	
Prairie Kingsnake <i>Lampropeltis calligaster</i>																					
Blanding's Turtle <i>Emydoidea blandingii</i>		E	X	X																X	
Common Snapping Turtle <i>Chelydra serpentina</i>																					
False Map Turtle <i>Graptemys pseudogeographica</i>																					
Ornate Box Turtle <i>Terrapene ornata</i>																				X	
Red-eared Slider <i>Trachemys scripta</i>																					
Midland Smooth Softshell <i>Apalone mutica</i>																					
Eastern Spiny Softshell <i>Apalone spinifera</i>																					

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Western Painted Turtle <i>Chrysemys picta bellii</i>																					
Coyote <i>Canis latrans</i>																					
Gray fox <i>Urocyon inereorgenteus</i>																					
Red fox <i>Vulpes vulpes</i>																					
Beaver <i>Castor canadensis</i>																					
White-tailed deer <i>Odocoileus virginianus</i>																					
Deermouse <i>Peromyscus maniculatus</i>																					
Muskrat <i>Ondatra zibethicus</i>																					
Western Harvest Mouse <i>Reithrodontomys Megalotis</i>																					
White-footed Deermouse <i>Peromyscus leucopus</i>																					
Southern Bog Lemming <i>Synaptomys cooperi</i>																					

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Virginia Opossum <i>Didelphis virginiana</i>																					
Meadow jumping mouse <i>Zapus hudsonius</i>																					
Bobcat <i>Lynx rufus</i>																					
Mountain Lion <i>Puma concolor</i>			X																		
Plains Pocket Gopher <i>Geomys bursarius</i>																					
Plains pocket mouse <i>Perognathus flavescens</i>			X																		
Eastern cottontail <i>Sylvilagus floridanus</i>																					
Spotted skunk <i>Spilogale putorius</i>		E	X																		
Striped skunk <i>Mephitis mephitis</i>																					
House mouse <i>Mus musculus</i>																					
Meadow vole <i>Microtus pennsylvanicus</i>																					

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Norway rat <i>Rattus norvegicus</i>																					
Pine Vole <i>Microtus pinetorum</i>																					
Prairie Vole <i>Microtus ochrogaster</i>																					
American Badger <i>Taxidea taxus</i>			X	X																	
Least Weasel <i>Mustela nivalis</i>			X																		
Long-tailed weasel <i>Mustela frenata</i>			X																		
Mink <i>Mustela vison</i>																					
River Otter <i>Lontra canadensis</i>																					
Raccoon <i>Procyon lotor</i>																					
Eastern fox squirrel <i>Sciurus niger</i>																					
Eastern gray squirrel <i>Sciurus carolinensis</i>																					

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Franklin's Ground Squirrel <i>Spermophilus franklinii</i>			X	X																	
Red Squirrel <i>Tamiasciurus hudsonicus</i>																					
Southern flying squirrel <i>Glaucomys volans</i>																					
Thirteen-lined ground squirrel <i>Spermophilus tridecemlineatus</i>			X	X																	
Woodchuck <i>Marmota monax</i>																					
Short-tailed shrew <i>Blarina brevicauda</i>																					
Masked Shrew <i>Sorex cinereus</i>																					
Least Shrew <i>Cryptotis parva</i>																					
Eastern Mole <i>Scalopus aquaticus</i>																					
Eastern Pipistrelle <i>Pipistrellus subflavus</i>																					
Evening Bat <i>Nycticeius humeralis</i>																					

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Hoary Bat <i>Lasiurus cinereus</i>																					
Indiana Bat <i>Myotis sodalis</i>	E	E	X						X												
Little Brown Myotis <i>Myotis lucifugus</i>																					
Northern Long-eared Bat <i>Myotis septentrionalis</i>	T																				
Red Bat <i>Lasiurus borealis</i>																					
Silver-haired Bat <i>Lasionycteris noctivagans</i>			X																		
Asian clam <i>Corbicula fluminea</i>																					
Mapleleaf <i>Quadrula quadrula</i>																					
Winged Mapleleaf <i>Quadrula fragosa</i>	E	E	X																		E
Zebra mussel <i>Dreissena polymorpha</i>																					

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Asian clam <i>Corbicula fluminea</i>																					
Mapleleaf <i>Quadrula quadrula</i>																					
Zebra mussel <i>Dreissena polymorpha</i>																					
Arkansas Mudalia <i>Leptoxis arkansensis</i>			X																		
Bankclimber <i>Plectomerus dombeyanus</i>			X																		
Capital Vertigo <i>Vertigo oscariana</i>			X																		
Cherrystone Snail <i>Hendersonia occulta</i>			X																		
Chert Pebblesnail <i>Somatogyrus rosewateri</i>			X																		
Crested Snaggletooth <i>Gastrocopta cristata</i>			X																		
Eightfold PineconeStrobilops affinis			X																		

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Engraved Bladetooth <i>Patera perigrapta</i>			X																		
Furrowed Lioplax <i>Lioplax sulculosa</i>			X																		
Giant Stone <i>Attaneuria ruralis</i>				X																	
Inland Slitmouth <i>Stenotrema stenotrema</i>			X																		
Marsh Pondsail <i>Stagnicola elodes</i>			X																		
Moss Pyrg <i>Pyrgulopsis scalariformis</i>			X																		
Oklahoma Liptooth <i>Millerelix deltoidea</i>			X																		
Ozark Pyrg <i>Marstonia ozarkensis</i>			X																		
Ozark Whitelip <i>Neohelix divesta</i>			X																		
Perforate Dome <i>Ventridens demissus</i>			X																		
Ponderous Campeloma <i>Campeloma crassulum</i>			X																		

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Post Oak Threetooth <i>Triodopsis cragini</i>			X																		
Rough Hornsnail <i>Pleurocera alveare</i>			X																		
Sampson Sprite <i>Micromenetus sampsoni</i>			X																		
Sandbar Pebblesnail <i>Somatogyrus depressus</i>			X																		
Sealed Goblet <i>Mesodon mitchellianus</i>			X																		
Slim Snaggletooth <i>Gastrocopta pellucida</i>			X																		

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Monarch Butterfly* <i>Danaus plexippus</i>										Gra											
Regal fritillary <i>Speyeria idalia</i>	C		X	X																V	C
American burying beetle <i>Nicrophorus americanus</i>	E	E	X																		E
Swift Tiger Beetle <i>Cicindela celeripes</i>				X																	
A Concealed-tymbal Cicada <i>Beameria venosa</i>				X																	
Austin Springfly <i>Hydroperla fugitans</i>				X																	
Brimstone Clubtail <i>Stylurus intricatus</i>			X																		
Eastern Red Damsel <i>Amphiagrion saucium</i>			X																		
Elusive Clubtail <i>Stylurus notatus</i>			X																		
Golden-winged Skimmer <i>Libellula auripennis</i>			X																		
Paiute Dancer <i>Argia alberta</i>			X																		

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A Blazing Star <i>Liatris punctata</i> var. <i>punctata</i>				X																	
Blue Grama <i>Bouteloua gracilis</i>				X																	
Buffalo Clover <i>Trifolium reflexum</i>																					
Columbia Water-meal <i>Wolffia columbiana</i>				X																	
Downy Painted Cup <i>Castilleja sessiliflora</i>				X																	
Hairy Grama <i>Bouteloua hirsuta</i> var. <i>hirsuta</i>				X																	
Lake-bank Sedge <i>Carex lacustris</i>				X																	
Longbeak Sedge <i>Carex sprengei</i>				X																	
Low Milk Vetch <i>Astragalus lotiflorus</i>				X																	
Nine-anther Dalea <i>Dalea enneandra</i>				X																	
Nodding Evening Primrose <i>Oenothera nutans</i>				X																	

	Threatened and Endangered		State Lists		Fish and Wildlife Service Lists					LCC	PIF	BCR	UMRGLRJV Bird Lists				ABC Watch List		Other Species Lists		
Common name Scientific Name	R3 T&E Species	MO T&E Species	MO SWAP SGCN 2013	MO Natural Heritage List	Nat'l List, 2008	BCR 22, 2008	Region 3, 2012	Focal Species	Conservation Priority List, 2012	Surrogate Species, 2014	Priority PIF 32	UMRGLR JV BCR 22 All Birds	Waterbirds	Shorebirds	Landbirds	Waterfowl	Red	Yellow	Interjurisdictional Fish 2009	PARC	Xerces
Pale Bulrush <i>Scirpus pallidus</i>				X																	
Prairie Bush Clover <i>Lespedeza leptostachya</i>	T								LM O												T
Sartwell's Sedge <i>Carex sartwellii</i>				X																	
Schweinitz's Flatsedge <i>Cyperus schweinitzii</i>				X																	
Silvery Psoralea <i>Pediomelum argophyllum</i>				X																	
Skeleton Plant <i>Lygodesmia juncea</i>				X																	
Small Soapweed Yucca <i>Yucca glauca</i>				X																	
Star Duckweed <i>Lemna trisulca</i>				X																	
Thimbleweed <i>Anemone cylindrica</i>				X																	
Tussock Sedge <i>Carex stricta</i>				X																	

	Threatened and Endangered		State Lists		Fish and Wildlife Service Lists					LCC	PIF	BCR	UMRGLRJV Bird Lists				ABC Watch List		Other Species Lists		
Common name <i>Scientific Name</i>	R3 T&E Species	MO T&E Species	MO SWAP SGCN 2013	MO Natural Heritage List	Nat'l List, 2008	BCR 22, 2008	Region 3, 2012	Focal Species	Conservation Priority List, 2012	Surrogate Species, 2014	Priority PIF 32	UMRGLR JV BCR 22 All Birds	Waterbirds	Shorebirds	Landbirds	Waterfowl	Red	Yellow	Interjurisdictional Fish 2009	PARC	Xerces
Mesic loess/glacial till forest				X																	
Wet-mesic bottomland prairie				X																	
Dry-mesic loess/glacial till prairie				X																	
Dry loess/glacial till prairie				X																	
Wet bottomland prairie				X																	
Wet-mesic bottomland prairie				X																	
Dry-mesic loess/glacial till prairie				X																	
Marsh				X																	