

MASTER PLAN

SALT VALLEY GREENWAY and PRAIRIE CORRIDOR



31 AUGUST 2012

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EXECUTIVE SUMMARY

INTRODUCTION

Whether a greenway is more urban or rural, more passive recreation than active, more historical than developed, more wildlife than human, etc. it is apparent that greenways serve many purposes. Generally, greenways enhance the quality of life in our communities; promote conservation of the natural environment and instill a sense of connectivity with nature. These benefits are important particularly in the context of an urbanized community. It is practical to consider greenway benefits from two perspectives: the natural resource benefits and the human or community benefits.

The term greenway itself instills “green” imagery such as tree lines and masses, shrubbery, native grasslands, ornamental plantings, etc. These are important components to a greenway, not only because of the images they project, but also based on their functions. Trees, shrubs and grasses are important links providing food and cover for birds, mammals, reptiles and insects. Greenways that are streamside and/or watershed based provide flood protection functions, improve water clarity and quality, improve fish, amphibians and reptile habitat and provide the cross-benefit of improved water recreation.

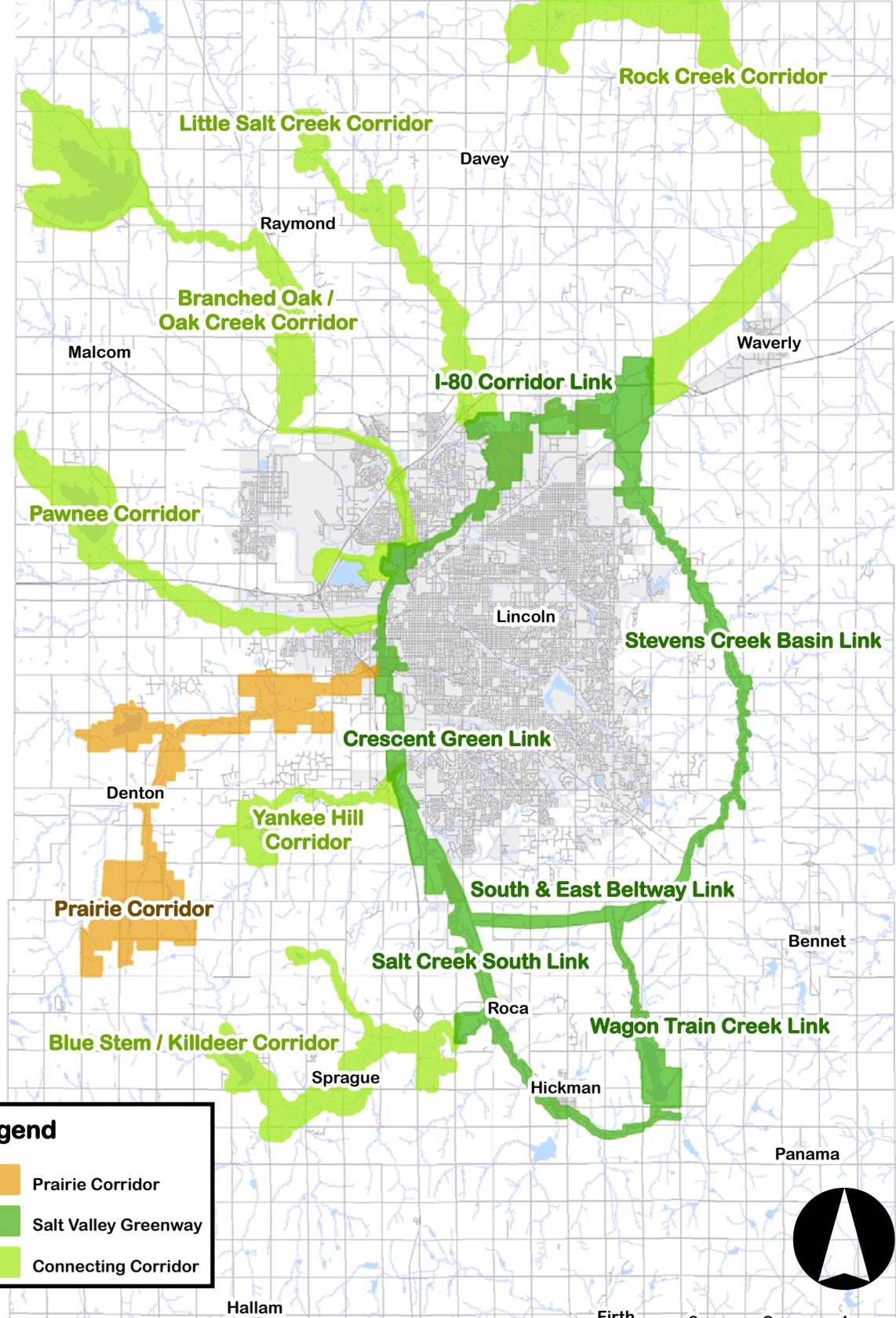
Historical and cultural resources are key elements in the establishment of the heritage of a community. These resources can be preserved and highlighted with greenway planning. Trails that are associated with cultural resources or provide a linkage to a known site or area may include informative kiosks, special signage generating a lively sense of pride in a community.

Elements of greenway planning for the City of Lincoln can be traced back to 1961, where a proposal for a linear park was included in the City’s Comprehensive plan. The “Crescent Green” name was given to the project in 1964 by Mr. Dale Gibbs, a University of Nebraska Architecture professor. The Crescent Green project identified various important elements such as bike trails, open spaces, playfields, and establishment and maintenance/enhancement of wetlands and forests. In 1966 the City purchased what is now Wilderness Park.

The 2040 Lincoln-Lancaster County Plan includes a vision for the Salt Valley Greenway, a ribbon of open space and greenway links within the Salt Valley drainage basin, and the Prairie Corridor on Haines Branch, one of the key connecting green corridors (see Map ES-1). This Master Plan represents that first step in implementation, providing a concept plan for the Salt Valley Greenway and a detailed inventory and plan for the Prairie Corridor. Together, the Greenway and Prairie Corridor embody the three core resource imperatives for Lincoln and Lancaster County identified by the Comprehensive Plan: Stream Corridors, Wetlands, and Native Prairies.



NW 140th St.
 NW 112th St.
 NW 84th St.
 NW 56th St.
 NW 27th St.
 1st St.
 27th St.
 56th St.
 84th St.
 112th St.
 148th St.
 176th St.



Ashland Rd.
 Agnew Rd.
 Davey Rd.
 Raymond Rd.
 Waverly Rd.
 McKelvie Rd.
 Fletcher Av.
 Adams St.
 "O" St.
 Van Dorn St.
 Old Cheney St.
 Yankee Hill Rd.
 Saltillo Rd.
 Wittstruck Rd.
 Martell Rd.
 Stagecoach Rd.
 Olive Creek Rd.
 Pella Rd.

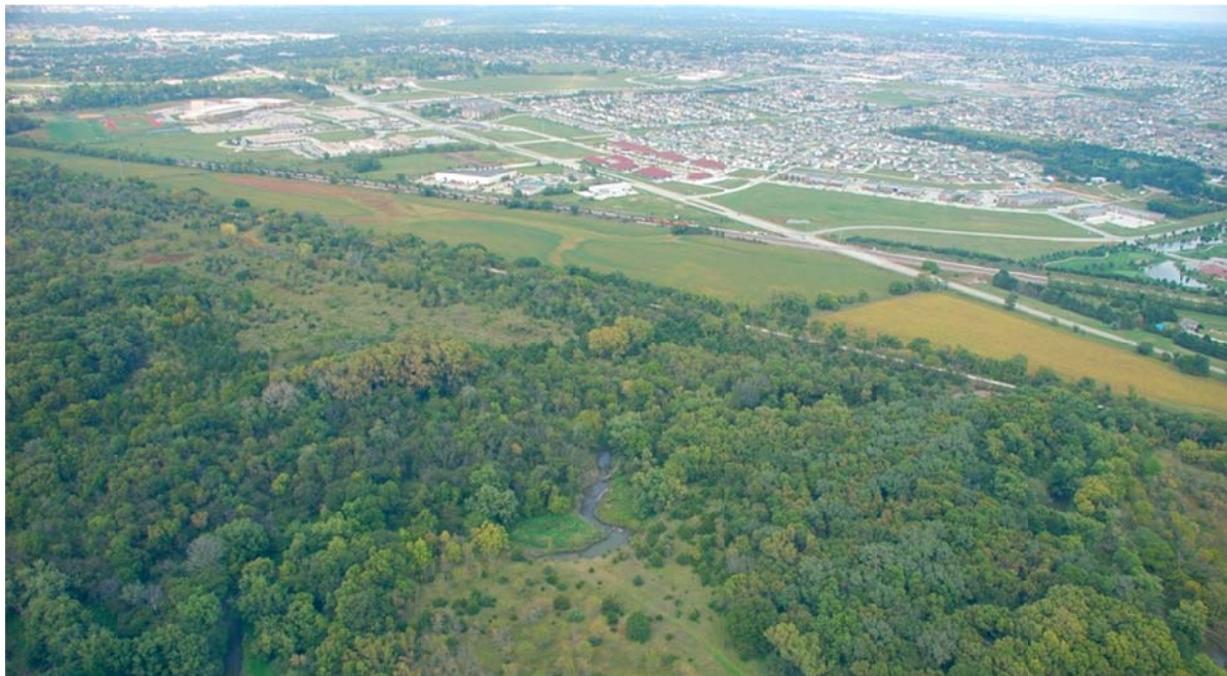
Legend

- Prairie Corridor
- Salt Valley Greenway
- Connecting Corridor



Map ES-1 Salt Valley Greenway and Connecting Corridors

SALT VALLEY GREENWAY



Lancaster County lies almost entirely within the Salt Valley drainage basin, a 1,621 square-mile watershed drained by Salt Creek and numerous tributaries that form the landscape of the county and are an important part of the fabric of the natural and cultural history of Lincoln and Lancaster County. The Salt Valley Greenway wraps around the City of Lincoln and is fed by tributaries that radiate out into the surrounding rolling hills. The effect is that of a large loop primarily made up of Salt Creek and Stevens Creek, with connecting green corridors linking urban and rural areas. The Salt Valley Greenway provides two primary functions; protection of natural, cultural and scenic resources and a link between these resources and people.

The Salt Valley Greenway includes an abundance of natural resources. Of all these resource categories, three are distilled and identified as core resources: saline and freshwater wetlands, native prairies and stream corridors. The strength of the diversity of the resource categories further solidifies the goals set forth by the greenway plan. This diversity is evident in numerous factors: varying topography, unique interior saline soils and saline groundwater at the surface, freshwater wetlands, grasslands and virgin prairie and distinctive species of both plants and animals. One of the overall goals of the greenway plan, and a guiding principle of LPlan 2040, is to preserve and consider these resources while considering policy and development decisions. The natural resources within the Salt Valley drainage basin along with research on riparian buffer width guided the refinement of the greenway as defined by the Comprehensive Plan 2040. Map ES-2 shows these resources and highlights where they are predominant within the greenway and its connecting corridors.



Connecting corridors follow tributary streams and tie natural resource features and public areas outside the main loop of Salt Creek and Stevens Creek back to the Salt Valley Greenway. LPlan 2040 identifies the following connecting green corridors:

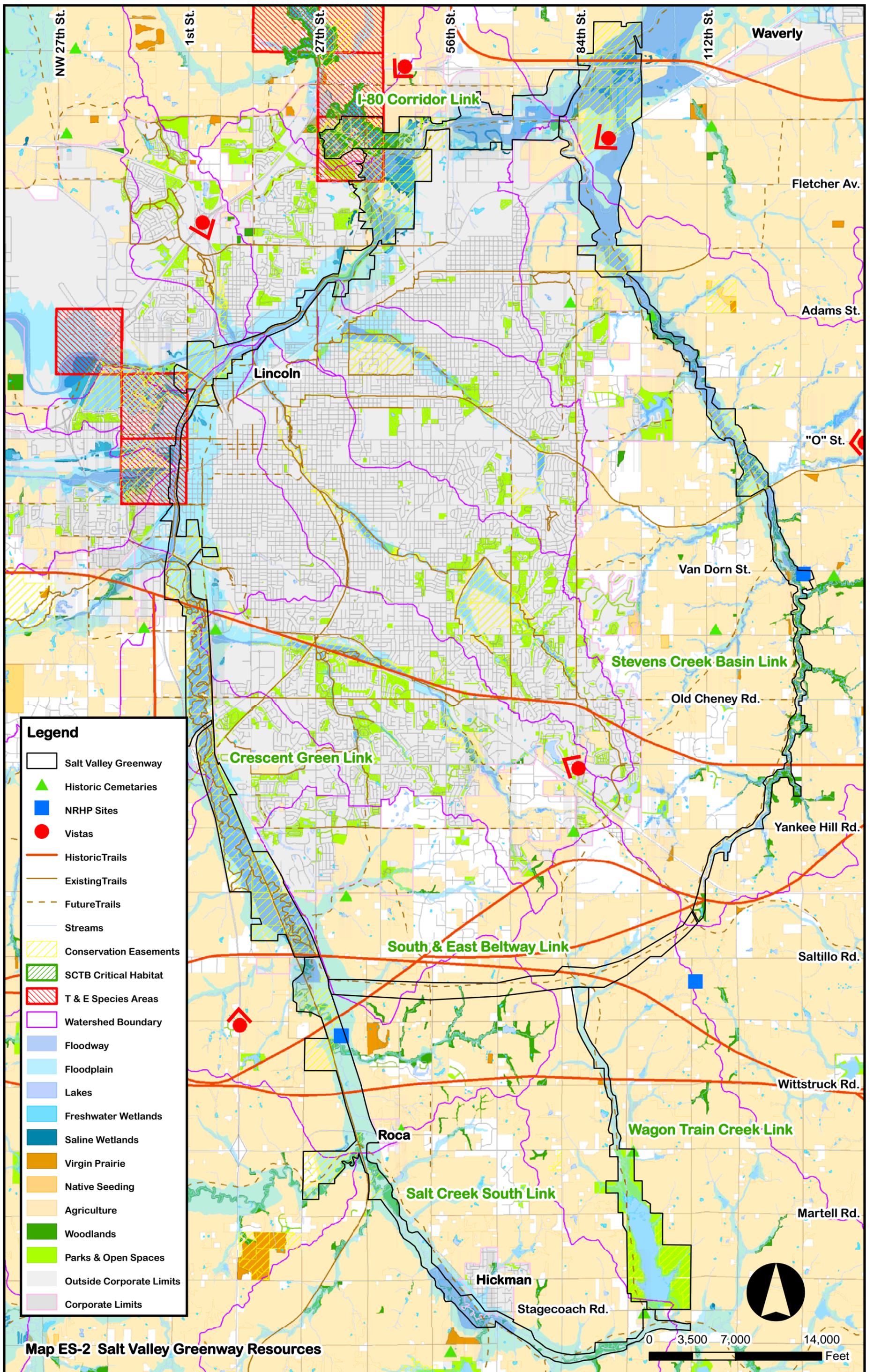
- **Prairie Corridor on Haines Branch corridor to Conestoga SRA and Spring Creek Prairie**
- **Cardwell Branch Corridor to Yankee Hill WMA**
- **Middle Creek Corridor to Pawnee SRA**
- **Salt Creek Corridor to Killdeer and Bluestem SRA**
- **Oak Creek Corridor to Branched Oak Lake**
- **Salt Creek Corridor East up the Little Salt Creek and Rock Creek Corridor.**

These key “corridors” to the Salt Valley Greenway will provide connectivity to existing natural resources including State Recreation Areas in the County.

This master plan refines the Salt Valley Greenway and connecting green corridors, broadly locating resources and opportunities. It also examines in greater detail the six “links” of the Greenway, which are segments of the Greenway loop, and evaluates the character, issues and challenges for each. These links are defined by separate basins and streams, developed or rural landscape and transportation corridors. The Salt Valley Greenway is comprised of six primary links:

- **Crescent Green**
- **I-80**
- **Stevens Creek**
- **South & East Beltway**
- **Wagon Train**
- **Salt Creek South**





PRAIRIE CORRIDOR ON HAINES BRANCH

Overview and Corridor Resources

Lincoln and Lancaster County are located in the Tallgrass Prairie Ecoregion (as defined by the Nebraska Natural Legacy Project), which was historically covered by native tallgrass prairie that served as a home to species such as buffalo, antelope, grassland birds, and many other smaller species of plants and animals. The historic prairie contributed significantly to the fertile soils that resulted in such productive farming resources for this region. **Tallgrass prairie is a remarkable part of our natural heritage and a core resource imperative to the community. The Prairie Corridor is an opportunity to celebrate our natural heritage and to build on the unique sense of place and strengths of Lincoln and Lancaster County.**

The Prairie Corridor also offers important economic opportunities: the Nebraska Natural Legacy Project notes that several of the state's top tourist attractions are outdoors in nature and provide conservation, education and recreation opportunities. The Prairie Corridor links Pioneers Park and Spring Creek Prairie, two of Lancaster County's most valuable resources for tallgrass prairie and environmental education. It represents an opportunity to connect the urban and rural areas of the county between Lincoln and the village of Denton.

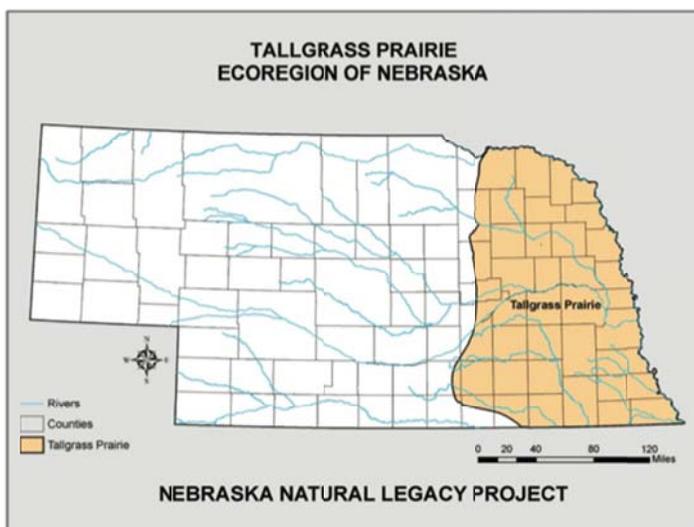


Image Source: Nebraska Game and Parks Commission

On the outskirts of west Lincoln along Haines Branch, the City of Lincoln owns and manages Pioneers Park. This park includes 1,130-acres and celebrates the prairie pioneers that settled in the county. On the west end of the park, over 500-acres of virgin and reseeded native prairie have been preserved at the Pioneers Park Nature Center. Established in 1963, this preserve offers over 8 miles of hiking trails and has had 246 species of birds identified that visit it and a variety of plants and wildlife available for viewing. Pioneers Park was listed on the National Register of Historic Places in 1993. Other resources in the park include a picnic area, recreational trails, winding roads and paths, and sculptural focal elements. This park is a significant natural resource asset to the City of Lincoln and Lancaster County.

About 6 miles upstream on Haines Branch from Pioneers Park, another expanse of virgin prairie exists at Spring Creek Prairie Audubon Center. Audubon established the prairie in 1998 on the former O'Brien ranch. The area includes 808-acres of tallgrass prairie with many acres of virgin prairie. This tallgrass nature preserve offers over three miles of walking trails, wetlands, wildflowers, and grasses. According to the Audubon Center, more than 210 bird species and 370 plant species have been recorded in addition to other wildlife. There are even 19th-century wagon ruts cut by pioneers that traversed the property.



Prairie Corridor Plan

The focus area plan for the Prairie Corridor on Haines Branch was developed by reviewing and supplementing a broad range of natural resources information with research and field work, using GIS data and input from experts and stakeholders. This plan includes a more detailed evaluation of the Prairie Corridor's



Spring Creek Prairie
Photo Credit: Nebraska Audubon

natural resources, opportunities for restoration and enhancement, trail and habitat connectivity, priorities for potential easements and acquisition, funding and land management strategies, and cost estimates. The Master Plan targets the Prairie Corridor on Haines Branch as a starting point for implementation to provide early protection and enhancement for this high priority area while serving as a model for implementation of the Salt Valley Greenway as a whole.

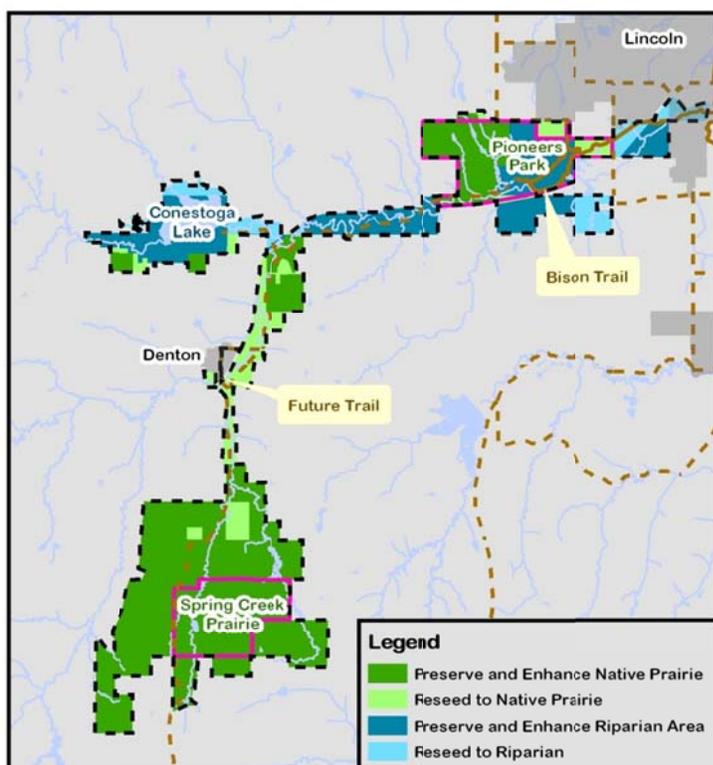


Figure ES-1: Prairie Corridor Strategy Areas

The Prairie Corridor boundary was defined by key features in the watershed (where Spring Creek drains into the Haines Branch): Haines Branch and Spring Creek stream centerlines, adjacent riparian areas, land ownership boundaries and conservation easements, virgin prairie areas and

In addition to expanding prairie, riparian and saline wetland habitat areas, the Prairie Corridor's vision seeks to build recreational and educational connections, and promote the enhancement and preservation of unique tallgrass prairie. While tallgrass prairie will be the primary feature of the corridor, it will be part of a collection of natural, open space and recreational land uses that will include riparian corridors, floodplains, woodlands, saline and freshwater wetlands, wildlife habitats, lowland and upland areas, trails and viewsheds. An overall conceptual approach to the Prairie Corridor is shown on Figure ES-1.

Spatial Analysis for Prairie Corridor Plan

The Prairie Corridor boundary was defined by key features in the watershed (where Spring Creek



wetlands. A number of the natural resources described above serve as a form of wildlife habitat. To further refine the corridor boundary and assist land managers in strategizing future natural resource preservation and enhancement techniques, spatial data analysis methods were developed. The results of the analysis comprise one tool that should be used together with other information in prioritizing and decision-making for the prairie corridor.

The goal of this analysis was to evaluate the natural resources in the Haines Branch Watershed and prioritize parcels based on existing habitat diversity and connectivity. Each parcel’s level of habitat diversity and connectivity was ranked 1 through 4, with 1 being the highest and 4 the lowest of each category. The detailed resources inventory of the Prairie Corridor is shown on Map ES-3.

For habitat diversity, natural resources such as virgin prairie, native prairie seeded areas, pasture, woodlands, saline and freshwater wetlands, and riparian vegetation were considered. Additionally, land use types were analyzed and categories include farmsteads, acreages, agricultural lands and urban development. These resources were prioritized for diversity of riparian and prairie areas with an emphasis on virgin prairie and saline wetlands (i.e. given a priority ranking of 1).

Habitat connectivity of riparian and prairie areas was evaluated for parcels based on management goals using two criteria. First, spatial relationships to the Haines Branch and Spring Creek stream centerlines were considered to evaluate an individual parcel. Second, adjacent parcels with existing prairie and riparian habitat, public ownership and easements were accounted for to place emphasis on existing protected parcels.

Through a matrix approach, the values assigned to habitat diversity and connectivity can be combined to assign an overall priority for each parcel. Through the matrix shown in Table ES-1, these two metrics were combined to determine the parcel priority rank. Parcel priority was ranked 1 through 5, with 1 being key parcels for acquisition and 5 being not considered for habitat in the Prairie Corridor.

TABLE ES-1: Parcel Priority Matrix

Habitat Connectivity		Habitat Diversity			
		Highest	→	Lowest	
		1	2	3	4
Highest	1	1	1	1	2
	2	1	2	3	4
↓	3	2	3	4	5
Lowest	4	3	4	5	5

The priority parcels were then flagged for different land management strategies based on existing habitat type, soil type related to re-establishment of native prairie, public ownership, conservation easements and proximity to key resources such as virgin prairie and saline wetlands. The breakdown of the different priority areas and land management strategies are shown in Table ES-2. The results of this matrix method throughout the Prairie Corridor will serve as a valuable tool for resource managers.



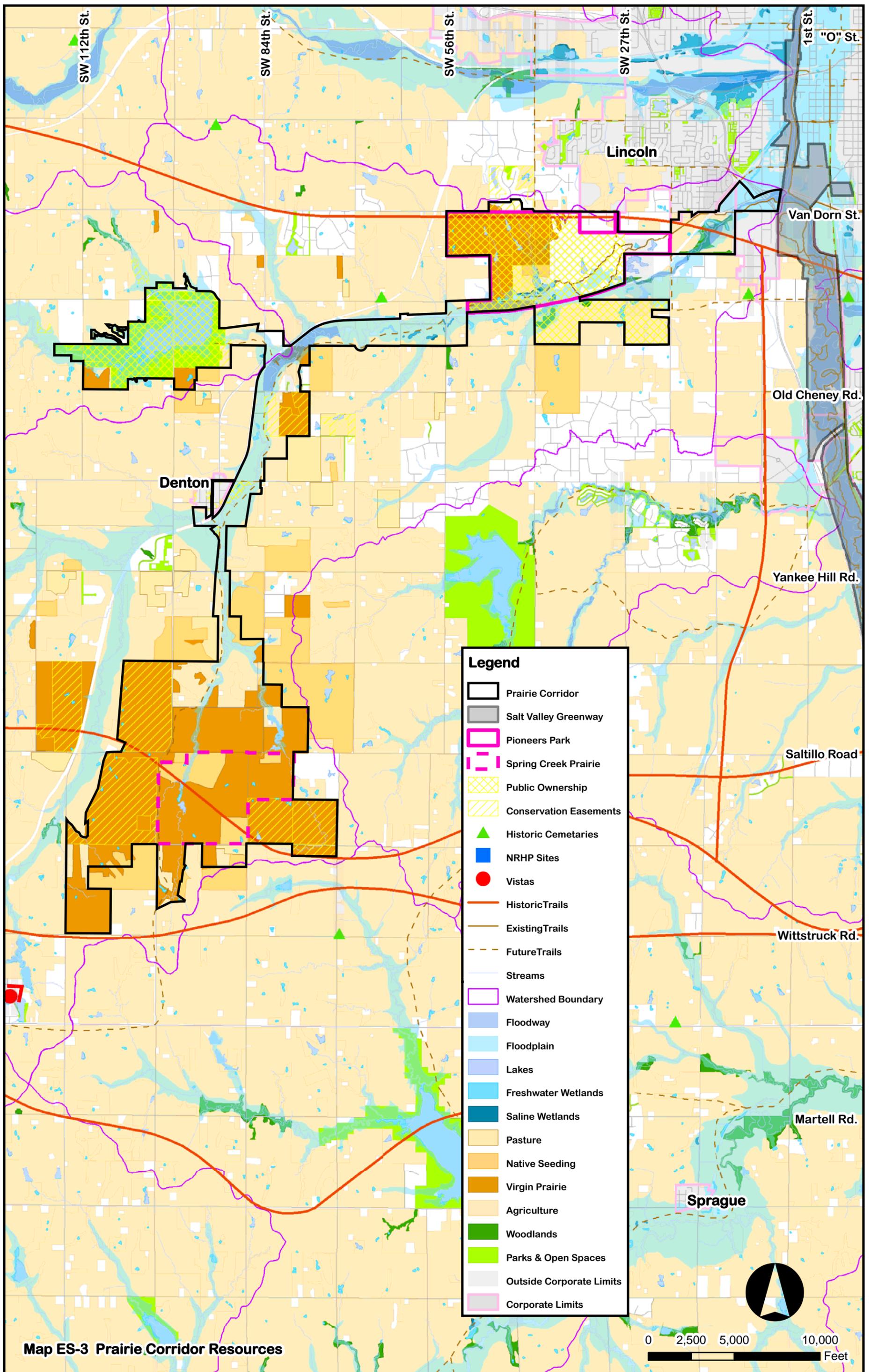


TABLE ES-2: Priority Areas and Land Management Strategies (acres)

Strategy	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Total
Preserve and Enhance Virgin Prairie	3,381	37	-	-	-	3,418
Enhance Existing Native Seeding	257	29	-	-	-	286
Reseed to Native Prairie	1,048	403	160	43	14	1,668
Preserve and Enhance Saline Wetlands	32	-	-	-	-	32
Enhance Existing Riparian Areas	354	778	109	-	-	1,242
Reseed to Riparian Area	-	87	316	63	8	474
Totals	5,072	1,333	585	106	22	7,119
Public Ownership						4,548
Private Ownership						2,571

Note: Public Ownership Includes Acres under Conservation Easement and Public Lands. Total Prairie Corridor Area is 7,310ac, of which 191ac are Road and Railroad Right-Of-Way.

A Functioning Prairie System

The Minnesota Prairie Conservation Plan describes eight attributes of a functional prairie system. The Prairie Corridor contains large areas of native prairie on both ends but also contains unique saline wetland habitat in its middle as well as riparian and freshwater wetland habitat. As a whole unit, the Prairie Corridor fulfills all eight attributes and is anticipated to fulfill a ninth attribute by exhibiting ecosystem stability, adaptability, and resilience to environmental change over the long term.

Species Reliance on the Prairie Corridor

The Prairie Corridor has the opportunity to maintain and enhance ecological integrity, biological diversity, and high quality water resources. Spring Creek Prairie boasts 216 bird species, 30 mammal species, 53 butterfly species and more than 360 plant species. This constitutes a high diversity system. As shown above in Table ES-2, there are approximately 7,310-acres within the Prairie Corridor and approximately 3,700-acres are tallgrass prairie. Based on the American Bird Conservancy’s “Partners in Flight Bird Conservation Plan for the Dissected Till Plains” this scale of native prairie habitat supports a core area for various species that have struggled for survival due to habitat fragmentation. Particularly, the scale of the Prairie Corridor begins to approach the overall management area goals to support the greater prairie chicken, short-eared owl and northern harrier bird species. These species rely on large, open, treeless grasslands. Numerous other species rely on the prairie corridor for habitat on the medium and small habitat dependence scales. In addition to prairie species, saline wetlands in the corridor provide unique habitat that supports a variety of plant and insect species.

Salt Valley Greenway and Prairie Corridor Master Plan Implementation

The following table (Table ES-3) presents planning level costs associated with various techniques that could likely be implemented within the Prairie Corridor. Land acquisition cost estimates are based on recent (April-June 2012) Lancaster County agricultural property sales. Conservation easement cost estimates are based on research that indicates easement costs are



in the range of 50-65 percent of that of acquisition. Trail development, wetland restoration and riparian zone restoration costs are based on recent projects in Lincoln and Lancaster County (projects completed for Lincoln Parks and Recreation and Lower Platte South NRD from 2008-2012) and include professional engineering design and construction costs. Acquisition costs are not included in the restoration/enhancement or development techniques described below.

TABLE ES-3: Planning Level Costs

Planning Level Cost Table	
Technique	Estimated Cost Range
Land Acquisition: Fee Simple	\$3,800 - \$4,500/acre
Conservation Easement on Existing Farmland: Permanent	\$2,400 - \$3,000/acre
Conservation Easement on Existing Grassland or Wetland	\$1,200 - \$2,000/acre
Reseeding to Native Prairie (includes site prep and establishment)	\$1,000 - \$3,000/acre
Prairie Management: Prescribed Burning	\$20 - \$120/acre
Wetland Restoration/Enhancement	\$5,000 - \$20,000/acre
Riparian Zone Restoration/Enhancement	\$60 - \$100/linear foot
Trail Development: Crushed Limestone	\$35 - \$40/linear foot
Trail Development: Concrete	\$75 - \$125/linear foot

Greenway Funding Strategies

There are a number of tools available to aid in the preservation and protection of land, both publically and privately held. There are cases (e.g. when public access is desired or when a property has high priority natural resources) when acquisition is the most appropriate mechanism to achieve the desired goal. General land preservation techniques and programs that are consistently used in greenway planning and that can be used for the Prairie Corridor, and larger Salt Valley Greenway are summarized and listed below.

- Fee Simple Acquisition
- Donation
- Right of First Refusal/Option
- Life Estate
- Conservation Easement
- Public Access Easement
- Transfer of Development Rights

Organizational Structure

An important consideration for the Salt Valley Greenway and the Prairie Corridor on Haines Branch will be the formation of a public-private partnership to realize the goals of this plan. It is critical to the success of this project that the full responsibility for implementation not fall on any one agency or private organization. On the contrary, a coalition should be formed that would work cooperatively to bring a range of strengths and resources to this project. By focusing on the Prairie Corridor as the first priority, the corridor will receive early protection and enhancement while serving as a model for implementation of the Salt Valley Greenway as a whole.

The City of Lincoln should be the lead agency for the initiation and early implementation of this plan, working cooperatively to develop and implement a public-private partnership. The best approach will be one that establishes a core coalition of partners to implement the overall vision



of the Salt Valley Greenway. Potential partners in this central group could include the City of Lincoln, the Lincoln Parks Foundation, Lancaster County, and the Lower Platte South Natural Resource District, but may include others as appropriate.

This core coalition should seek out additional partners to implement the various components of the Salt Valley Greenway, beginning with the Prairie Corridor on Haines Branch. It is envisioned that the partnership described above will come together with the Spring Creek Prairie Audubon Center, the Village of Denton and other potential partners for the application of an initial 3-year grant to the Nebraska Environmental Trust. The next step would be to formalize the partnership via an agreement to implement this Master Plan and any supplemental planning documents.

While the overall representation from varied groups will be essential to the planning process, a primary leadership role is highly recommended. A coordinator should oversee the project details and work with the partnership to promote and coordinate the plan, conduct public outreach and education and participate in and promote fundraising activities for the Prairie Corridor and Salt Valley Greenway projects.



PART I: SALT VALLEY GREENWAY

OVERVIEW AND CONTEXT

Greenways are about connections: connections between people and the land, between natural settings, open spaces, public parks, historic places, and between preservation and the human experience. Greenways vary in function, condition and definition, but overall a greenway will typically protect natural, cultural and scenic resources. In *Greenways for America*, Charles Little describes a greenway as follows:

A greenway is a linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, scenic road, or other route. It is any natural or landscaped course for pedestrian or bicycle passage. An open-space connector linking parks, nature reserves, cultural features, or historic sites with each other and with populated areas. Locally, certain strip or linear parks designated as parkway or greenbelt.

Greenways: the Beginning of an International Movement defines them this way:

Greenways are networks of land that are planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable land use.

Whether a greenway is more urban or rural, more passive recreation than active, more historical than developed, more wildlife than human, etc. it is apparent that greenways serve many purposes. Greenways help to build a “sense of place” for a community, and certain greenways will have a different character than others. Generally, greenways enhance the quality of life in our communities, promote conservation of the natural environment and instill a sense of connectivity with nature. These benefits are important particularly in



The Helen Boosalis Trail Corridor between 40th and 48th streets



the context of an urbanized community. It is practical to consider greenway benefits from two perspectives: the natural resource benefits and the human or community benefits. Natural resource benefits of greenways can be seen at local, regional and even global levels. The connectivity of natural elements and the role they play in sustainability can also be realized in greenway planning. Greenways support many ecological functions simply because they keep areas clear of most development, providing habitat for plants and animals (Hellmund and Smith).

Greenways provide active and passive recreational opportunities. Trail systems have long been associated with greenways, providing increased opportunities for safe pedestrian movement (walking, jogging, bicycling, etc.). Trails can also provide links from urban areas to more rural recreation areas (e.g. wildlife management areas, lakes, open spaces, etc.). These trails provide healthy recreational opportunities thus improving quality of life for communities.

Historical and cultural resources are key elements in the establishment of the heritage of a community. These resources can be preserved and highlighted with greenway planning. Trails that are associated with cultural resources or provide a linkage to a known site or area may include informative kiosks, special signage generating a lively sense of pride in a community.

Greenway Case Studies

An excellent tool for framing the key elements of the master plan is a review of greenway plans prepared for other communities. While every community is unique with regards to natural resources, assets, constraints and other issues, identifying and understanding similar greenway planning approaches can be a useful exercise. A select sampling of case study review is provided in Appendix A of this Master Plan.

Greenway Planning for Lincoln-Lancaster County

Elements of greenway planning for the City of Lincoln can be traced back to 1961; where a proposal for a linear park was included in the City's Comprehensive plan. The "Crescent Green" name was given to the project in 1964 when Professor Dale Gibbs used it as design problem for his undergraduate students in architecture (Clark & Enersen, Hamersky, Schlaebitz, Burroughs & Thomsen). Crescent Green was envisioned to extend along Salt Creek, providing a continuous greenway and open space corridor along the west and north part of Lincoln. The Crescent Green project identified various important elements such as bike trails, open spaces, playfields, and establishment and maintenance/enhancement of wetlands and forests. In 1966 the City (with Lancaster County and the Salt Valley Watershed District) purchased what is now Wilderness Park. A master plan for Wilderness Park was completed in 1972 by Clark & Enersen, Hamersky, Schlaebitz, Burroughs and Thomsen, Rand and Harter. In 1982, the City of Lincoln and the Lower Platte South Natural Resources District (the successor to the Salt Valley Watershed District) entered into an agreement setting out a framework and responsibilities for Crescent Green Park, with an update to the agreement in 1986.

In 2001 the City of Lincoln-Lancaster County Planning Department in conjunction with the Parks and Recreation Department and Lower Platte South Natural Resources District developed the *Greenprint Challenge*. The Greenprint Challenge was designed to provide the City-County with an approach for sound development providing a county-wide snapshot of the resources of Lancaster County for inclusion in the 2025 Comprehensive Plan. The Greenprint Challenge



documents existing environmental conditions in the City and County and it begins to define how the community should draw upon our natural and cultural resources in future planning efforts. It is a valuable resource that has been carried forward into subsequent Comprehensive Plan updates.

In the fall 2011, Lincoln City Council and Lancaster County Board adopted the 2040 Comprehensive Plan, called “LPlan 2040.” Chapter 3 of LPlan 2040 includes an outline of the guiding principles for environmental resources in Lincoln-Lancaster County. LPlan 2040 notes the unique opportunity the geography of Lancaster County presents for creating an overall greenway and associated linkages.

The vision for the Salt Valley Greenway is a ribbon of open space and greenway links within the Salt Valley drainage basin in Lincoln and Lancaster County. Expanding and protecting the unique natural resources in the region while providing trail, recreational and educational connections are the foundations to the Salt Valley Greenway. **The Prairie Corridor on Haines Branch is an important connecting corridor that was emphasized in LPlan 2040. This key corridor will be the starting point for addressing project implementation and will serve as a model for future implementation of the Salt Valley Greenway as a whole.**

This Master Plan represents that first step in implementation, providing a concept plan for the Salt Valley Greenway and a detailed inventory and plan for the Prairie Corridor. Together, the Greenway and Prairie Corridor embody the three core resource imperatives for Lincoln and Lancaster County identified by the Comprehensive Plan: Stream Corridors, Wetlands, and Native Prairies. The Salt Valley Greenway provides two primary functions; protection of natural, cultural and scenic resources and a link between these resources and people. With much of the Crescent Green corridor well established, the master plan will aid in implementation of additional phases of Crescent Green and the additional links.

Lancaster County lies almost entirely within the Salt Valley drainage basin, a 1,621 square-mile watershed drained by Salt Creek (see Figure 1-1). The numerous tributaries that form the landscape of the county are an important part of the fabric of the natural and cultural history of Lincoln and Lancaster County. The Salt Valley Greenway wraps

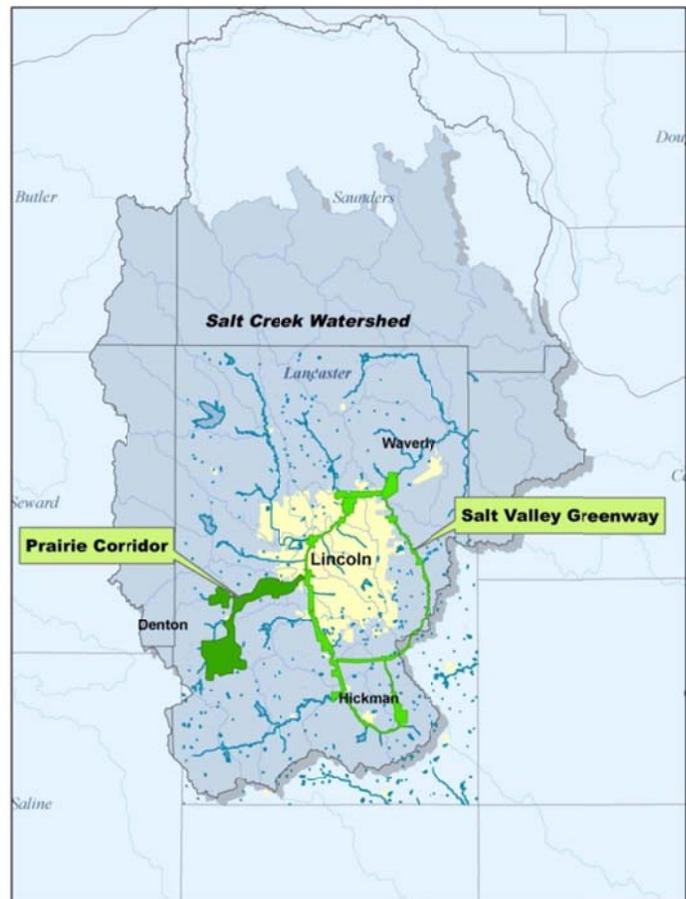


Figure 1-1: Salt Creek Watershed Map

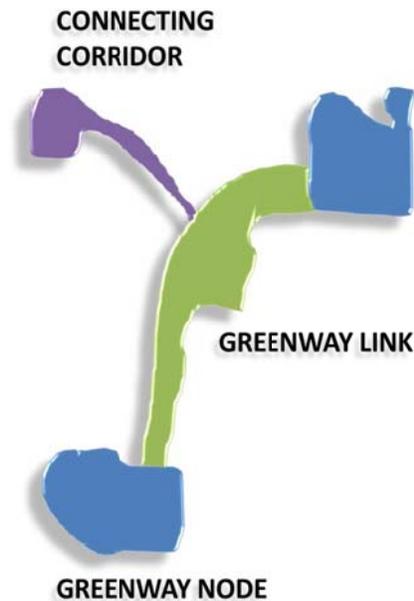


around the City of Lincoln and is fed by tributaries that radiate out into the surrounding rolling hills.

The effect is that of a large loop primarily made up of Salt Creek and Stevens Creek, with connecting green corridors linking urban and rural areas.

The Salt Valley drainage basin's floodplain boundary (primarily made up of Salt Creek and Stevens Creek) essentially wraps around the City of Lincoln. This large loop, while anchored in the streams, wetlands and floodplains of Salt Creek and Stevens Creek, has been defined by many ecological factors. In addition to the hydrologic factors, other ecological factors include existing physiography, soils and slopes, woodlands, grasslands, wildlife and wildlife habitat. The location of the Salt Valley Greenway (shown on Map 1-1) is generally described as traversing along Salt Creek beginning on the northeast outskirts of Lincoln, proceeding upstream along Salt Creek on the west side of Lincoln (including Wilderness Park), following the Salt Creek floodplain south of Wilderness Park connecting with Roca and continuing south to Hickman. The greenway proceeds east from Hickman to Wagon Train Lake and then follows Salt Creek north to its headwaters near the planned South Beltway. The greenway follows the beltway alignments east until turning north and following Stevens Creek downstream to the confluence with Salt Creek on the northeast corner of Lincoln's city limits.

There are a number of boundary terms that are used to describe the pieces of the broader greenway within this plan. These are links, connecting corridors and nodes (see Figure 1-2).



Links – These areas are the segments that make up the total greenway. Ranging in length from 3.5 miles long to 16 miles long within the Salt Valley Greenway, these links are split up by separate basins and streams, developed or rural landscape and transportation corridors.

Connecting Corridors – The connecting corridors tie natural resource features and public areas outside the boundary of the greenway back to the greenway itself. The connecting corridors follow tributary streams that connect with Salt Creek.

Nodes – These greenway planning components highlight natural resource features that are offset from the connecting corridor or link. An example of a node is a native prairie area. A node can exist at the end of a connecting corridor but could also be adjacent to a portion of the connecting corridor or link.

Figure 1-2: Greenway terminology



LPlan 2040 notes the importance of the Salt Valley Greenway for recreation, transportation, resource preservation, education and economic development. It is anticipated that this opportunity to achieve cross-benefit from multiple resources within the greenway will solidify a sense of community and enhance regional tourism.

Connecting corridors follow tributary streams and tie natural resource features and public areas outside the main loop of Salt Creek and Stevens Creek back to the Salt Valley Greenway. LPlan 2040 identifies the following connecting green corridors:

- Prairie Corridor on Haines Branch corridor to Conestoga SRA and Spring Creek Prairie
- Cardwell Branch Corridor to Yankee Hill WMA
- Middle Creek Corridor to Pawnee SRA; Salt Creek Corridor to Killdeer and Bluestem SRA
- Oak Creek Corridor to Branched Oak Lake
- Salt Creek Corridor East up the Little Salt Creek and Rock Creek Corridor.

These key “corridors” to the Salt Valley Greenway will provide connectivity to existing natural resources including State Recreation Areas in the County (see Map 1-1).



Yankee Hill Reservoir Wildlife Management Area



GREENWAY RESOURCES

The Salt Valley Greenway includes an abundance of those resources described in the 2001 Greenprint Challenge document for Lincoln and Lancaster County. The Greenprint Challenge identifies a number of key natural resource categories. Of these resource categories, three are distilled and identified as core resources “that uniquely contribute to the natural resource heritage of the region and whose safeguarding for future generations is indispensable” (Greenprint Challenge 2001). The core imperatives include saline and freshwater wetlands, native prairies and stream corridors. The strength of the diversity of the resource categories further anchors the goals set forth by the greenway plan.

This diversity is evident in numerous factors: varying topography, unique interior saline soils and saline groundwater at the surface, freshwater wetlands, grasslands and virgin prairie and distinctive species of both plants and animals. One of the overall goals of the greenway plan, and a guiding principle of LPlan 2040, is to preserve and consider these resources while considering policy and development decisions. The natural resources within the Salt Valley drainage basin along with research on riparian buffer width (see Appendix B) guided the greenway refinement process. A more detailed description of the greenway refinement process can be found in Appendix B.

Figure 1-3 shows these resources and highlights where they are predominant within the greenway and its connecting corridors. Summaries of these resources are listed below with further descriptions also provided in Appendix B.

Native Prairies - The tallgrass prairie of eastern Nebraska is one of the state’s most endangered ecosystems. In addition to plant species, prairies are home to a variety of bird, reptile, mammal and insect species. They also provide a valuable educational venue in that native prairie was the dominant pre-European settlement land type in the region, state and county.

Freshwater Wetlands - Freshwater wetlands exist throughout the county in low areas within the floodplain and also in isolated upland areas. Many of these upland wetlands are constructed impoundments for agricultural/rangeland use. Numerous freshwater wetlands are found throughout the greenway and connecting corridors.

Saline Wetlands - Eastern Nebraska’s saline wetlands are a unique and endangered ecosystem within the county - only about 1,400 acres remain today. The high salinity has created wetlands that are home to uniquely adapted plant species (such as the state endangered saltwort) and a federally and state endangered insect, the Salt Creek tiger beetle.

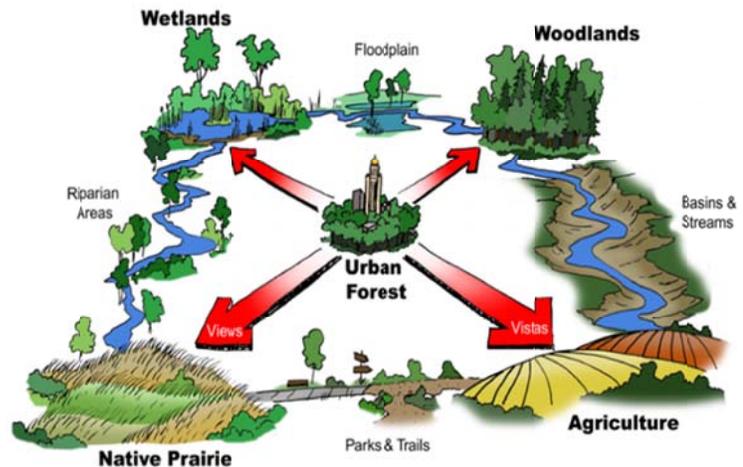


Figure 1-3: Greenway Resources
Source - City of Lincoln Greenprint Challenge



Threatened & Endangered Species - A number of threatened and endangered species reside within the greenway and connecting corridors. Unique species within the greenway highlight the importance of conservation of habitat and further accentuate the value of these ecosystems.

Basins & Streams - The greenway boundary lies entirely within the broader Salt Creek basin with the sub-basins of Little Salt Creek, Haines Branch, Oak Creek, and Stevens Creek. Streams and creeks drain these basins and shape the natural topography of the greenway. These streams provide direction to the overall shape of the greenway corridor.

Floodplains & Riparian Areas - Floodplain areas store and convey storm water through the watershed. The alluvial soils that formed in these low-lying areas are highly productive for native species and crop production. The diversity and quality of these alluvial soils and hydrology constitute the core value of floodplain habitat.

Parks, Trails & Other Recreation Areas - There are over 6,000 acres of parks and public lands and over 128 miles of trails within the City of Lincoln and Lancaster County. There are also numerous public recreation areas. These resources are critical to greenway planning.

Urban Forest - Urban forest areas exist throughout the city limits and consist of some native stand areas as well as many planted acres. Urban parks contain stands of trees and there are many acres of forest along lowlands in riparian areas and floodplains. These urban forest areas provide valuable habitat to a variety of mammal species and nesting areas for migratory birds.

Woodlands - Scattered among stands of tallgrass prairie, native woodlands historically grew on steeply sloped areas in narrow floodplains along meandering streams dissecting the landscape. The native wooded areas of the county consisted of bur oak and hickory varieties. For the greenway, woodlands provide a significant buffer between land uses and habitat types.

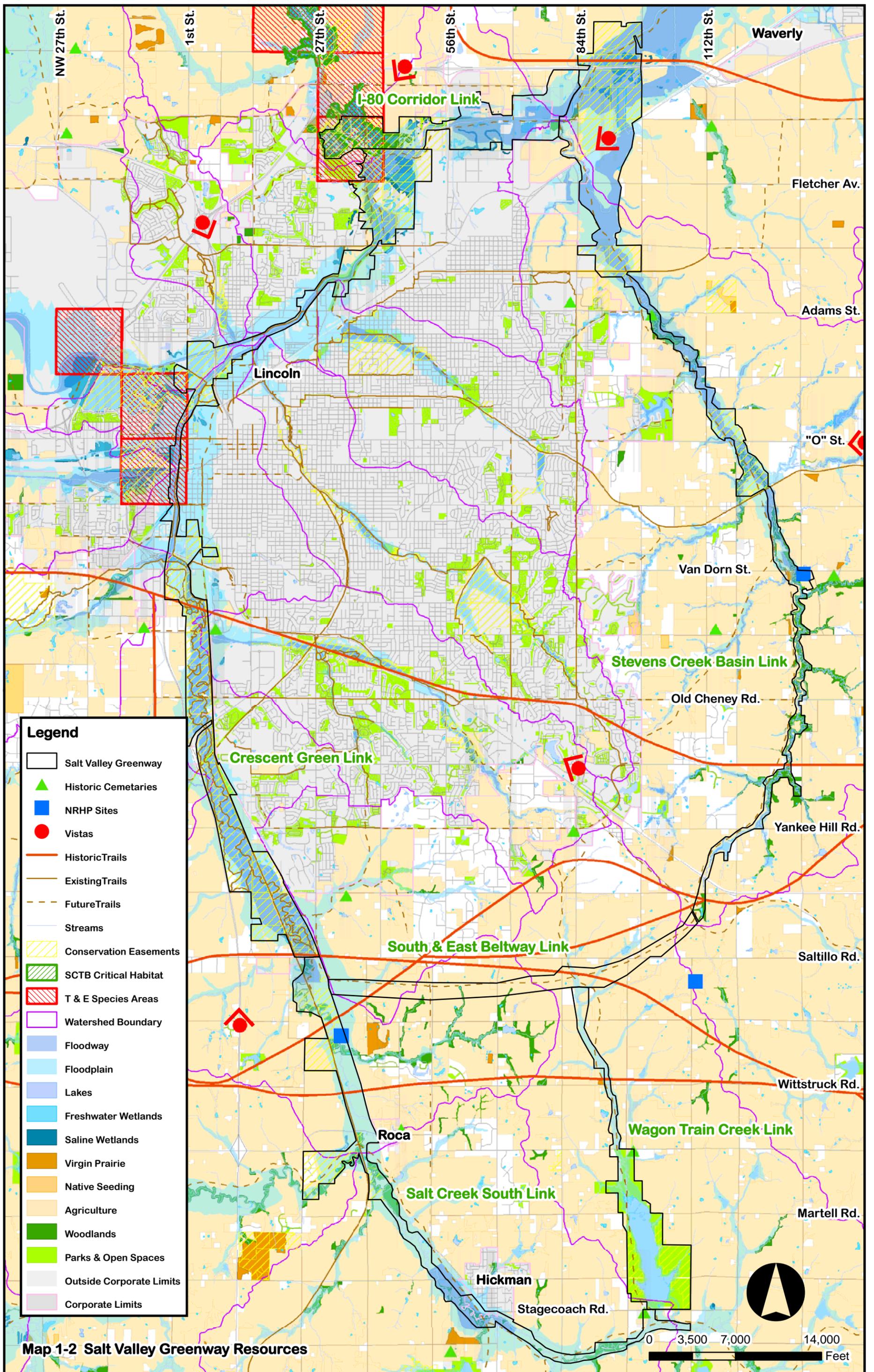
Agricultural Lands - Agriculture is a vital component of the county's economy. Soils developed over thousands of years by the breakdown of tallgrass prairie material and other native plants; this is the source of the county's high quality farmland.

Cultural & Historic Landscapes - The cultural and historical resources in the county provide a valuable educational element and help maintain Nebraska's heritage.

Views & Vistas - The greenway alignment largely follows floodplain and low-lying areas but some portions of the greenway links provide scenic vistas of the county. High points along basin ridgelines and within greenway links provide views over the rolling hills of Lancaster County.

The City of Lincoln compiled and provided the following comprehensive GIS geodatabase information as related to the Salt Valley Greenway: major basins, existing and future land use and trails, conservation easements, FEMA floodplain and floodway, grasslands, streams and lakes, National Wetland Inventory, saline wetlands, Lancaster County cadastral parcels, ownership boundaries, zoning districts, preliminary greenway and corridor boundaries and 2010 aerial photography. The GIS coverage information, including the resources highlighted above, was used to develop a refined greenway boundary and detailed resource inventory (see Map 1-2).





Map 1-2 Salt Valley Greenway Resources

0 3,500 7,000 14,000 Feet

SALT VALLEY GREENWAY LINKS

Links are the segments that comprise the primary greenway. They are split up by separate basins and streams, developed or rural landscape and transportation corridors. The Salt Valley Greenway is comprised of six primary links: Crescent Green, I-80, Stevens Creek, South & East Beltway, Wagon Train, and Salt Creek South. These links are further characterized and described below.



I-80 Link



Crescent Green Link



The Crescent Green link is approximately 15 miles long with a land area of about 6 square miles, with Wilderness Park occupying a large portion of the total corridor area. The link encompasses Salt Creek and is the most urban of the greenway links. It generally acts as the western border of the city following Salt Creek along the edge of Lincoln. The southern half of the link is occupied by Wilderness Park. North of Wilderness Park, the link includes the following individual confluences with Salt Creek: Haines Branch, Middle Creek, Oak Creek, Antelope Creek and Dead Mans Run. The confluence of Haines Branch and Salt Creek is located at the midpoint of the link and is an important connection to Pioneers Park and the Prairie Corridor. The existing Salt Creek Levee Trail follows the high bank of Salt Creek where the corridor is relatively narrow due to existing and future land use. Some of the key resources and nodes of the corridor include Wilderness Park, Salt Creek and the Salt Creek Levee Trail; Salt Creek flood storage areas, Oak Lake Park, Haymarket Park Stadium, Nebraska Innovation Campus, and existing conservation easements. Resources are shown on Map 1-3.

The potential challenges in this corridor include maintaining existing open space amid the urbanized setting, maintaining corridors for pedestrian use, working within the floodway and floodplain, and keeping the corridor contiguous to facilitate wildlife movement.

Priorities for the Crescent Green Link should include:

- Maintained master planning for Wilderness Park
- Development of future trails on the north end of the link
- Protection of Salt Creek, Oak Lake and wetland resources
- Promoting water quality features for the multiple confluences with Salt Creek
- Maintained parks and open spaces.



I-80 Corridor Link



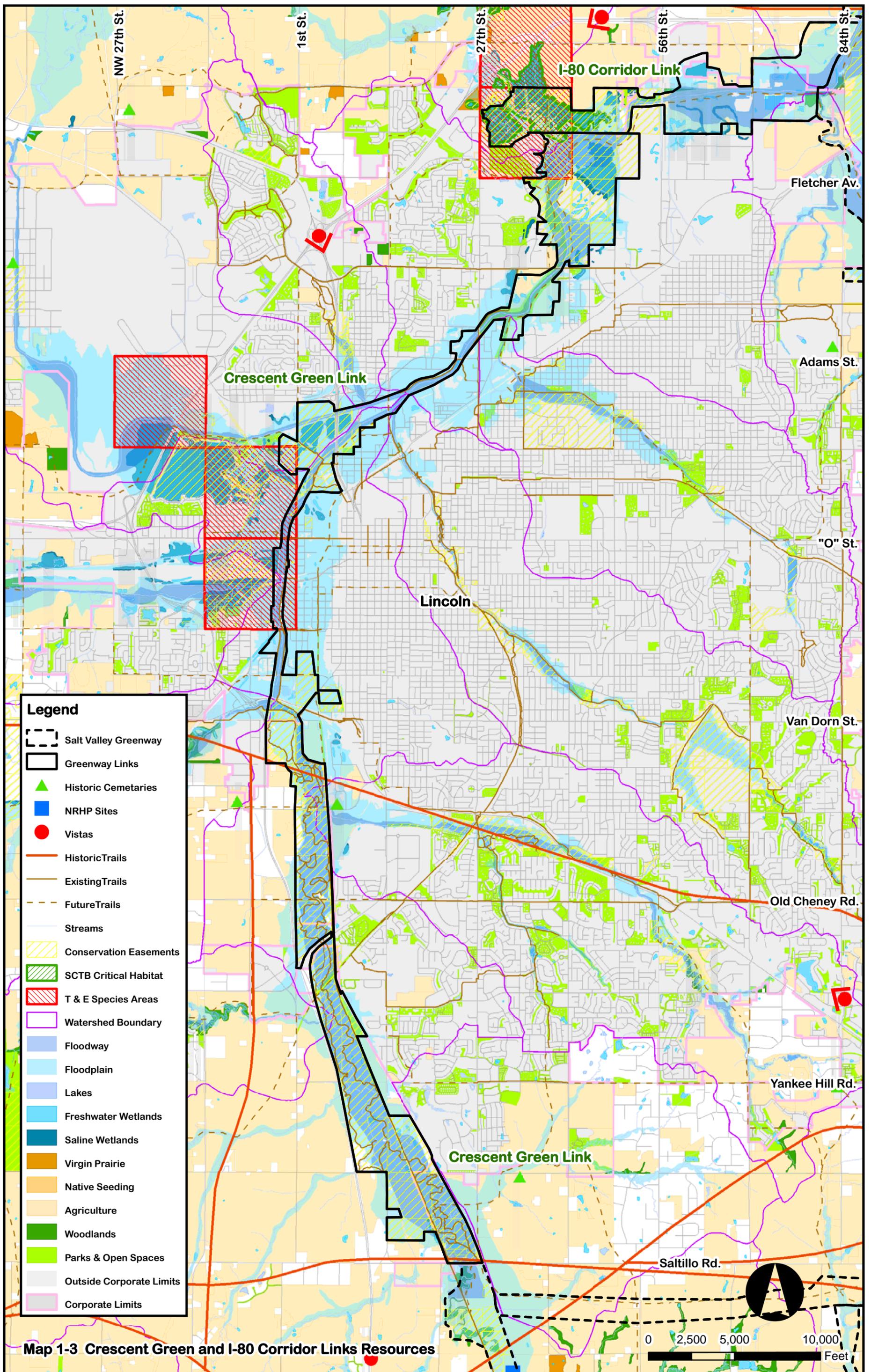
The I-80 corridor link is approximately 3.7 miles long with a land area of about 1.7 square miles. The corridor is dominated by low lying floodplains on the northern fringe of Lincoln. Interstate 80 is a major transportation corridor located north of this greenway link. Some of the key resources in this link include saline wetlands, restored saline and freshwater wetlands, freshwater wetlands, Salt Creek, Little Salt Creek and its confluence with Salt Creek, Salt Creek tiger beetle habitat, wildlife habitat and the Abbott Sports Complex. Wetland resources as well as an area of existing conservation easement are abundant within the link. Resources are shown on Map 1-3.

Urban growth is both a potential challenge and opportunity within this greenway link. The west end of the corridor is adjacent to residential and a mix of land uses but the existing conservation easements act as a buffer between the corridor and these developments. To the north of the corridor, there is an industrial zone that is just south of Interstate 80 near North 56th Street. There is also a residential development on the west end of the industrial zone north of Salt Creek and west of North 56th Street. The east end of the corridor link includes Abbott Sports Complex, the City of Lincoln Northeast Water Treatment Facility and private industry. The opportunities within this corridor include future trail links between the conservation easement areas and the developed land areas, and interpretive points for recreationists to learn about the unique critical habitat within a large portion of the conservation easement areas.

Priorities for the I-80 Corridor Link should include:

- Development of future trails, including educational and interpretive components, connecting to Crescent Green Link and Stevens Creek Corridor Link
- Protection of existing saline and freshwater wetlands and SCTB critical habitat
- Protection of Salt Creek and Little Salt Creek resources
- Maintained parks and open spaces.





Stevens Creek Basin Link



The Stevens Creek Basin Link is approximately 16 miles long with a land area of about 4 square miles. This corridor is dominated by agricultural land in floodplain areas adjacent to Stevens Creek. The headwaters of Stevens Creek are located at the south end of the link.

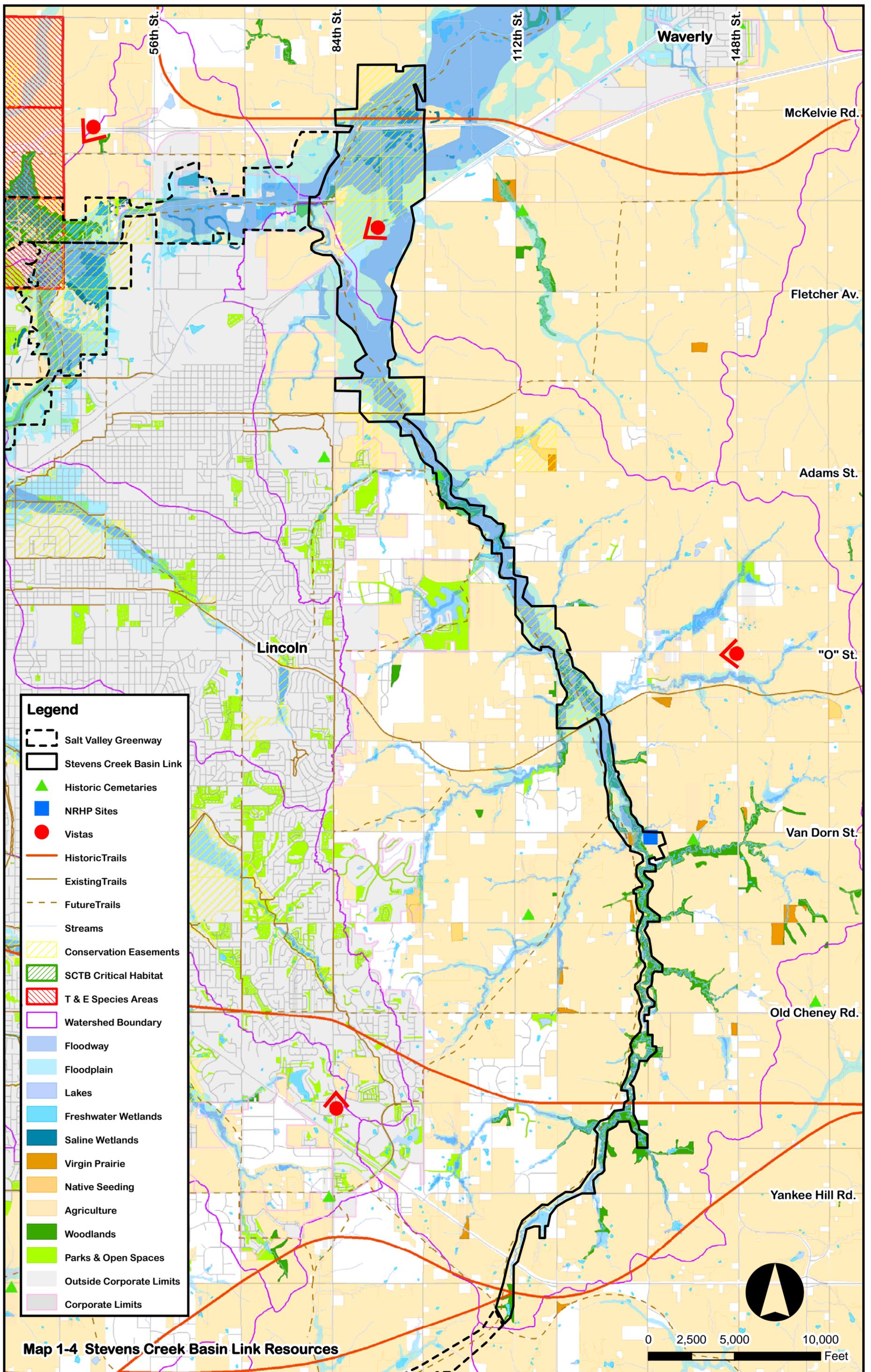
The Stevens Creek Basin Link includes a number of areas where elements come together to provide multiple benefits and opportunities to protect or enhance floodplain, natural resources, historical and cultural features and open space. For example, at approximately 130th and Van Dorn Street, the 240-acre Stevens Creek Stock Farm (listed on National Historic Register) enhances the historical and cultural resources of the link. Preservation of the farm also helps to maintain a connection to early settlers in the basin. Also at that approximate location, native woodland areas provide valuable riparian habitat for wildlife and migratory bird species. To highlight other historical resources in the link, interpretive signage could be added where two historic wagon trails cross the link.

Future urban development is both a potential challenge and opportunity for this link. The city is experiencing growth into the Stevens Creek basin. Maintaining open space as the watershed experiences urban growth will be important.

Priorities for the Stevens Creek Basin Link should include:

- Maintained master planning for Stevens Creek Watershed
- Development of future trails connecting with the Murdock and MoPac trails
- Protection of wildlife habitat corridors
- Development of future regional park
- Existing easements / future NRD easements





- Legend**
- Salt Valley Greenway
 - Stevens Creek Basin Link
 - ▲ Historic Cemeteries
 - NRHP Sites
 - Vistas
 - Historic Trails
 - Existing Trails
 - Future Trails
 - Streams
 - Conservation Easements
 - SCTB Critical Habitat
 - T & E Species Areas
 - Watershed Boundary
 - Floodway
 - Floodplain
 - Lakes
 - Freshwater Wetlands
 - Saline Wetlands
 - Virgin Prairie
 - Native Seeding
 - Agriculture
 - Woodlands
 - Parks & Open Spaces
 - Outside Corporate Limits
 - Corporate Limits

Map 1-4 Stevens Creek Basin Link Resources



South & East Beltway Link



The South & East Beltway Link is almost 6 miles long and occupies about 1.2 square miles. The link follows the future planned transportation beltway that will connect U.S. Highway 77 on the western part of the county around Lincoln and back north to Interstate 80. This link is dominated by agricultural land and follows a ridge line in the southern half of the county. Small tributaries cross the link in a few locations but overall the link is different than other links because it does not follow a major stream.

Key resources include agricultural land, minor view sheds based on the ridge line, wildlife habitat and a connection between the Salt Creek South Link, Wagon Trail Creek Link, Crescent Green Link and Stevens Creek Basin Link.

Urban development and the beltway project are both a challenge and opportunity in the South & East Beltway Link. Future trail development will be a critical element within the South & East Beltway Link. The timing of the beltway project is strategic for this greenway link and will require coordination as the beltway plan further develops.

Opportunities in this link include future trail development, creating habitat corridors and crossings for wildlife movement across the sub-basin divide. By protecting existing stands of trees and planting new trees, valuable stopover habitat for migratory will be maintained and created. Buffers should be considered downstream of storm drains to capture pollutants such as de-icing chemicals from the beltway pavement. Lastly, to highlight historical resources in the link, interpretive signage could be added where two historic wagon trails cross the link.



Wagon Train Creek Link



The Wagon Train Creek link encompasses about 2 square miles and is just over 5 miles in length. Wagon Train Lake State Recreation Area and its associated public land comprise a large portion of the land area in this link. The remaining land is predominantly agricultural land and floodplain.

A key resource of this link is Wagon Train Lake State Recreation Area. The dam is operated and maintained by the U.S. Army Corps of Engineers and provides flood storage for Salt Creek. The public land surrounding the lake provides good wildlife habitat. This corridor connects the other links to the very south edge of Lancaster County. The link also includes agricultural land and bird and wildlife habitat.

Opportunities in this link include the existing lake and surrounding open space, and a connection to the beltway link. Water quality improvement opportunities also exist within this link. Buffers would capture pollutant runoff from agricultural fields and minimize the concentrations of agricultural chemicals entering Wagon Train Lake. Trees could be planted within the link north of Wagon Train Lake to create a connecting corridor for wildlife movement and migratory bird stopover habitat. A number of forested areas exist north of Wagon Train Lake that could be expanded to improve wildlife movement back to the South & East Beltway link.

A tract of virgin prairie is located on private property near the crossing of Wittstruck Road just west of the greenway link. Wagon Train Creek Link has the opportunity for native prairie re-establishment that would enhance the open space on the southern half of the link around Wagon Train Lake. The north end of the link is upland habitat that would be suitable for a variety of native prairie plants.

Historical resources (historic trail crossings) in the link could be highlighted with interpretive signage.



Salt Creek South Link



The Salt Creek South link is 9.5 miles long in the southern edge of the county and includes about 2.7 square miles. The link borders both the villages of Hickman and Roca. The link is predominately agricultural land and floodplain.

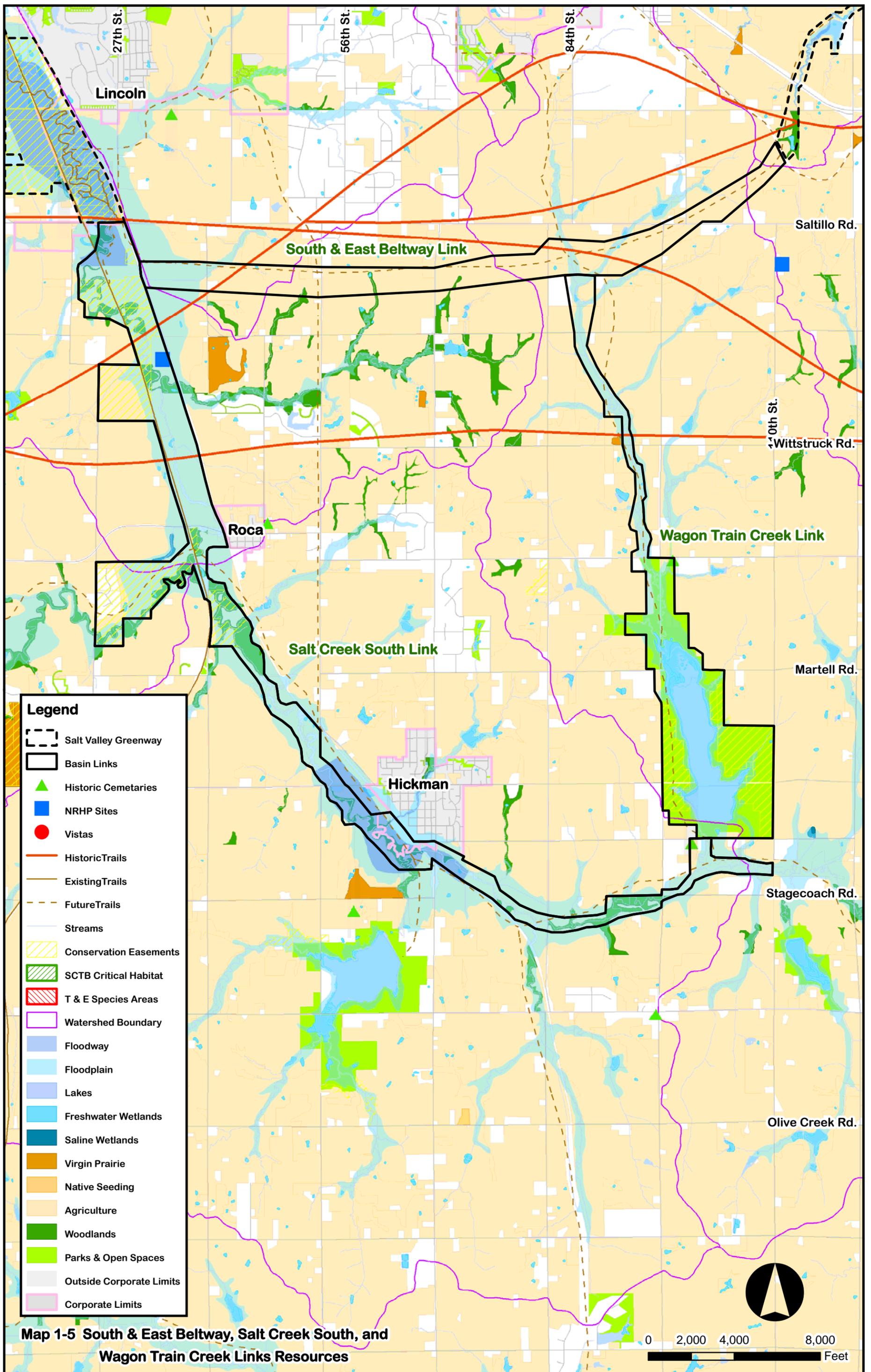
Key resources include the communities of Hickman and Roca, a few conservation easements, agricultural land and woodlands. The link follows Salt Creek and provides wildlife movement avenues and migratory bird stopover habitat in the southern portion of the county. Stagecoach Lake and Bluestem Lake provide valuable flood storage for large parts of the county downstream.

The link opportunities include connectivity to the communities of Hickman and Roca. These towns provide many transportation amenities along the link. The link connects these communities together and also with the greater county area. Other opportunities include links to the existing recreational facilities of Stagecoach Lake and Bluestem Lake.

The Homestead Trail is located within the north half of the link and a future trail is planned in the southern half of the link. Historic wagon trails cross the link in two locations. These crossings could be marked with interpretive signs to denote the historical significance of these trails.

A number of relatively large woodland areas exist within the link west and south of Roca. These woodlands provide valuable bird and wildlife habitat. The woodlands provide rookeries for bird species and wildlife cover. Woodland areas could be expanded north and south of Roca to connect woodland areas south of Hickman to the north with woodlands near Roca and up toward the southern end of Wilderness Park. The woodland expansion would create an enhanced wildlife corridor throughout the link.





Legend

- Salt Valley Greenway
- Basin Links
- Historic Cemeteries
- NRHP Sites
- Vistas
- Historic Trails
- Existing Trails
- Future Trails
- Streams
- Conservation Easements
- SCTB Critical Habitat
- T & E Species Areas
- Watershed Boundary
- Floodway
- Floodplain
- Lakes
- Freshwater Wetlands
- Saline Wetlands
- Virgin Prairie
- Native Seeding
- Agriculture
- Woodlands
- Parks & Open Spaces
- Outside Corporate Limits
- Corporate Limits

Map 1-5 South & East Beltway, Salt Creek South, and Wagon Train Creek Links Resources



PART II: PRAIRIE CORRIDOR ON HAINES BRANCH

PRAIRIE CORRIDOR OVERVIEW

The vision of the Prairie Corridor on Haines Branch is to establish a linking corridor between the two native prairie areas at Spring Creek Prairie and Pioneers Park. These are two of Lancaster County's most valuable resources in the areas of environmental education and preservation, together offering more than 2,670 acres of native and reseeded tallgrass prairie. See Figure 2-1.

The value of these prairie areas will be best maintained through protection and enhancement of the natural corridor between them. Spring Creek Prairie and Pioneers Park anchor both ends of the Prairie Corridor. Larger topographic, physiographic and hydrological forces shape the corridor between these prairie anchors and other natural resource features such as saline wetlands and riparian corridors form the middle section of the corridor. In the middle section of the corridor, prairie re-establishment is not as applicable as saline wetlands and/or riparian corridor enhancement. The resource diversity within this corridor further lends identity to the link as a vital component of the Salt Valley Greenway.

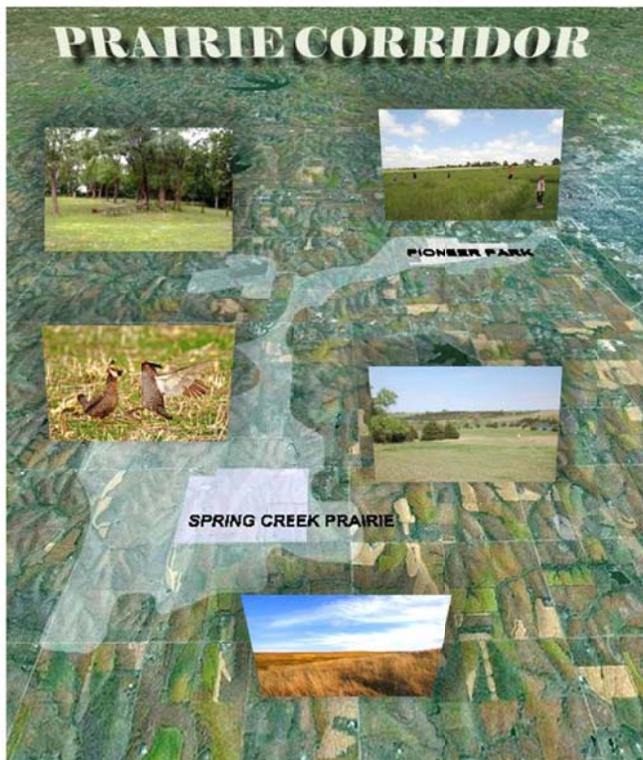


Figure 2-1: Prairie Corridor on Haines Branch

Lincoln and Lancaster County are located in the Tallgrass Prairie Ecoregion (Figure 2-2), which was historically covered by native tallgrass prairie that served as home to buffalo, antelope, grassland birds, and many other smaller species of plants and animals. Tallgrass prairie is a remarkable part of our natural heritage and a core resource imperative for the community. The Prairie Corridor is an opportunity to celebrate our natural heritage and to build on the unique sense of place and the strengths of Lincoln and Lancaster County. The historic tallgrass prairie in eastern Nebraska contributed significantly to the fertile soils that resulted in such productive farmground for this region.

The Prairie Corridor also offers important economic opportunities: the Nebraska Natural Legacy Project notes that several of the state's top tourist attractions are outdoors in nature and provide conservation, education and recreation opportunities. The corridor links Pioneers Park and Spring Creek Prairie, two of Lancaster County's most valuable resources for tallgrass



prairie and environmental education. It represents an opportunity to connect the urban and rural areas of the county through the village of Denton.

The focus area plan for the Prairie Corridor on Haines Branch was developed by reviewing and supplementing a broad range of natural resources information with research and field work, using GIS data and input from experts and stakeholders. The City of Lincoln compiled GIS coverage information for the following natural resources types: soils and soil properties; wetlands; floodplain, floodway and basins; threatened and endangered species; and native grasslands. Additional GIS coverage information related to the Prairie Corridor included existing and future trails; parcel/ownership maps; and conservation easement boundary maps.

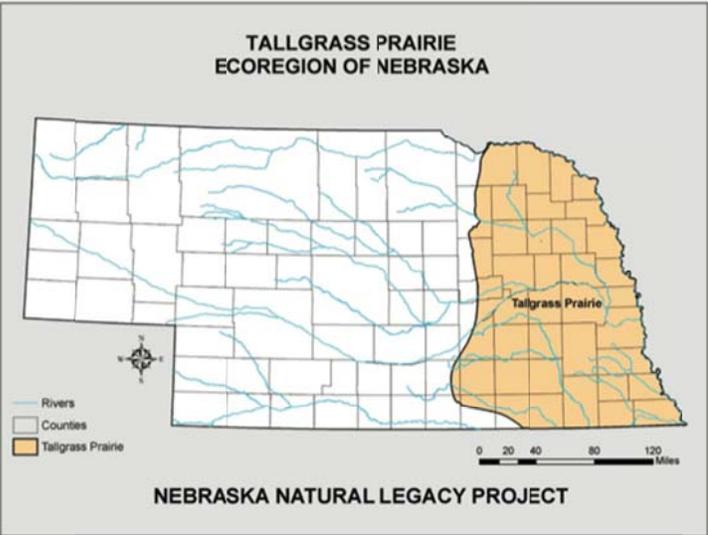


Figure 2-2: Tallgrass Prairie Ecoregion of Nebraska
Image Credit: Nebraska Game and Parks Commission

This plan includes a more detailed evaluation of the Prairie Corridor’s natural resources, opportunities for restoration and enhancement, trail and habitat connectivity, priorities for potential easements and acquisition, funding and land management strategies, and cost estimates. The Master Plan targets the Prairie Corridor on Haines Branch as a starting point for implementation to provide early protection and enhancement for this high priority area while serving as a model for implementation of the Salt Valley Greenway as a whole.

In addition to expanding prairie, riparian and saline wetland habitat areas, the Prairie Corridor’s vision seeks to build recreational and educational connections, and promote the enhancement and preservation of unique tallgrass prairie. While tallgrass prairie will be the primary feature of the corridor, it will be part of a collection of natural, open space and recreational land uses that will include riparian corridors, floodplains, woodlands, saline and freshwater wetlands, wildlife habitats, lowland and upland areas, trails and viewsheds.



PRAIRIE CORRIDOR INVENTORY

The following section provides descriptions of natural resource types within the Prairie Corridor on Haines Branch. The GIS coverage information was used to develop a detailed inventory of the Prairie Corridor (see Map 2-1).



Spring Creek Prairie

Photo Credit: UNL Recreation & Tourism Class Blog

Soils and Soil Properties

Tallgrass prairie soils are among the deepest and most productive for grain crops of any soils on earth. These soils are comprised of plant material that has broken down for thousands of generations. Due to the organic matter in conjunction with clays in the soil, tallgrass prairie soils have an excellent water holding capacity (Johnsgard 2007).

Within the Prairie Corridor a variety of soil types exist and dictate the existing vegetation communities. Soils at Spring Creek Prairie are part of the Steinauer-Pawnee-Burchard association as defined by the Soil Conservation Service (Kottas 2001). This soil association is comprised of fine and fine-loamy soils that are generally well drained, loamy to clayey soils formed on glacial till (Kottas 2001).

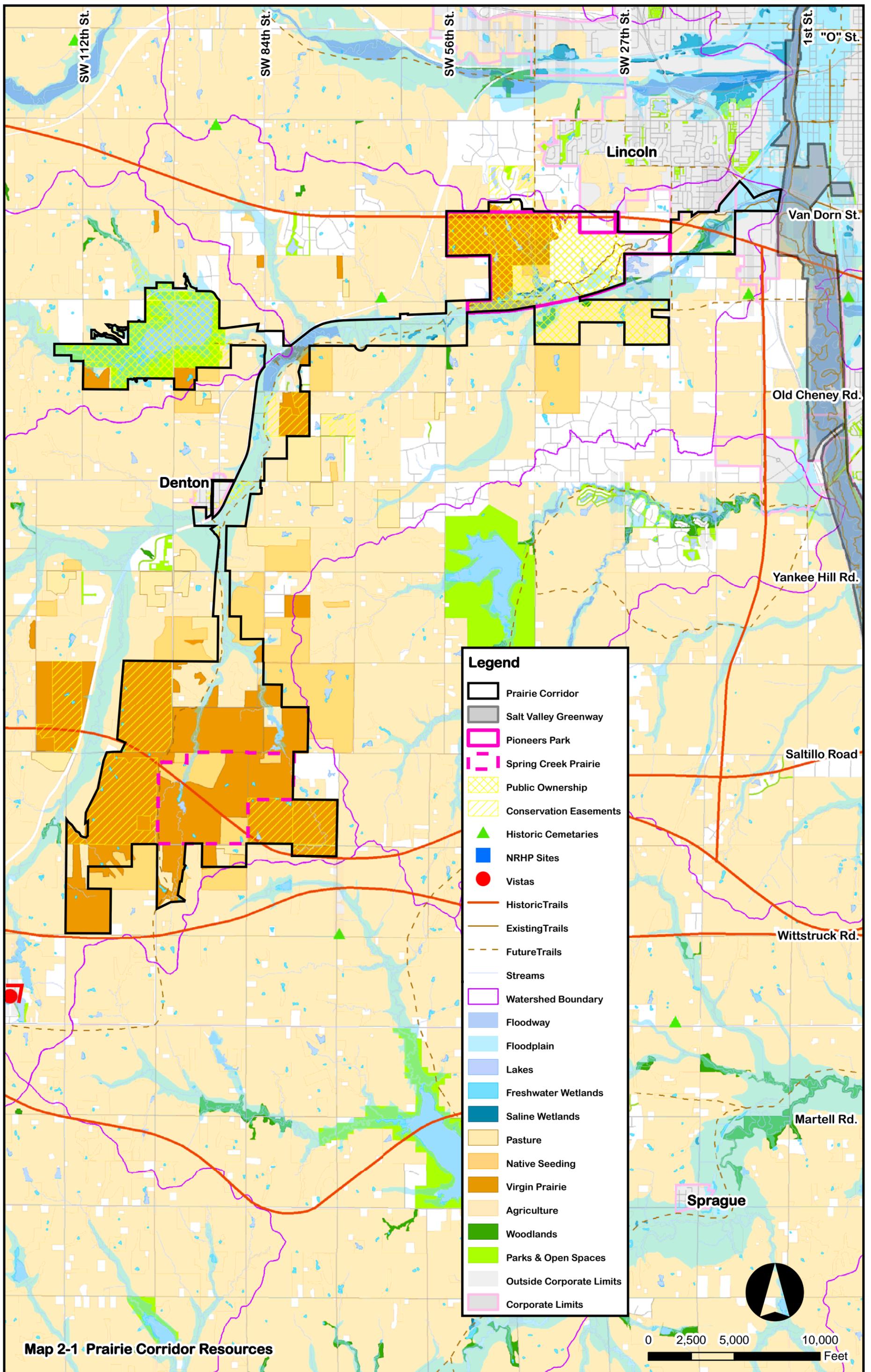
The City and County, with the assistance of resource agencies and the County Ecological Advisory Committee, have assembled detailed soils maps for the Prairie Corridor including soil attributes like erodibility and slope. This soils information is another tool in the broader prairie corridor plan that will be particularly important in informing decisions about native prairie plantings. A detailed soils map for the Prairie Corridor is located in Appendix C.



Prairie Soil Profile

Photo Credit: Glenn Padbury





Map 2-1 Prairie Corridor Resources

0 2,500 5,000 10,000 Feet

Saline and freshwater wetlands

Eastern Nebraska's saline wetlands are another very unique endangered ecosystem within Lancaster County. Historically occupying as many as 40,000 acres, there are only about 1,400 acres remaining. The salt source of these groundwater discharge wetlands is a deep limestone formation. The high salinity has created wetlands that are home to uniquely adapted plant species (such as the state threatened saltwort) and a federally endangered insect, the Salt Creek tiger beetle. The saline wetlands are located primarily along the Little Salt and Rock Creek Corridors, but also exist along segments of Haines Branch and in Salt Creek tributaries in the southern part of the county.

In the Resource Categorization of Nebraska's Eastern Saline Wetlands, wetlands are categorized into one of four groups:

- **Category 1 – Site currently provides saline wetland functions of high value or has the potential to provide high values following restoration or enhancement measures.**
- **Category 2 – Given current land use and degree of degradation, site currently provides limited saline wetland functions and low values. Restoration potential is low.**



Saline wetlands at Arbor Lake Complex north of Lincoln

- **Category 3 – Site is functioning as a freshwater wetland having freshwater plant communities on a saline soil. Currently provides freshwater wetland values and no feasible restoration measures exist to re-establish the historic salt source and saline plant associations.**
- **Category 4 – Site is functioning as a freshwater wetland having freshwater plant communities on a non-saline hydric soil.**

In 2002, the Saline Wetland Conservation Partnership was formed and includes public agency partners that address saline wetland conservation with a primary goal of no net loss of these wetlands. A few areas of eastern Nebraska's saline wetlands exist within the Prairie Corridor on Haines Branch. Near SW 42nd Street and Pioneers Blvd there are a few acres of Category 3 saline wetlands. A few small pockets of Category 1 saline wetlands remain south of Pioneers Blvd near SW 56th Street with a few additional acres of Category 2 saline wetlands just west of this area.



A number of species are listed as “at-risk” in the saline wetlands by the Nebraska Legacy Project. Saltwort is an at-risk plant species and animal species include Bell’s Vireo, Regal Fritillary butterfly, Salt Creek tiger beetle, plains harvest mouse and pimpleback mussel.

The freshwater wetlands throughout the prairie corridor are dominated by wetlands categorized in the palustrine system of wetland types. Based on the “Classification of Wetlands and Deepwater Habitats of the United States,” the palustrine system includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas with specific salinity levels. This classification also includes wetlands lacking vegetation with an area less than 20 acres. This classification was developed to group vegetated wetlands traditionally called marshes, swamps, bogs, fens, prairie and small, shallow permanent or intermittent water bodies often called ponds. The class types within the palustrine system include emergent, forested, scrub-shrub, unconsolidated bottom and aquatic bed.

In the lower reach of the Haines Branch link, the palustrine wetland classes are dominated by freshwater emergent wetlands located in the low-lying floodplain adjacent to Haines Branch and within oxbows. Upstream of the Conestoga Lake node and Holmes Creek confluence, wetlands are primarily freshwater ponds within impoundments for rangeland and agricultural uses.

Opportunities exist to protect, restore and possibly even expand the existing saline wetlands (identified as Category 1 and 3) within the prairie corridor. Since the adoption of the Implementation Plan, new management techniques (wetland restoration and hydrologic management) are underway to restore saline wetland functions of Category 3 sites. Additional information about the categorization of saline wetlands can be found in the “*Implementation Plan*



Saline wetlands at Arbor Lake Complex north of Lincoln

for the Conservation of Nebraska’s Eastern Saline Wetlands”. The Saline Wetland Conservation Partnership continues to have measured success with restoration efforts primarily in the Little Salt Creek watershed north of Lincoln. Based on successes in that watershed, managers can develop localized plans for restoration efforts.

Streams, Riparian Corridors and Floodplains

Streams and associated riparian corridors and floodplains provide a wide range of benefits within the corridor. These hydrologically based

features are the heart of the physical link along the corridor between the two native prairie areas. Haines Branch and Spring Creek begin in the southwest uplands of Lancaster County and dissect the prairie plains. The creeks converge just south of Denton and then Haines Branch traverses east toward its confluence with Salt Creek near Highway 77 and West Van Dorn Street.



The streams and riparian corridors provide aquatic and terrestrial habitat within the corridor. The low-lying areas near the stream are floodplains that convey stormwater. These floodplain soils are historically known as high-quality organic soils that produce abundant vegetation.

Bird and Wildlife Habitat

As identified in the Nebraska Legacy project, throughout the tallgrass prairie eco-region there are more than 300 species of resident and migratory birds. Wood ducks, green heron, northern pintail, blue-winged teal and mallard are examples of nesting waterbirds. The greater prairie-chicken and other grassland birds such as Henslow's sparrow, dickcissel, grasshopper sparrow, bobolink, vesper sparrow and Swainson's hawk are also present in the region. Stream corridor woodlands also support Bell's vireo, black- and white- warbler, rose-breasted grosbeak, and orchard oriole (Nebraska Legacy Project).



Greater Prairie Chicken
Photo Credit: Birdlife International

The Nebraska Legacy Project also identifies more than 55 mammalian species in the tallgrass prairie eco-region. Small mammals include plains gopher, prairie vole, plains pocket mouse, thirteen-lined ground squirrel and Franklin's ground squirrel. Prior to European settlement, the tallgrass prairie was home to large mammals like bison and elk and large predators such as mountain lion, black bear, grizzly bear and gray wolf. The remaining large predators in the tallgrass prairie include coyote, red fox and American badger. Bobcats, weasels and American mink can be found in wooded areas and wetlands (Nebraska Legacy Project).

Fifty-three species of amphibians and reptiles exist in the tallgrass prairie including salamanders, toads, frogs, turtles, lizards and snakes. All of the amphibians use wetlands and streams for breeding while the toad species are found predominantly in the upland areas. Turtle species such as northern painted turtle, false map turtle and common snapping turtle are common in wetlands, ponds and streams. Bull snake, western fox snake, yellow-bellied racer and plains garter snake are the most common snakes in the prairie.

According to the Spring Creek Prairie Audubon Center website, the area is home to 216 bird species, 30 mammal species, 53 butterfly species and 35 species of dragonflies/damselflies. The Prairie Corridor and adjacent open space provide abundant habitat for birds and wildlife, with the stream and associated floodplain providing natural trails for movement, predation and cover.



Woodlands

Historically, woodlands existed among areas of tallgrass prairie on steep slopes and in narrow floodplains adjacent to meandering streams. Bur oak trees grew on steep slopes whereas cottonwoods, ash, elm, and boxelder grew in lowland areas (Lancaster County Soil Survey). Bur oak savannas formed near or amongst tallgrass prairie where annual burning or grazing controlled understory vegetation (Johnsgard 2007).

Woodlands provide a natural resource value in the corridor as a wildlife movement avenue. Migratory birds use trees for cover and habitat. In addition to wildlife movement, woodlands further diversify the landscape and maintain a historical reference to ecosystems prior to settlement. The largest groupings of woodland areas in the prairie corridor exist on the south end of Spring Creek north of Spring Creek Prairie and also about a mile east of Conestoga Lake.

Many other woodland areas exist throughout the corridor as well.



Woodlands of Wilderness Park
Photo Credit: Great Plains Trail Network

Other Resources

The Prairie Corridor offers a unique opportunity to connect the City of Lincoln to an adjacent rural portion of Lancaster County while maintaining the natural integrity. Future trail connections could include a network of natural open spaces and parks within the Prairie Corridor.

With the unique natural resources in this corridor and the goal of maintaining and enhancing those resources, the plan seeks to highlight educational opportunities and economic benefits for the community. An important node within the Prairie Corridor is the Village of Denton, Nebraska. Future trail connections linking Lincoln's vast trail system and the Village of Denton are a goal of the master plan. Trails and green spaces are amenities that are proven to bolster economic development. Using greenways, urban parks and trails as economic development tools is common practice for many communities, including Lincoln. Communities recognize the economic potential of trails as destinations that bring dollars to the places they serve.

The Prairie Corridor and associated amenities of trails and open space will attract visitors from near and far. The amenity value of a well-planned trail can increase property values and tax revenues for Lincoln and Denton. With the natural heritage and history of the area, the proximity to Spring Creek Prairie and the City of Lincoln; the Village of Denton, as a primary node within the corridor, could realize tourism and economic benefits from the Prairie Corridor.



Bison Trail looking toward
State Capitol from Pioneers Park



PRAIRIE CORRIDOR PLAN

Spring Creek Prairie, Pioneers Park and other prairie areas (public and private ownership) in the Haines Branch connecting corridor contain areas of virgin prairie that have never been turned by a plow. In addition to the virgin prairie, many acres of native reseeded prairie also exist within the link. As mentioned above, the primary focus of this corridor is the protection and expansion of tallgrass prairie. In addition to this natural resource, there are many other resources that provide corridor-wide diversity that add value to the corridor as a whole. An overall concept plan for the Prairie Corridor is shown on Figure 1.



Spring Creek Prairie
Photo Credit: Nebraska Audubon

On the outskirts of west Lincoln along Haines Branch, the City of Lincoln owns and manages Pioneers Park. This park includes 668-acres and celebrates the prairie pioneers that settled in the county. On the west end of the park, over 500-acres of virgin and restored prairie have been preserved. Pioneers Park was listed on the

National Register of Historic Places in 1993. Other resources in the park include a picnic area, a zoo, recreational trails, winding roads and paths, and sculptural focal elements. This park is a significant natural resource asset to the City of Lincoln and Lancaster County.

About 6 miles upstream on Haines Branch from Pioneers Park, another expanse of virgin prairie exists on Spring Creek Prairie. The National Audubon Society established the prairie in 1998 on the former O'Brien ranch. The area includes 808-acres of tallgrass prairie with many acres of virgin prairie. This tallgrass nature preserve offers over three miles of walking trails, wetlands, wildflowers, and grasses. Amongst the preserve, more than 210 bird species and 370 plant species have been recorded in addition to other wildlife. There are even 19th-century wagon ruts cut by pioneers that traversed the property.



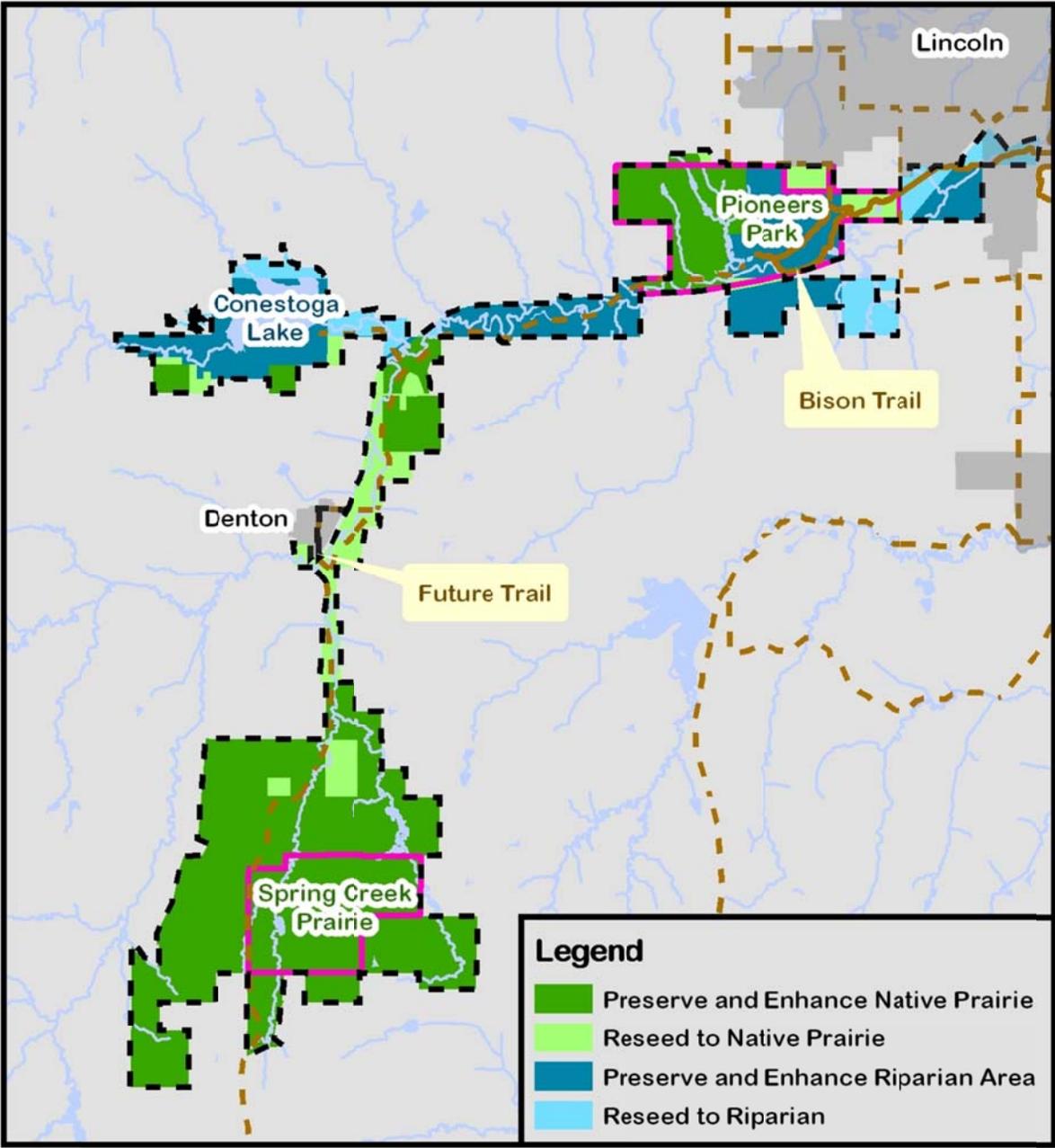


Figure 1: Prairie Corridor Concept Plan



Natural Resource Preservation and Enhancement

Based on the natural resources inventory, the Prairie Corridor has opportunities to maintain and enhance ecological integrity, biological diversity, and high quality water resources and to decrease the impacts of habitat fragmentation. In particular, the corridor contains relatively large contiguous tallgrass prairie areas for the region. Therefore, the Prairie Corridor has the opportunity to conserve and establish habitat for unique species.

The American Bird Conservancy's "Partners in Flight Bird Conservation Plan for the Dissected Till Plains" (PIF) identifies conservation priority bird species based on six criteria. The criteria consider species' vulnerability to extinction range-wide, population trend in physiographic area and whether the PIF planning unit is a center of abundance for the species. Priority bird species for open, treeless grassland habitat as identified in the PIF include the greater prairie chicken, short-eared owl and northern harrier. Priority bird species preferring moderate-sized, open grasslands include Henslow's sparrow, dickcissel, bobolink, and grasshopper sparrow (Fitzgerald and Pashley 2000).

Most of the priority species above have large breeding and wintering areas but the Dissected Till Plains have a relatively large portion of the global population of dickcissels and grasshopper sparrows and important wintering areas for northern harriers and short-eared owls. Historically, the greater prairie chicken was prevalent and widespread on the Dissected Till Plains but now it is the species in the grassland habitat that is the most immediately threatened with extirpation in this planning unit (Fitzgerald and Pashley 2000).

In the open, treeless grasslands, species have large area requirements. Greater prairie chickens may occupy greater than 2,000-acres throughout the year, short-eared owls may be found among 5.5 square-miles of winter feeding grounds and the northern harrier cruising area may be 0.5 square-mile (Fitzgerald and Pashley 2000).

The PIF estimates a management area requirement for the greater prairie chicken to be 10,000-acres with 2,000-acres at the core. Within the 2,000-acre core, experts recommended at least one-third of the area within greater prairie chicken range be maintained as permanent grassland with 75% grassland and 25% cropland optimal. The 8,000-acres surrounding the core is referred to as the "matrix" and should contain at least 40% grassland.

There are 7,310-acres within the Prairie Corridor and approximately 3,700-acres are tallgrass prairie. Based on the PIF conservation model, this scale of native prairie habitat supports a core area for various species that have struggled for survival due to habitat fragmentation. Particularly, the scale of the Prairie Corridor begins to approach the overall management area goals to support the greater prairie chicken, short-eared owl and northern harrier bird species. These species rely on large, open, treeless grasslands. Numerous other species rely on the prairie corridor for habitat on the medium and small habitat dependence scales. In addition to prairie species, saline wetlands in the corridor provide unique habitat that supports a variety of plant and insect species.

The Minnesota Prairie Conservation Plan (2010) describes the biological attributes of a functional prairie system. The eight attributes are listed below with specific examples within the Prairie Corridor.



1. *Supports moderate to high diversity of vegetation types and native species within predominantly native prairie and associated habitats.* The Spring Creek Prairie boasts 216 bird species, 30 mammal species, 53 butterfly species and more than 360 plant species. This constitutes a high diversity system.
2. *Maintains viable populations of prairie landscape dependent fauna and flora.* The species statistics above show that the viable populations are present within the corridor.
3. *Is of adequate scale to support animal species that have large home ranges or require a variety of different habitat types throughout their life cycle (e.g. greater prairie-chicken, American badgers, and many amphibians).* The PIF discussion above shows there is adequate habitat for the greater prairie-chicken. Spring Creek Prairie is home to American badgers and many amphibians.
4. *Provides connectivity between grassland sites for plant and animal populations by facilitating movement and gene flow, including for species with relatively low capacity for movement.* As identified in the Prairie Corridor Concept plan, the corridor shape is designed to facilitate movement throughout the corridor and this should improve gene flow.
5. *Provides linkages between upland and wetlands for animals that utilize both habitats.* The corridor shape provides a linkage between the uplands near Spring Creek Prairie and Pioneers Park and the low-lying areas adjacent to Haines Branch.
6. *Has a natural disturbance regime (e.g. fire, grazing, and changing water levels).* Fire is commonly used at Spring Creek Prairie in addition to grazing throughout the corridor. Water level fluctuations also exist in areas and wetlands adjacent to Haines Branch and in upland isolated wetlands.
7. *Represents grasslands and wetlands with different histories of fire and grazing and time since disturbance (different successional stages).* Warm and cool season grasses exist throughout the corridor and this supports different successional stages. Freshwater and saline wetlands exist within the corridor.
8. *Contains a complex of different habitat types including savannas, brush prairie, groundwater seepages, and a variety of wetlands that can range from temporary wetlands to shallow lakes.* Freshwater and saline wetlands provide wetland variety and many small ponds exist throughout the corridor.
9. *Exhibits ecosystem stability, adaptability, and resilience to environmental change.* This final attribute is difficult to quantify for any prairie. Based on diversity and ecological stability, the Prairie Corridor is anticipated to provide stability as a prairie area and maintain resilience to environmental changes.

There is not a set size for how large a prairie area must be to maintain ecosystem function and plant and animal populations. The attributes discussed can be functional at different prairie scales. Small prairie parcels can cycle nutrients and maintain populations of some plant and animal communities but cannot support large animal populations or retain natural hydrology (Minnesota Prairie Plan Working Group 2011).



The Minnesota Prairie Plan Working Group has determined the **best way to re-habilitate prairie is to build from concentrations of existing prairie remnants**. Specifically, they reference the Minnesota Statewide Conservation and Preservation Plan that recommended to “restore ecoregion-appropriate, landscape-scale complexes of habitat centered on concentrations of existing remnant habitat”. In the Prairie Corridor, a foundation of existing prairie remnants is available and provides the opportunity to achieve ecological integrity, biological diversity and high quality water resources.

Priorities for Easements and Land Acquisition – The Prairie Corridor Spatial Analysis

The Prairie Corridor boundary was defined by key features in the watershed; Haines Branch and Spring Creek stream centerlines, adjacent riparian areas, land ownership boundaries, conservation easements, virgin prairie areas and wetlands. A number of the natural resources described above serve as a form of habitat. To further refine the corridor boundary and assist land managers in strategizing future natural resource preservation and enhancement, a spatial data analysis method was developed. This method is based on assessing a qualitative ranking of individual parcels surrounding the planned corridor boundary. The goal of this analysis is to evaluate the natural resources in the Haines Branch Watershed and prioritize parcels based on existing habitat diversity and connectivity. Each parcel’s level of habitat diversity and connectivity was ranked 1 through 4, with 1 being the highest and 4 the lowest of each category.



Portion of Prairie Corridor Spatial Analysis

For habitat diversity, corridor natural resources such as virgin prairie, native prairie seeded areas, pasture, woodlands, saline and freshwater wetlands and riparian vegetation were considered. Additionally, land use types were analyzed and categories include farmsteads, acreages, agricultural lands and urban development. These resources were prioritized and ranked for diversity of riparian and prairie areas with an emphasis on virgin native prairie and saline wetlands (i.e. given a priority ranking of 1).

Habitat connectivity of riparian and prairie areas was evaluated for parcels based on management goals using two criteria. First, spatial relationships to the Haines Branch and Spring Creek stream centerlines were considered to evaluate an individual parcel. Parcels that fall within a 500ft buffer of these stream centerlines were given the highest connectivity rating. Second, adjacent parcels with existing prairie and riparian habitat, public ownership and easements were accounted for to place emphasis on existing protected parcels. Disconnected parcels have a lower connectivity rating radiating outward from the stream centerline. This method of analysis puts an emphasis on maintaining a connected stream corridor and on parcels with public ownership and conservation easements.



Through a matrix approach, the values assigned to habitat diversity and connectivity can be combined to assign an overall priority for each parcel. Through the matrix shown in Table 2-1, these two metrics were combined to determine the parcel priority ranked. Parcel priority was ranked 1 through 5, with 1 being key parcels for acquisition and 5 being not considered for habitat in the Prairie Corridor.

TABLE 2-1: Parcel Priority Matrix

Habitat Connectivity		Habitat Diversity			
		Highest 1	→ 2	Lowest 3	4
Highest ↓ Lowest	1	1	1	1	2
	2	1	2	3	4
	3	2	3	4	5
	4	3	4	5	5

The results of this matrix method throughout the Prairie Corridor will serve as a valuable tool for resource managers. Further description of the methodology and process are presented in Appendix C.

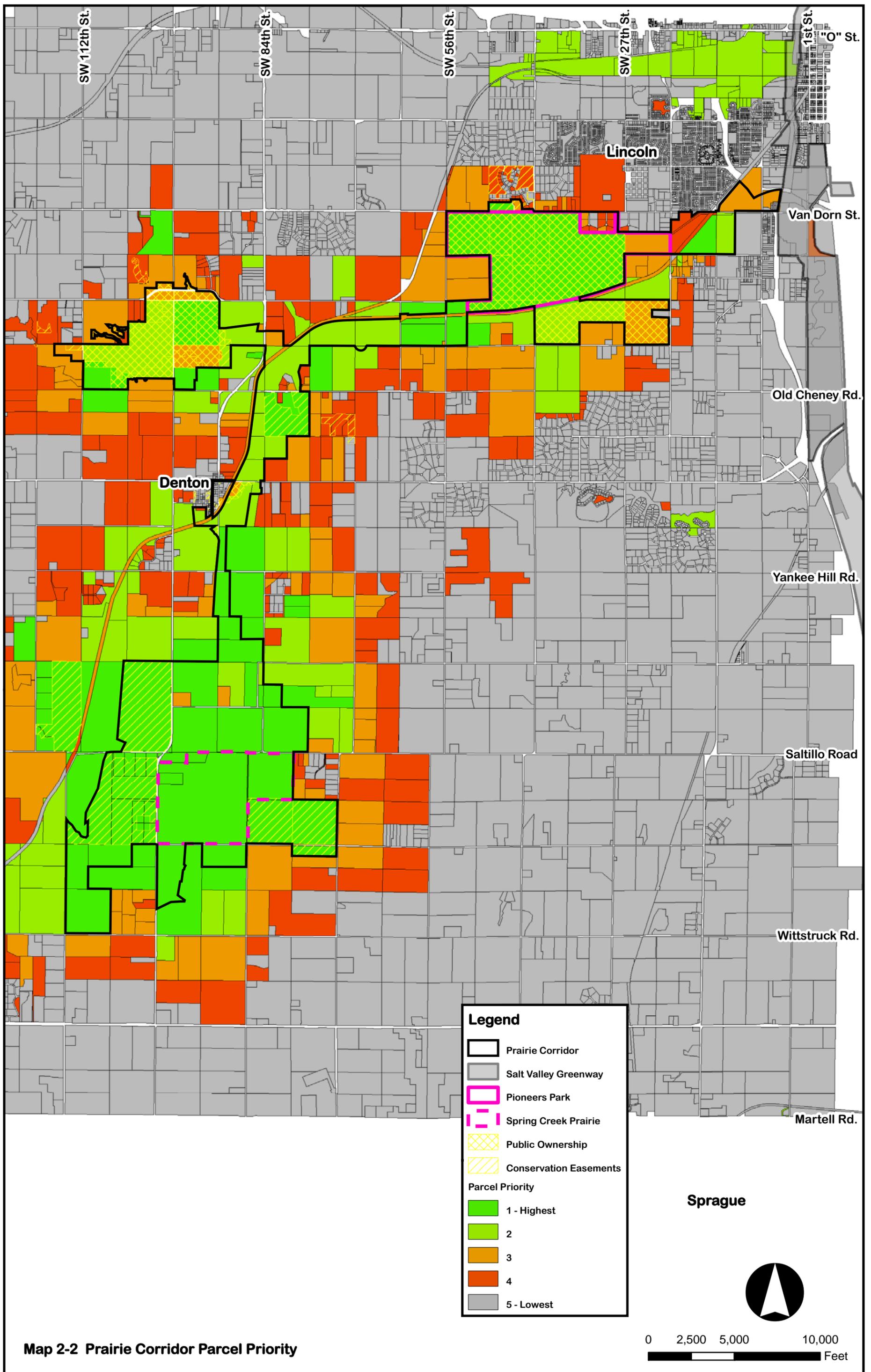
Map 2-2 is the result of the parcel priority analysis. The priority parcels were then flagged for different land management strategies based on existing habitat type, soil type related to re-establishment of native prairie, public ownership, conservation easements and proximity to key resources such as virgin prairie and saline wetlands. The breakdown of the different priority areas and land management strategies are shown in Table 2-2.

TABLE 2-2: Parcel Priority and Land Management Strategy Acres within the Prairie Corridor

Strategy	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Total
Preserve and Enhance Virgin Prairie	3,381	37	-	-	-	3,418
Enhance Existing Native Seeding	257	29	-	-	-	286
Reseed to Native Prairie	1,048	403	160	43	14	1,668
Preserve and Enhance Saline Wetlands	32	-	-	-	-	32
Enhance Existing Riparian Areas	354	778	109	-	-	1,242
Reseed to Riparian Area	-	87	316	63	8	474
Totals	5,072	1,333	585	106	22	7,119
Public Ownership						4,548
Private Ownership						2,571

Note: Public Ownership Includes Acres under Conservation Easement and Public Lands. Total Prairie Corridor Area is 7,310ac, of which 191ac are Road and Railroad Right-Of-Way.





Map 2-2 Prairie Corridor Parcel Priority

0 2,500 5,000 10,000 Feet

General Cost Estimate

The following table (Table 2-3) presents planning level costs associated with various techniques that could likely be implemented within the Prairie Corridor. Land acquisition cost estimates are based on recent (April-June 2012) Lancaster County agricultural property sales. Conservation easement cost estimates are based on research that indicates easement costs are in the range of 70 percent of that of acquisition. Trail development, wetland restoration and riparian zone restoration costs are based on recent projects in Lincoln and Lancaster County (projects completed for Lincoln Parks and Recreation and Lower Platte South NRD 2008-2012) and include professional engineering design and construction costs. Acquisition costs are not included in the restoration or development techniques described below.

Table 2-3: Planning Level Cost Table	
Technique	Estimated Cost Range
Land Acquisition: Fee Simple	\$3,800 – \$4,500/acre
Conservation Easement on Existing Farmland: Permanent	\$2,400 - \$3,000/acre
Conservation Easement on Existing Grassland or Wetland	\$1,200 - \$2,000/acre
Reseeding to Native Prairie (includes site prep and establishment)	\$1,000 - \$3,000/acre
Prairie Management: Prescribed Burning	\$20 - \$120/acre
Wetland Restoration/Enhancement	\$5,000 - \$20,000/acre
Riparian Zone Restoration/Enhancement	\$60 - \$100/linear foot
Trail Development: Crushed Limestone	\$35 - \$40/linear foot
Trail Development: Concrete	\$75 - \$125/linear foot

Land Management Strategies

Prairie Re-establishment

The goal of prairie re-establishment is to rebuild a diverse ecosystem of plant and animal communities that function in a similar manner to the native prairie in the area. The re-establishment of native prairie plants is a slow process. According to “A Guide to Prairie and Wetland Restoration in Eastern Nebraska”, the size of the re-establishment area will dictate diversity and abundance of native plants and wildlife that it can support. Larger native plant plots will be more genetically diverse and have a greater defense against disease and environmental factors. On the contrary, small re-establishment areas provide habitat for native plants, small mammals, birds and insects. The re-establishment process takes 3-5 years for most prairie and wetland plantings to become well established (Steinauer et al. 2003).



Spring Creek Prairie prescribed burn.
Photo Credit: Nebraska Audubon



In the Prairie Corridor, the topography, soil texture and drainage vary between the ends of the corridor and the midsection which is generally bounded by SW 40th and SW 84th Streets. Parcels in this section of the corridor would be more appropriately re-established with floodplain prairie species such as big bluestem, Canada wildrye, fox sedge, switchgrass, Virginia wildrye, western wheatgrass and eastern gamagrass.

In the uplands of the corridor around Spring Creek Prairie, well drained soils are best suited for upland tallgrass prairie grasses including little bluestem, needlegrass, prairie drop-seed, Junegrass, and side-oats grama. Upland prairie forbs include prairie goldenrod, prairie flax, wild alfalfa, heath aster, bastard toadflax, and daisy fleabane (Johnsgard 2007).

Big bluestem historically comprised 80-90% of the total vegetation in wet mesic prairie. Mesic prairie is defined as prairie that has a balanced level of moisture and this is the characteristic prairie re-establishment type for the midsection of the Prairie Corridor. Grasses dominant in wet mesic prairie include Indiangrass, switchgrass, and Canada wildrye. Other dominant plants include sunflowers, goldenrods and asters (Johnsgard 2007).

Site Selection

Most prairie plants need a minimum of 6-10 hours of direct sunlight per day for survival. Prairie re-establishments are best located in sunny areas with minimal shade from windbreaks. Sites adjacent to stands of non-native species like smooth brome, reed canary grass, tall wheatgrass or other aggressive and hardy exotic plants should be avoided when possible. These species are difficult to control and can infiltrate the re-establishment plots if not controlled with herbicide, mechanical means or prescribed burning before planting (Steinauer et al 2003). The specific moisture requirements of prairie plants will dictate which varieties are most appropriate for each location.

Areas located downhill from cropland are subject to silt and fertilizer runoff. Land management techniques like terraces and buffer strips can provide protection upslope of the prairie plots and minimize introduction of silt and fertilizers to the prairie area (Steinauer 2003). Some possible re-establishment areas in the Prairie Corridor midsection are downhill from row cropland. Sections of railway will provide a barrier to prevent siltation and fertilizer runoff from new prairie areas but some other areas will require buffers and terraces to protect prairie plantings.

There are often misconceptions about the effect of past herbicide applications on prairie re-establishment. According to Steinauer et al (2003), atrazine is the only herbicide that might limit seeding growth of native plants for one or more years after its last application. If possible, atrazine should not be applied for 2-3 years before native seeding. Atrazine is a grass and broadleaf herbicide applied to cornfields in eastern Nebraska.

Site Preparation

The Prairie Plains Resource Institute (PPRI) has shown wide success with prairie re-establishment on cropland, especially corn and soybeans. PPRI says that cropland provides good seedbeds that require minimal preparation before native seeding. As discussed above, Atrazine is the only herbicide used in the area that will affect prairie plantings. The residual



stubble left from row crops provides soil cover to protect against erosion. Fields that have ridges from tilling need to be disked prior to prairie planting. Disking can be used to fight back weeds as well (Steinauer et al 2003). Regarding other types of vegetative cover on prairie planting success, NRCS personnel have indicated that plots containing western wheatgrass will need a fallow year prior to prairie planting. Otherwise, prairie plantings will begin to have establishment success on plots previously planted as other agricultural crops such as alfalfa and hay.



Copyright Chris Helzer/The Nature Conservancy

Broadcast seeding at a prairie re-establishment
Photo Credit: Chris Helzer - The Nature Conservancy

***Prairie Enhancement:
Invasive Species Control,
Prescribed Fire and
Grazing***

As mentioned above, prairie re-establishment is a slow process. In the first few years, the seed bed will produce weeds that will be nourished by nitrogen that remains from cropping in years past. In the 3-5 years after prairie planting, weeds will be diminished and warm-season grasses and other prairie perennials will become dominant. Weeds will generally be gone by

years 5-10 after prairie planting (Steinauer et al. 2003).

PPRI discusses irrigation to new prairie plantings, mowing annual weeds, natural disturbance, fire and grazing as elements of post-planting management. If feasible, irrigation can improve the chances of native seed germination especially in times of drought. Years of normal precipitation should not cause a problem with germination. Some managers mow weeds in the first summer after planting. Mowing can also help to limit the takeover of some planted species such as big bluestem (Steinauer et al. 2003).

Natural disturbance was a key element to maintaining the diversity of native prairies. Types of disturbances included fire and grazing by native species such as bison. The health of the prairie relied upon the removal of litter by these types of disturbances. In addition to litter control, fire blackens the soil and then sunlight warms the soil. Warmer soil temperatures stimulate microbial action in the soil and increase nutrient availability (Steinauer et al. 2003).

Another important element of fire is control of eastern redcedar. Eastern redcedar is often improperly described as a habitat-friendly tree. On the contrary, the spread of redcedar in the prairie landscape is a problem for many species. Eastern redcedar expansion fragments prairie



and destroys habitat for songbirds and species like greater prairie chickens (Ortmann et. al 2007).

An integrated management approach has been the most successful for eastern red cedar. A combination of prescribed fire, herbicides and cutting have proven successful in prairie environments. Fire can be very effective in tallgrass prairie due to the biomass available as fuel for fire. The fragmented landscape of eastern redcedar in eastern Nebraska allows for smaller and more intense burns which improve fire effectiveness (Ortmann et. al 2007). The publication “Integrated Management of Eastern Redcedar on Grasslands” provides further detail for eastern redcedar management in grasslands and this can be found in Appendix D.



Eastern redcedar expansion (red outline) in Prairie Corridor. Photo Credit: Google Maps

The spread of eastern red cedar throughout the Prairie Corridor is a significant vegetative threat. Without species suppression from fire or mechanical control, the red cedar population expands and creates a forest canopy. Low-lying branches of cedars scour vegetation and out-compete prairie vegetation.

Grazing is another management tool for prairie re-establishment. A variety of combinations of animal grazing density and season timing provide managers flexibility in regulating location, intensity and season of disturbance. Grazing may not be feasible in some smaller prairie re-establishment areas due to lack of fencing or water for animals (Steinauer et al. 2003).

Early efforts by The Nature Conservancy led to a patch-burn grazing method used today. This method calls for burning a portion of prairie and this attracts grazing animals. Animals are attracted to the new vegetation that grows on burned patches. Oklahoma State University researchers have documented the benefits of patch-burn grazing to wildlife species and plant/insect diversity. The Nature Conservancy in Nebraska is using the patch-burn grazing method as a way to increase and maintain floristic quality in prairies. By monitoring the animal stocking rate on a parcel, The Nature Conservancy found that grazing recently burned prairie led to increased plant diversity because cattle chose to eat grasses and allow forbs to expand (Helzer 2011).

Numerous management strategies apply to prairie re-establishment including irrigation (where applicable and feasible), mowing annual weeds, natural disturbance, prescribed fire and grazing as elements of post-planting management. Where feasible, irrigation can improve the chances of native seed germination especially in times of drought. Years of normal precipitation should not cause a problem with germination. Some managers mow weeds in the first summer after planting. Mowing can also help to limit the takeover of some planted species such as big bluestem (Steinauer et al. 2003).



Conservation haying is a management technique used by the USDA's Conservation Reserve Program (CRP). CRP land can be hayed or grazed one of out every three years once cover is fully established. The USDA authorizes haying for a single period up to 90 days whereas managed grazing is authorized for a single period up to 120 days or two 60-day periods (USDA-FSA website 2012). This plan recommends compliance with the CRP regulations for haying and grazing on land within the Prairie Corridor. Lastly, ineligible acreage for haying or grazing on CRP land is land within 100 feet of a stream or permanent water body (USDA-FSA 2012).

Saline Wetland Rehabilitation as a Management Strategy

In addition to native prairie re-establishment in the Prairie Corridor, unique saline wetland areas also exist. Based on rehabilitation projects in saline wetland areas just north of Lincoln, many saline wetland sites were historically managed too wet. The complex soil hydrology of wetting and drying and resultant salty expression on the soil is muted by long periods of standing water. Saline wetlands need to be managed to allow minimal surface inundation of saline soils.

For the saline wetland sites within the Prairie Corridor, vegetation inventories should be conducted to assess the biological health of the remaining wetlands. Due to the incision of Haines Branch, the water table in these wetlands has declined thus isolating portions of these wetlands from the original source of saline groundwater. Salinity remains in the soil in some areas and this provides the opportunity for rehabilitation. More advanced restoration measures could include raising the streambed of Haines Branch or immediate tributaries to reconnect the water table to saline wetland soils. Many complicated issues would likely arise from raising the streambed (primarily floodplain concerns) in Haines Branch but oxbows near and within the saline wetland area could provide the opportunity for rehabilitation and expansion of existing areas. Current research in the saline wetlands north of Lincoln is investigating whether saline groundwater can be pumped to the surface to rehabilitate these wetlands.

Greenway Funding Strategies

There are a number of tools available to aid in the preservation and protection of land, both publically and privately held. Some of these tools may be implemented as part of the development process, however these options are more limited and are more of a reactive approach. There are cases (e.g. when public access is desired or when a property has high priority natural resources) when acquisition is the most appropriate mechanism to achieve the desired goal. General land preservation techniques and programs that are consistently used in greenway planning and that can be used for the Prairie Corridor, and larger Salt Valley Greenway are summarized and described below.

Fee Simple Acquisition. Fee simple acquisition requires direct purchase of land from the present owner and involves the conveyance of all rights associated with land ownership, including use, access, development, subdivision, and disposition. Because there is transfer of all rights, fee simple acquisition is a costly form of acquisition over large areas. Funding sources could include municipal funds (tax dollars), municipal bonds, local and state resource agency funds, lease-back agreements (e.g. term agreement of leasing back agricultural land for agricultural production or open space to offset purchase price), state and federal grants, private foundations and donations.

Donation. A donation or gift of land involves a property owner giving all or a portion of private ownership to the organization. Any development and/or maintenance costs should



be evaluated as part of the acquisition by donation technique. Donations may present advantages to the private landowner in the way of property tax credits or estate or income tax deductions.

Right of First Refusal/Option. The right of first refusal technique is a legal agreement into which a conservation organization would enter with a property owner that provides the organization the first opportunity to purchase the property before it is listed on the open market. The conservation organization is given a limited amount of time to exercise the option to purchase the land.

Life Estate. A life estate technique would allow a property owner to donate to a municipality or conservation organization upon landowner’s death. Private landowners (heirs) may benefit from reduced taxes and are ensured the property is preserved for greenway purposes.

Conservation Easement. A conservation easement is a legal agreement limiting the use and development of land in order to protect natural resources. The easement can be purchased or donated and restrictions and the degree of public access are agreed upon by both parties. If the easement is permanent and provides public access, the property owner may be eligible for tax benefits and/or estate and gift tax reductions.

Public Access Easement. A public access easement specifically provides public access to a defined area of land for a specific purpose (e.g. greenway used for trail crossing).

Transfer of Development Rights. The transfer of development rights (TDRs) involves a landowner selling development rights to a developer who in turn transfers development rights to another area where increased residential density is desired. This strategy will require state enabling legislation before it is an option.

Potential funding sources and the administering bodies are summarized below:

Administering Bodies and Potential Funding Sources	
Administered By:	Funding Resource
Public: Federal	FHWA-ISTEA, NPS, FWS
Public: State	NGPC, NDOR, NET, NDEQ
Public: Local (Lincoln, Lancaster Co., LPSNRD, Denton)	RTSD
Private: Individual or Corporation	Private Fundraising
Private: Foundation	Private Grants
Private: Other	Land Trusts, Conservation Organizations

Organizational Strategies

An important consideration for the Salt Valley Greenway and the Prairie Corridor on Haines Branch will be the formation of a public-private partnership to realize the goals of this plan. It is critical to the success of this project that the full responsibility for implementation not fall on any one agency or private organization, but that a coalition work cooperatively to bring a range of strengths and resources to this project. By focusing on the Prairie Corridor as the first priority, the corridor will receive early protection and enhancement while serving as a model for implementation of the Salt Valley Greenway as a whole.



The City of Lincoln should be the lead agency for the initiation and early implementation of this plan, working cooperatively to develop and implement a public-private partnership. The best approach will be one that establishes a core group of partners to implement the overall vision of the Salt Valley Greenway. Potential partners in this central group include the City of Lincoln, the Lincoln Parks Foundation, Lancaster County, and the Lower Platte South Natural Resource District, but may include others as appropriate.

This core coalition should seek out additional partners to implement the various components of the Salt Valley Greenway, beginning with the Prairie Corridor on Haines Branch. It is envisioned that the partnership described above will come together with the Spring Creek Prairie Audubon Center, the Village of Denton and other potential partners listed below for the application of an initial 3-year grant to the Nebraska Environmental Trust. The next step would be to formalize the partnership via an agreement to implement this Master Plan and any supplemental planning documents. The coalition's agreement should consider the following:

- Vision for project outcome
- Long-term goals
- Priorities
- Project guidelines or parameters for implementation
- Resources - the financial, technical, staffing or organizational support that is needed to implement various elements of the plan and how to make it available
- Roles and responsibilities of the partners relative to:
 - Planning and technical evaluation
 - Outreach to other partners, landowners and the public
 - Negotiations with private landowners
 - Acquisition of land or easements
 - Trail corridor and construction
 - Land management
 - Habitat restoration
 - Economic and tourism benefits
 - Active and passive recreation areas
- Methods for measuring and reporting progress

Time-specific objectives, actions, budgeting and funding commitments should be outlined in an annual work plan that is reviewed on a regular basis with the coalition.



Full implementation of the Prairie Corridor and Salt Valley Greenway is expected to involve a broad range of public and private partners, the composition of which is tailored to specific corridors and links in the Greenway to best represent interests and maximize benefits. In addition to the coalition identified above, partners for the implementation of the Prairie Corridor and other links in the Salt Valley Greenway are expected to include:

- Other cities and villages in Lancaster County
- Private landowners
- Environmental and trails organizations (Great Plains Trails Network, Nebraska Trails Council)
- Businesses and business organizations
- Conservation trusts
- Private foundations and donors
- Other political subdivisions such as the Railroad Transportation Safety District (RTSD)
- Other state and federal agencies

For the implementation of the Prairie Corridor on Haines Branch, it would be appropriate to establish representation from this broader set of partners to form a Prairie Corridor Committee. This committee would be the model for future implementation of other Greenway links that would likely have similar representation.

While the overall representation from varied groups will be essential to the planning process, a primary leadership role is highly recommended. A coordinator should oversee the project details and work with the partnership to:

- Promote and support implementation of the recommendations of the Prairie Corridor and Greenway Plan
- Coordinate activities for plan implementation
- Conduct public outreach and education
- Participate in and promote fundraising activities for Prairie Corridor and Salt Valley Greenway projects
- Encourage planning actions that promote the establishment of greenways



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APPENDIX A

GREENWAY DEFINED

Greenways are about connections: connections between people and the land, between natural settings, open spaces, public parks, historic places, and between preservation and the human experience. Greenways vary in function, condition and definition, but overall a greenway will typically protect natural, cultural and scenic resources. In *Greenways for America*, Charles Little describes a greenway as:

A greenway is a linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, scenic road, or other route. It is any natural or landscaped course for pedestrian or bicycle passage. An open-space connector linking parks, nature reserves, cultural features, or historic sites with each other and with populated areas. Locally, certain strip or linear parks designated as parkway or greenbelt.

Breaking down greenway typology has also been an important component to definitions and ultimately action plans for a given setting or community. While this may benefit a community with setting goals, identifying action plans, and/or securing resources for implementation; ultimately greenways and associated greenway plans are multi-purpose. In *Greenways: the Beginning of an International Movement*, Jack Ahern defines greenways as:

Greenways are networks of land that are planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable land use.

Whether a greenway is more urban or rural, more passive recreation than active, more historical than developed, more wildlife than human, etc. it is apparent that greenways serve many purposes. Generally, greenways enhance the quality of life in our communities; promote conservation of the natural environment and instill a sense of connectivity with nature. These benefits are important particularly in the context of an urbanized community. It is practical to consider greenway benefits from two perspectives: the natural resource benefits and the human or community benefits.

Natural resource benefits of greenways can be seen at local, regional and even global levels. The connectivity of natural elements and the role they play in sustainability can also be realized in greenway planning. Greenways support many ecological functions simply because they keep areas clear of most development, providing habitat for plants and animals (Hellmund and Smith).

The term greenway itself instills “green” imagery such as tree lines and masses, shrubbery, native grasslands, ornamental plantings, etc. These are important components to a greenway, not only because of the images they project, but also based on the functions of trees, shrubs, grasses and plantings. Trees, shrubs and grasses are important links providing food and cover for birds, mammals, reptiles and insects. Greenways that are streamside and/or watershed based provide flood protection functions, improve water clarity and quality, improve fish, amphibians and reptile habitat and provide the cross-benefit of improved water recreation.

Many of the benefits associated with natural resources are cross-benefits to the human experience. Conservation or enhancement of natural resources for plants and animals has a



broad-reaching impact on a community. However, the quality of life benefits for a community, derived from a greenway, can also be specifically evaluated.

Greenways provide active and passive recreational opportunities. Trail systems have long been associated with greenways, providing increased opportunities for safe pedestrian movement (walking, jogging, bicycling, etc.). Trails can also provide links from urban areas to more rural recreation areas (e.g. wildlife management areas, lakes, open spaces, etc.). These trails provide healthy recreational opportunities thus improving quality of life for communities.

Historical and cultural resources are key elements in the establishment of the heritage of a community. These resources can be preserved and highlighted with greenway planning. Trails that are associated with cultural resources or provide a linkage to a known site or area may include informative kiosks, special signage generating a lively sense of pride in a community.

Greenways improve the opportunity to connect with natural resources, cultural areas and historic places. This builds a “sense of place” for a community and increases both the stakeholders and beneficiaries of a comprehensive greenway plan. Greenways that promote natural resource conservation and recreation also positively impact the “eco-tourism” for a community; which in turn can sustain the economic health of the community.

SALT VALLEY GREENWAY PLANNING BACKGROUND

Elements of greenway planning for the City of Lincoln can be traced back to 1961; where a proposal for a linear park was included in the City’s Comprehensive plan. The “Crescent Green” name was given to the project in 1964 when Professor Dale Gibbs used it as design problem for his undergraduate students in architecture (Clark & Enersen, Hamersky, Schlaebitz, Burroughs & Thomsen). Crescent Green was envisioned to extend along Salt Creek, providing a continuous greenway and open space corridor along the west and north part of Lincoln. The Crescent Green project identified various important elements such as bike trails, open spaces, playfields, and establishment and maintenance/enhancement of wetlands and forests. In 1966 the City (with Lancaster County and the Salt Valley Watershed District) purchased what is now Wilderness Park. A master plan for Wilderness Park was completed in 1972 by Clark & Enersen, Hamersky, Schlaebitz, Burroughs and Thomsen, Rand and Harter. In 1982, the City of Lincoln and the Lower Platte South Natural Resources District (the successor of the Salt Valley Watershed District) entered into an agreement setting out a framework and responsibilities for Crescent Green Park, with an update to the agreement in 1986.

In 2000, David Danner completed a graduate studies project titled: Lancaster County Conceptual Greenway Corridors and Trails Plan. The project idea was evaluated by the Lancaster County Commissioners in 1999 and later explored by the Lincoln-Lancaster County Ecological Advisory Committee. The intent of the Danner project was to create a conceptual greenway and trail corridors plan which identified natural and cultural resources in Lancaster County. While not specific to what is currently being evaluated as the Salt Valley Greenway, the Danner project includes a comprehensive evaluation of county-wide resources.

In 2001 the City of Lincoln-Lancaster County Planning Department in conjunction with the Parks and Recreation Department and Lower Platte South Natural Resources District developed the *Greenprint Challenge*. The Greenprint Challenge was designed to provide the City-County with an approach for sound development providing a County-wide snapshot of the resources of



Lancaster County for inclusion in the 2025 Comprehensive Plan. The Greenprint Challenge documents existing environmental conditions in the City and County and it begins to define how the community should draw upon our natural and cultural resources in future planning efforts. It is a valuable resource that has been carried forward into subsequent Comprehensive Plan updates.

In the fall of 2011, Lincoln City Council and Lancaster County Board adopted the 2040 Comprehensive Plan, called “LPlan 2040.” Chapter 3 of LPlan 2040 includes an outline of the guiding principles for environmental resources in Lincoln-Lancaster County. LPlan 2040 notes the unique opportunity the geography of Lancaster County presents for creating an overall greenway and associated linkages.

The vision of the Salt Valley Greenway is a ribbon of open space and greenway links within the Salt Valley drainage basin in Lincoln and Lancaster County. Expanding and protecting the unique natural resources in the region while providing trail, recreational and educational connections are the foundations to the Salt Valley Greenway. The Prairie Corridor on Haines Branch is an important connecting corridor that was emphasized in LPlan 2040. This key corridor will be the starting point for addressing project implementation and will serve as a model for future implementation of the Salt Valley Greenway as a whole.

The City of Lincoln identified a preliminary greenway within the Salt Valley drainage basin. Refinement of the greenway limits/width included evaluation of a number of items including identified and mapped floodway and floodplain; existing and future land use; existing easements; and research regarding wildlife corridors, water quality, and trail development.

CASE STUDIES

An excellent tool for framing the key elements of the master plan is a review of greenway plans prepared for other communities. While every community is unique with regards to natural resources, assets, constraints and issues, identifying and understanding similar greenway planning approaches can be a useful exercise. A select sampling of case study review is provided below.

Case Study: Hay Creek Watershed Greenway Plan, Berks County, Pennsylvania

The Hay Creek Watershed Greenway Plan was prepared by Stell Environmental Enterprises, Inc. in January 2007. Hay Creek Watershed is located in the Schuylkill Watershed and flows into the Schuylkill River in southeast Pennsylvania. The watershed is a 22-square mile area that includes numerous boroughs. Hay Creek flows north until its confluence with the Schuylkill watershed. While the larger Schuylkill watershed includes the greater Philadelphia area, Hay Creek Watershed has numerous natural resources and sites that benefit from the greenway plan. Typical natural resources identified in the greenway plan include water, earth, biological and recreational resources. Goals identified in the plan include natural resource protection, recreation opportunities, historic and cultural resource preservation and educational opportunities. The plan does not provide any mapping or reference previously produced GIS geodatabase coverage. The plan does go into detail regarding implementation, funding and future management of the plan.



Case Study: Greenway Plan for the Darby Creek Watershed, Delaware County, Pennsylvania

The Greenway Plan for the Darby Creek Watershed was prepared by Urban Research and Development Corporation, Bethlehem, Pennsylvania in May 2010. Darby Creek Watershed is located in Delaware County, Pennsylvania. The watershed is 76 square miles and contains 26 municipalities. The overall watershed is very diverse, and land patterns and demographics vary greatly throughout. Due to the size and nature of the watershed, the greenway plan is broken down into segments for more detailed planning and analysis. The main focus of the plan is to identify and develop green connections along tributary streams and provide connections to destination hubs. This plan includes summaries of existing watershed conditions (natural features, transportation facilities, demographics, land use and recreational, historical and cultural resources), clear goals and objectives, extensive mapping and implementation action plans and policies. The framework of the plan is well defined and also includes pilot implementation projects. Specific to implementation, and associated with pilot projects, the plan describes land preservation techniques including acquisition, easements, zoning and subdivision techniques and funding.

Case Study: East Bay Greenway, Oakland, California

East Bay Greenway Concept Plan was prepared by Urban Ecology with DKS Associates and Human Impact Partners, San Francisco, California in September 2008. The East Bay Greenway Concept Plan is a greenway plan for approximately twelve miles of primarily urban areas from Oakland to Hayward, Alameda County, California. The twelve mile corridor is directly linked to a segment of the Bay Area Rapid Transit (BART) elevated track. The original conception, and promotional information of BART included landscaped grounds beneath the structure, free movement, bike trails, connections to communities and amenities. The plan provides good insight to narrow greenways in developed urban areas. The plan provides a well-defined overview of the origins of the project, contextual history and the planning process. This plan included and documented an extensive public involvement process. This greenway plan focuses primarily on a pedestrian trail. Based on the urban setting of the project the focus is on the human conditions relative to the community; including statistical data on crime, health-related conditions, socio-economics, etc. This plan has limited/brief information on existing natural resources or preservation techniques. While the focus of the plan is primarily on a pedestrian trail the plan provides an excellent overview of the design concept of link, edge and seam. This is carried out in good detail related to the goals and objectives of the plan.

Case Study: MetroGreen, Kansas City, Missouri

MetroGreen is a comprehensive regional trail planning tool that was developed in the early 1990s by the American Society of Landscape Architects (ASLA). The ASLA created a vision that was based on 1890s landscape architect George Kessler's corridor plan for the region. Kessler's plan was presented to Kansas City Parks and Recreation Commission in 1893 for approval and implementation. The new vision prepared by ASLA was an effort that would ultimately become the MetroGreen project. The Mid-American Regional Council (MARC) is now the steward and supporter of the MetroGreen project and works with the local communities on implementation. MetroGreen is a large-scale system of interconnected corridors that span over 1,000 miles connecting seven counties in the Kansas City region. The plan connects urban and rural green corridors and is designed to protect and improve water quality, conserve natural resources and provide trail systems throughout. In 2001, MARC launched an effort to expand



the project. MetroGreen 2002 is the plan update that addresses that project expansion. The planning efforts of MetroGreen come with great history. At such a large-scale, it requires cooperative efforts by many agencies and communities. MARC offers an online GIS database specifically for the ongoing MetroGreen projects. This tool is available for the general public and is used by communities on specific projects.

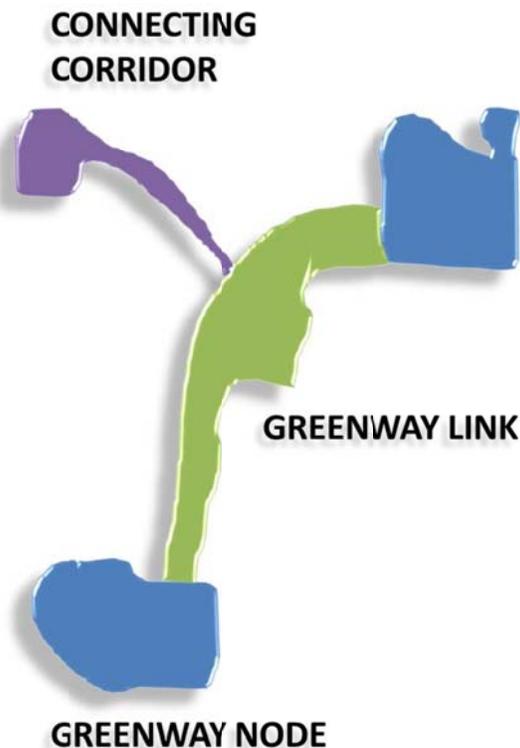


APPENDIX B

GREENWAY RESOURCES

The Salt Valley drainage basin's floodplain boundary (primarily made up of Salt Creek and Stevens Creek) essentially wraps around the City of Lincoln. This large loop, while anchored in the streams, wetlands and floodplains of Salt Creek and Stevens Creek, has been defined by many ecological factors. In addition to the hydrology factors, other ecological factors include existing physiography, soils and slopes, woodlands, grasslands, wildlife and wildlife habitat. The location of the Salt Valley Greenway is generally described as traversing along Salt Creek beginning on the northeast outskirts of Lincoln, proceeding upstream along Salt Creek on the west side of Lincoln (including Wilderness Park), following the Salt Creek floodplain south of Wilderness Park connecting with Roca and continuing south to Hickman. The greenway proceeds east from Hickman to Wagon Train Lake and then follows Salt Creek north to its headwaters near the planned South Beltway. The greenway follows the beltway alignments east until turning north and following Stevens Creek downstream to the confluence with Salt Creek on the northeast corner of Lincoln's city limits.

There are a number of boundary terms that are used to describe the pieces of the broader greenway within this plan. These are links, connecting corridors and nodes.



Links – These areas are the segments that comprise the total greenway. Ranging in length from 3.5 miles long to 16 miles long within the Salt Valley Greenway, these links are split up by separate basins and streams, developed or rural landscape and transportation corridors.

Connecting Corridors – The connecting corridors tie natural resource features and public areas outside the boundary of the greenway back to the greenway itself. The connecting corridors follow tributary streams that connect with Salt Creek.

Nodes – These greenway planning components highlight natural resource features that are offset from the connecting corridor or link. An example of a node is a native prairie area. A node can exist at the end of a connecting corridor but could also be adjacent to a portion of the connecting corridor or link.



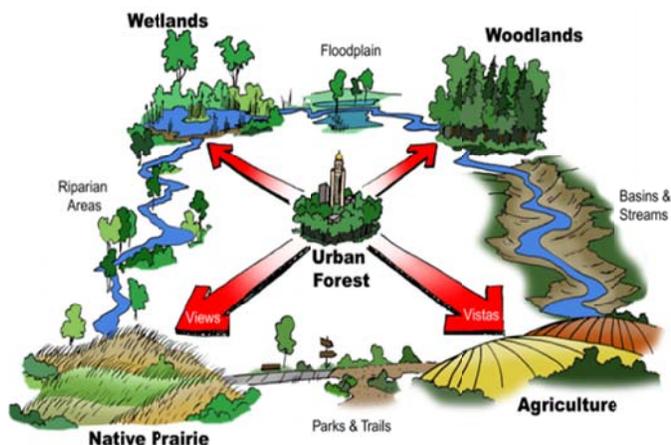
LPlan 2040 notes the importance of the Salt Valley Greenway for recreation, transportation, resource preservation, education and economic development. It is anticipated that this opportunity to achieve cross-benefit from multiple resources within the greenway will solidify a sense of community and enhance regional tourism.



The Salt Valley Greenway will provide connectivity with current and future trails and corridors that extend out from the City such as the MoPac Trail Corridor, Murdock Trail Corridor, Antelope Valley, Dietrich Bikeway, and Billy Wolff Trail Corridor.

The Salt Valley Greenway includes an abundance of those resources described in the 2001 Greenprint Challenge document for Lincoln and Lancaster County. This section describes those resources and highlights where they are predominant within the Greenway and its connecting corridors. The Greenprint Challenge identifies a number of key natural resource categories listed below:

Native Prairies
Freshwater Wetlands
Saline Wetlands
Threatened & Endangered Species
Basins & Streams
Floodplains & Riparian Areas
Parks, Trails & Other Recreation Areas
Urban Forest
Woodlands
Agricultural Lands
Cultural & Historic Landscapes
Views & Vistas



Source: City of Lincoln Greenprint Challenge

Of these resource categories, three are distilled and identified as core resources “that uniquely contribute to the natural resource heritage of the region and whose safeguarding for future generations is indispensable” (Greenprint Challenge 2001). The core imperatives include saline and freshwater wetlands, native prairies and stream corridors. The strength of the diversity of the resource categories further anchors the goals set forth by the greenway plan.

This diversity is evident in numerous factors; varying topography, unique interior saline soils and saline groundwater at the surface, freshwater wetlands, grasslands and virgin prairie and distinctive species of both plants and animals. One of the overall goals of the greenway plan, and a guiding principle of LPlan 2040, is to preserve and consider these resources while considering policy and development decisions.



Native Prairie

The tallgrass prairie of North America once covered 170 million acres. Due to agriculture and development, the National Park Service estimates only 4% of the original expanse of tallgrass prairie remains. The Nebraska Game and Parks Commission Natural Legacy Project estimates that less than 1% of the tallgrass prairie remains in the continental United States, and the



Spring Creek Prairie
Photo Credit: Nebraska

tallgrass prairie of eastern Nebraska is one of the state's most endangered ecosystems. Specifically, only about 2% of Nebraska's tallgrass prairie remains and most parcels are 80 acres or less in size. Lancaster County contains about 8,640 acres of native prairie with most acres in the west areas of the county (LPlan 2040). Approximately 40% of the remaining virgin

prairie is located in the Prairie Corridor on Haines Branch. The public areas of Pioneers Park and Spring Creek Prairie contain large contiguous areas of native prairie.

Dominant native prairie plant species include big and little bluestem, indiangrass, sideoats grama and switchgrass. Wildflowers and forbs are also common and these species include purple coneflower, purple prairie clover, and black-eyed susan. In addition to plant species, prairies are home to a variety of bird, reptile, mammal and insect species. They also provide a valuable educational venue in that native prairie was the dominant pre-European settlement land cover in the region, state and county.

Freshwater Wetlands

Wetlands are defined by hydric soils, plants adapted to these hydric soils and either



permanently or seasonally saturated conditions. Freshwater wetlands exist throughout the county in low areas within the floodplain and also in isolated upland areas. Many of these upland wetlands are constructed impoundments for agricultural/rangeland use. Wetland sizes range from thousands of acres in the northern portions of the county to smaller urban detention areas within the boundaries of the greenway. Wetland benefits include habitat for plant and animal species, conservation, recharge, water filtration and other biological functions, flood control and interpretive opportunities. Numerous freshwater

wetlands are found throughout the Greenway and connecting corridors.



Saline Wetlands

Eastern Nebraska's saline wetlands are another unique endangered ecosystem within the county. Historically occupying as many as 40,000 acres, there are only about 1,400 acres remaining. The salt source of these groundwater discharge wetlands are deep limestone formations. The high salinity has created wetlands that are home to uniquely adapted plant species (such as the state endangered saltwort) and a federally endangered insect, the Salt Creek tiger beetle. The saline wetlands are located primarily along the Little Salt and Rock Creek Corridors, but also exist along segments Haines Branch and in Salt Creek tributaries in the southern part of the county.

In the Resource Categorization of Nebraska's Eastern Saline Wetlands, wetlands are categorized into one of four groups:

- **Category 1** – Site currently provides saline wetland functions of high value or has the potential to provide high values following restoration or enhancement measures.
- **Category 2** – Given current land use and degree of degradation, site currently provides limited saline wetland functions and low values. Restoration potential is low.
- **Category 3** – Site is functioning as a freshwater wetland having freshwater plant communities on a saline soil. Currently provides freshwater wetland values and no feasible restoration measures exist to re-establish the historic salt source and saline plant associations.
- **Category 4** – Site is functioning as a freshwater wetland having freshwater plant communities on a non-saline hydric soil.



In 2002, the Saline Wetland Conservation Partnership was formed and includes public agency partners that address saline wetland conservation with a primary goal of no net loss of these wetlands. The Partnership is currently responsible for the management of over 2,600 acres of saline wetlands and associated conservation zones.



Threatened and Endangered Species

A number of threatened and endangered species reside within the Greenway and connecting corridors. Unique species within the greenway highlight the importance of conservation of habitat and further accentuate the value of these ecosystems.

Threatened and Endangered Species listings in the County:

- Salt Creek tiger beetle – State and Federally Endangered
- Western Prairie Fringed Orchid – State and Federally Threatened
- Western Massasauga (rattlesnake) – State Threatened
- Saltwort – State Endangered

A focus of the greenway plan is to ensure threatened and endangered species habitat is protected and enhanced or expanded where possible. Buffers should also be considered to protect these areas.



Salt Creek Tiger Beetle
Photo Credit: Mitch Paine



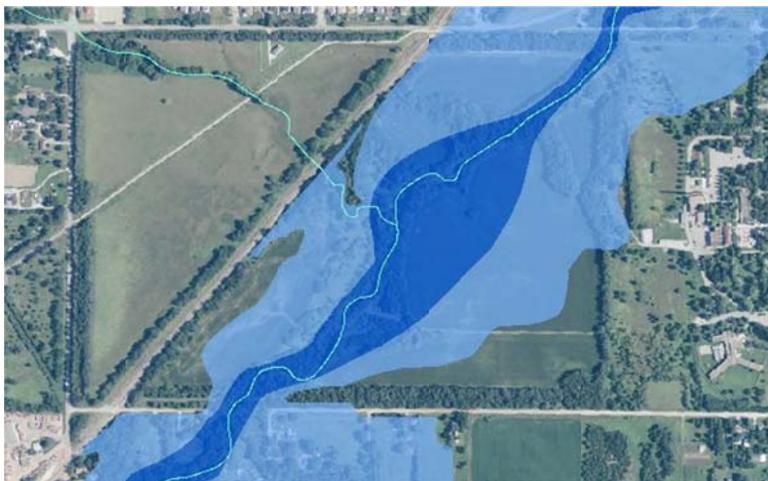
Basins and Streams

The greenway boundary lies entirely within the broader Salt Creek basin with the sub-basins of Little Salt Creek, Haines Branch, Oak Creek, and Stevens Creek. The Greenway's connecting corridors exist along floodplain areas in sub-basins to Salt Creek. Streams and creeks drain these basins and shape the natural topography of the greenway. These streams provide an anchor to a large portion of the shape of the greenway corridor. As a key feature of the greenway, streams provide ecological functions, habitat, recreation and the conveyance and storage of floodwaters. Additionally, streams provide the core of valuable riparian habitat and many woodland habitat areas. Lastly, these stream courses provide corridors for wildlife movement which is especially vital in urbanized portions of the greenway.



Floodplains and Riparian Areas

As streams provide an anchor to the alignment of the greenway, the adjacent floodplain areas store and convey storm water through the watershed. Historically, flooding shaped the landform of low-lying areas and maintained a variety of habitats. The alluvial soils that formed in these low-lying areas are highly productive for native species and crop production. The diversity and quality of these alluvial soils and hydrology constitute the core value of floodplain habitat. Today, floodplains still function as a habitat corridor but also provide storage of



floodwaters in urban environments. Large portions of the greenway are defined by floodplains and riparian areas. Floodplains provide valuable water conveyance during extreme precipitation events. They also often include hydric soils which provide habitat to a variety of plant communities and wildlife habitat. Riparian areas provide habitat and buffers between urban and agricultural areas and streams to help improve the water quality of runoff before it enters a watercourse.



Parks

There are over 6,000 acres of parks and public land within the City of Lincoln. The greenway and associated links provide a network of connections between the many park areas of the county. In addition to urban parks, county rural lands also contain many acres of public lands owned by the county, state and federal government. Parks provide areas for passive and active recreation. Within the city limits, parks offer valuable habitat for urban wildlife.



Trail Corridors

Trails provide an active link between people and greenway. Trail corridors provide an intra-greenway link between parks and open space and between urban and rural areas. Trail corridors are often a feature of greenways but not required. The City of Lincoln includes over 128 miles of existing trails with additional trails planned that will extend outside the city limits. Lincoln has been recognized by the League of American Bicyclists as one of 214 Bike Friendly Communities in 47 states. The National Recreation Trails Program lists thirteen miles of trail in Wilderness Park as a National Recreation Trail. The trail is easily accessible and meanders through woods, meadows and along Salt Creek throughout the park. In addition to human movement along trail corridors, wildlife uses these corridors for movement as well.

Other Recreational Areas

In addition to the public areas within the city limits, public lands outside the city limits include land areas owned and managed by the Nebraska Game and Parks Commission, U.S. Army Corps of Engineers, Lower Platte South NRD, National Resource Conservation Service (NRCS), and other public entities. In addition to publicly owned land, many acres of easements exist within or adjacent to the greenway that provide additional recreational/open space in the county.



Urban Forest

Urban forest areas exist throughout the city limits and consist of some native stand areas as well as many planted acres. Urban parks contain stands of trees and there are many acres of forest along lowlands in riparian areas and floodplains. These urban forest areas provide valuable habitat to a variety of mammal species and nesting areas for migratory birds. In addition to habitat, urban forest diversifies and improves the aesthetics of the urban landscape, provides space for recreationists and also provides shade relief in residential and commercial areas of the city.



Since 1976, Lincoln has been nationally recognized as a Tree City USA by the National Arbor Day Foundation. Additional awards include 19 consecutive years as a Tree City USA Growth Award and named the Sterling Tree City USA in 2000. City of Lincoln Parks & Recreation maintains over 125,000 public trees, of which 87,000 are located on 1,217 miles of streets.



Woodlands

Scattered amongst stands of tallgrass prairie, native woodlands historically grew on steeply sloped areas in narrow floodplains along meandering streams dissecting the landscape. The native wooded areas of the county consisted of bur oak and hickory varieties. Some areas of woodlands still exist in addition to stands of trees planted as windbreaks to support farming and land management practices. Woodlands also offer diversity to the landscape and provide

valuable habitat. For the greenway, woodlands provide a significant buffer between land uses and habitat types. Maintaining healthy woodland areas provides valuable habitat diversity amongst large areas of agricultural lands.



Agricultural Lands

Agriculture is a vital component to the county's economy. According to the Nebraska Department of Agriculture, Nebraska was 3rd nationally in corn production and 4th nationally in cash receipts from all farm commodities in 2011. While agriculture is no longer the primary occupation or major source of income in the county, it still accounts for 78% of all county land (LPlan2040). Soils developed over thousands of years by the breakdown of tallgrass prairie material and other native plants. This is the source of the county's high quality farmland. By educating citizens about the connection between natural history and agricultural development and economic success, a balance can be made between agricultural lands and natural resource preservation and restoration.



Cultural and Historic Landscapes

Native Americans subsisted on wild game, fish, and native fruits among the dense stands of tall grasses on what is now Lancaster County. John D. Prey founded the first settlement in the county along Salt Creek in 1856. A settlement called Lancaster was made near present day Capitol Beach (historically called Salt Lake) in 1857 by W.T. Donovan. The Lancaster settlement was later abandoned but the name was given to a village later formed near the site of present day Lincoln (NRCS Lancaster County Soil Survey).



Early settlers were drawn to the unique salt deposits of the Salt Creek Valley. Settlers and Native Americans purchased salts harvested from the deposits and commercial salt production efforts were attempted. The salt deposits were difficult to purify and therefore salt production efforts were abandoned. In 1859, the overland trail route was redirected through this area and that increased the pace of settlement in Lancaster. Lancaster County was formed in 1859 and later expanded in 1863 to its present land area. The village of Lancaster was made county seat in 1864 and renamed Lincoln and the state capital.



Views and Vistas

The greenway alignment largely follows floodplain and low-lying areas but some portions of the greenway links provide scenic vistas of the county. High points along basin ridgelines and within greenway links provide views over the rolling hills of Lancaster County. Interpretive signs at these distinguished vistas could provide the public information about the topography. (As in the other resource items – need to reference where in Greenway or corridors these are strong).



Greenway Boundary Refinement Process

A primary task of the master planning process was to refine the greenway boundary established by the City-County Planning Department in the 2040 Comprehensive Plan. The refinement process took many spatial resources into consideration. These spatial resources included floodplain and floodway boundaries, vegetation boundaries (such as agricultural land, grasslands, and trees/shrub cover) as identified from aerial photography, public and private property lines and widths necessary for new trails and right-of-way. In addition to these spatial considerations, published research on minimum riparian corridor width for bird and mammal movement and research on minimum buffer widths for water quality were utilized to refine the greenway boundary. Generally speaking for the entire greenway, a minimum width of approximately 500 feet was used in the refinement process.

In 2010, Samantha Bray at the University of Nebraska-Lincoln completed a thesis titled “Minimum Riparian Buffer Width for Maintaining Water Quality and Habitat Along Stevens Creek”. The thesis is a literature review that determined minimum riparian buffer widths for maintaining water quality and habitat along Stevens Creek. Only literature sources with a specific water quality and habitat element were considered. ArcGIS software was used to visually represent future land use in the Stevens Creek watershed. The review concluded a width of about 500 feet would be adequate for all wildlife groups (birds, mammals, reptiles and amphibians) and water quality considerations (water temperature, pollutants, and sediment). Although specific to the Stevens Creek basin, the width recommendations of the literature review were applied to the entire greenway refinement process. The minimum width recommendations can be found in Figure 1-4. The full publication can be found in Appendix D.

Category	Minimum Width		Additional notes	Source
	ft	m		
Water Quality				
Water temperature	15	5	For small streams; forested	Palone and Todd, 1998
Pollutants				
Nitrates	35	11		Palone and Todd, 1998
Pesticides	45	14		Palone and Todd, 1998
Sediment				
General	25	8	On slopes <16%; Expand by 5 ft for each 1% increase in slope	Palone and Todd, 1998
Sand	10	3		Wilson, 1967
Silt	50	15		Wilson, 1967
Clay	300	91		Wilson, 1967
Wildlife				
Edge Species	25	8		Keller et al., 1993
Aquatic Communities	50	15	Depends on stream size	Klapproth and Johnson, 2001
Bird Communities	82	25	Includes area-sensitive species	Croonquist and Brooks, 1991
Large Mammals	100	30		Croonquist and Brooks, 1991
Semi-aquatic Reptiles	417	127		Semlitsch and Bodie, 2003
Semi-aquatic Amphibians	522	159		Semlitsch and Bodie, 2003

Figure 1-4: Minimum riparian buffer widths (adapted from “Minimum Riparian Buffers Widths for Maintaining Water Quality and Habitat Along Stevens Creek” (Bray 2010).

An additional reference was used to determine greenway width. Iowa State University’s extension service published a document titled “Conservation Buffers & Water Quality”. This publication is most applicable to the links located where the primary land use is agricultural such as Stevens Creek, South & East Beltway, Wagon Train and Salt Creek South. Although focused on the water quality value of buffers, this study also provided recommendations for buffer strip widths for a variety of functions. A table from the publication was adapted and included here as Figure 1-5. The full publication can be found in Appendix D.



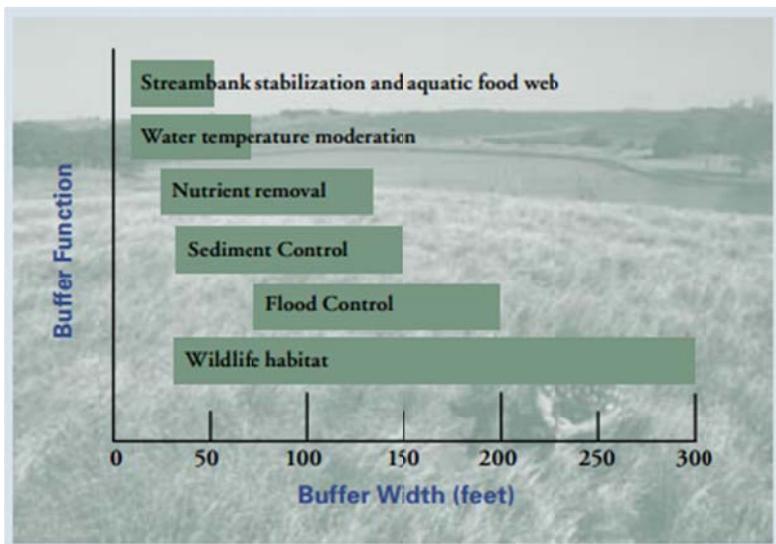


Figure 1-5: Buffer Widths (adapted from “Conservation Buffers & Water Quality” publication by Iowa State Univ (Al-Kaisi et. Al 2009)



APPENDIX C

PRAIRIE CORRIDOR SPATIAL ANALYSIS

The Prairie Corridor boundary was defined by key features in the watershed; the stream centerlines of Haines Branch and Spring Creek, adjacent riparian areas, land ownership boundaries, conservation easements, native prairies and wetlands. A potential prairie corridor expansion has also been defined and is shown on Map C-1. To further refine the corridor boundary and assist land managers in strategizing future natural resource preservation and enhancement, a spatial data analysis method was developed. The method is based at the individual parcel level. The analysis utilized data collected in the prairie corridor inventory as shown in Map C-1. Additionally, aerial photography (Map C-2) and soils information related to the ease of native prairie re-establishment (Map C-3) were considered. Additional soils data and analysis can be found in Appendix E. Qualitative rankings were applied to these GIS based data sources to both evaluate and delineate the Prairie Corridor. The results of this method throughout the corridor will serve as a valuable tool in the Prairie Corridor master plan.

Parcel Level Analysis

The goal of the *parcel-based* analysis is to evaluate the natural resources in the Haines Branch Watershed and prioritize parcels based on existing habitat diversity and connectivity. Each parcel was assigned a value of 1 to 4 for both diversity and connectivity with 1 being the highest and 4 being the lowest. Using a matrix approach, these two metrics are combined to assign an overall priority on each parcel. This parcel priority map will be a tool for managers of the Prairie Corridor Master Plan to purchase and manage properties.

Habitat Diversity

Pre-dominate habitat types by coverage area were assigned on a parcel basis as shown in Map C-4. These habitat types include corridor natural resources such as virgin prairie, native prairie seeded areas, pasture, woodlands, saline and freshwater wetlands and lakes. Additionally, landuse types were analyzed including farmsteads, acreages, agricultural lands and urban development. These resources were ranked as shown below and in Map C-5.

1. Highest – Woodlands or Virgin Prairie or Saline Wetlands
2. Native Seeding or Freshwater Wetlands or Lakes
3. Pasture or Open Areas or Agricultural Lands
4. Lowest – Farmsteads or Acreages or Urban Development

Habitat Connectivity

Connectivity of riparian habitat was evaluated based on two general criteria. First, parcel proximity to the Haines Branch and Spring Creek stream centerlines. Second, parcel proximity to areas with existing wildlife habitat, public ownership or conservation easements. Parcels that fall within a buffer of 250ft on each side of the stream centerline have the highest connectivity. A total buffer width of 500ft was chosen for the connectivity test based on wildlife corridor minimum distances and riparian buffer width minimum distances to improve water quality from agricultural runoff. This number was based on NRCS research and a literature review conducted in the Stevens Creek watershed (Bray 2010). Buffer recommendations ranged from 25-300ft for sediment capture and runoff water quality improvement and 25-522ft for wildlife habitat/movement. Based on these ranges, a total conservative buffer corridor width of 500ft was used for the connectivity analysis. Parcel Connectivity was ranked as shown below and in Map C-6.

1. Highest – Parcels that are either
 - a. within a 250' buffer of a corridor stream centerline
 - b. within the FEMA floodway
2. Parcels adjacent to a parcel with a "1" or "2" connectivity that also have a habitat diversity value of 1 or 2 and/or is publicly owned or has a conservation easement.



3. Parcels that are adjacent to either
 - a. a parcel with a parcel with a “1” or “2” connectivity that also have a habitat diversity value of 3 or 4 and/or is privately owned or,
 - b. a parcel with a “3” connectivity that also has a habitat diversity value of 1 or 2 and/or is publicly owned or has a conservation easement.
4. Parcels that are adjacent to either
 - a. a parcel with a “3” connectivity with a habitat diversity value of 3 or 4 and/or is privately owned or,
 - b. a parcel with a “4” connectivity.

Priority Matrix for Evaluating Habitat Diversity and Connectivity

Through a matrix approach, the values assigned to habitat diversity and connectivity can be combined to assign an overall priority for each parcel. Table C-1 demonstrates how this process works. Take for example a parcel with saline wetlands that is adjacent to a parcel with “2” connectivity and has a conservation easement on agricultural land. Using the habitat diversity and connectivity definitions above, this parcel would receive a value of “1” for habitat diversity and a value of “2” for habitat connectivity. Using the matrix below, this parcel would receive an overall priority rating of “1”. If the adjacent parcel did not have a conservation easement, the habitat connectivity would drop to a “3” and the overall priority rating would become a “2”. The parcel priority analysis results are shown in Maps C-7 and C-8. The latter map contains the delineated prairie corridor boundary based on this analysis.

Table C-1: Parcel Priority Matrix

Habitat Connectivity		Habitat Diversity				
		Highest	→	Lowest		
		1	2	3	4	
↓	Highest	1	1	1	2	
		2	1	2	3	4
		3	2	3	4	5
	Lowest	4	3	4	5	5

Land Management Strategies

A Land Management Strategies Map was generated (Map C-9) based on the Predominate Habitat Map discussed above (Map C-4). A parcel that was determined to have virgin prairie on either all or a portion of it would be considered for preservation or enhancement of virgin prairie. Likewise if a parcel contained saline wetlands it would be considered for preservation or enhancement of riparian areas. Parcels containing agricultural or urban habitat types would be considered for conversion to either native prairie or riparian areas depending on soil types and proximity to existing habitats. The strategies and their related habitat type are provided below.

1. Preservation or Enhancement of Virgin Prairie – Virgin Prairie
2. Enhance Native Seeding – Native Seeding
3. Convert to Native Prairie – Pasture, Agriculture, Urban and Open Areas
4. Preservation or Enhancement of Riparian Area – Saline and Freshwater Wetlands, Lakes and woodlands
5. Convert to Riparian Area – Pasture, Agriculture, Urban and Open Areas



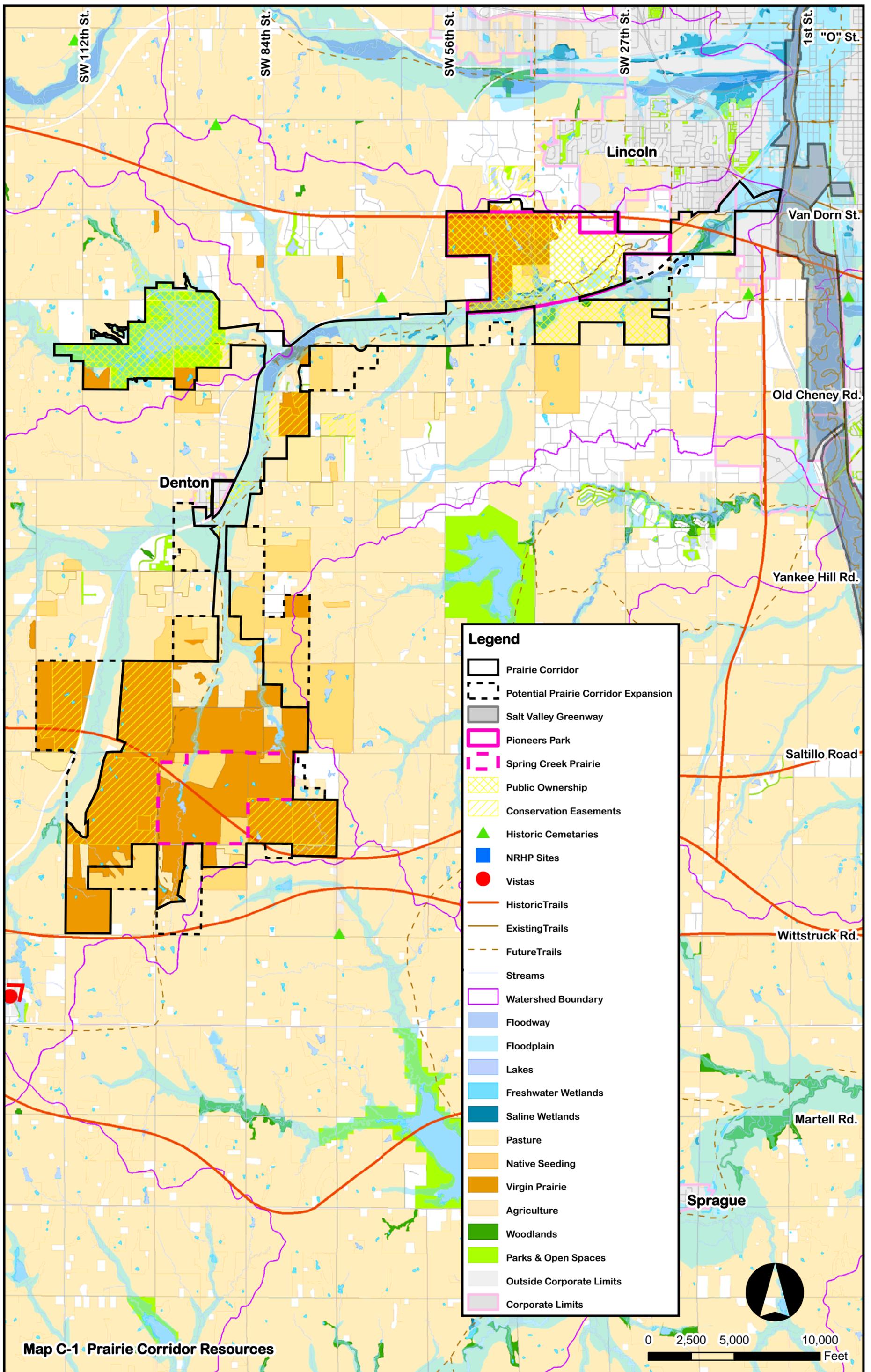
The land management strategies were incorporated into the Parcel Priority Analysis to yield Table C-2.

Table C-2: Parcel Priority and Land Management Strategy Acres within the Prairie Corridor

Strategy	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Total
Preserve and Enhance Virgin Prairie	3,381	37	-	-	-	3,418
Enhance Existing Native Seeding	257	29	-	-	-	286
Reseed to Native Prairie	1,048	403	160	43	14	1,668
Preserve and Enhance Saline Wetlands	32	-	-	-	-	32
Enhance Existing Riparian Areas	354	778	109	-	-	1,242
Reseed to Riparian Area	-	87	316	63	8	474
Totals	5,072	1,333	585	106	22	7,119
Public Ownership						4,548
Private Ownership						2,571

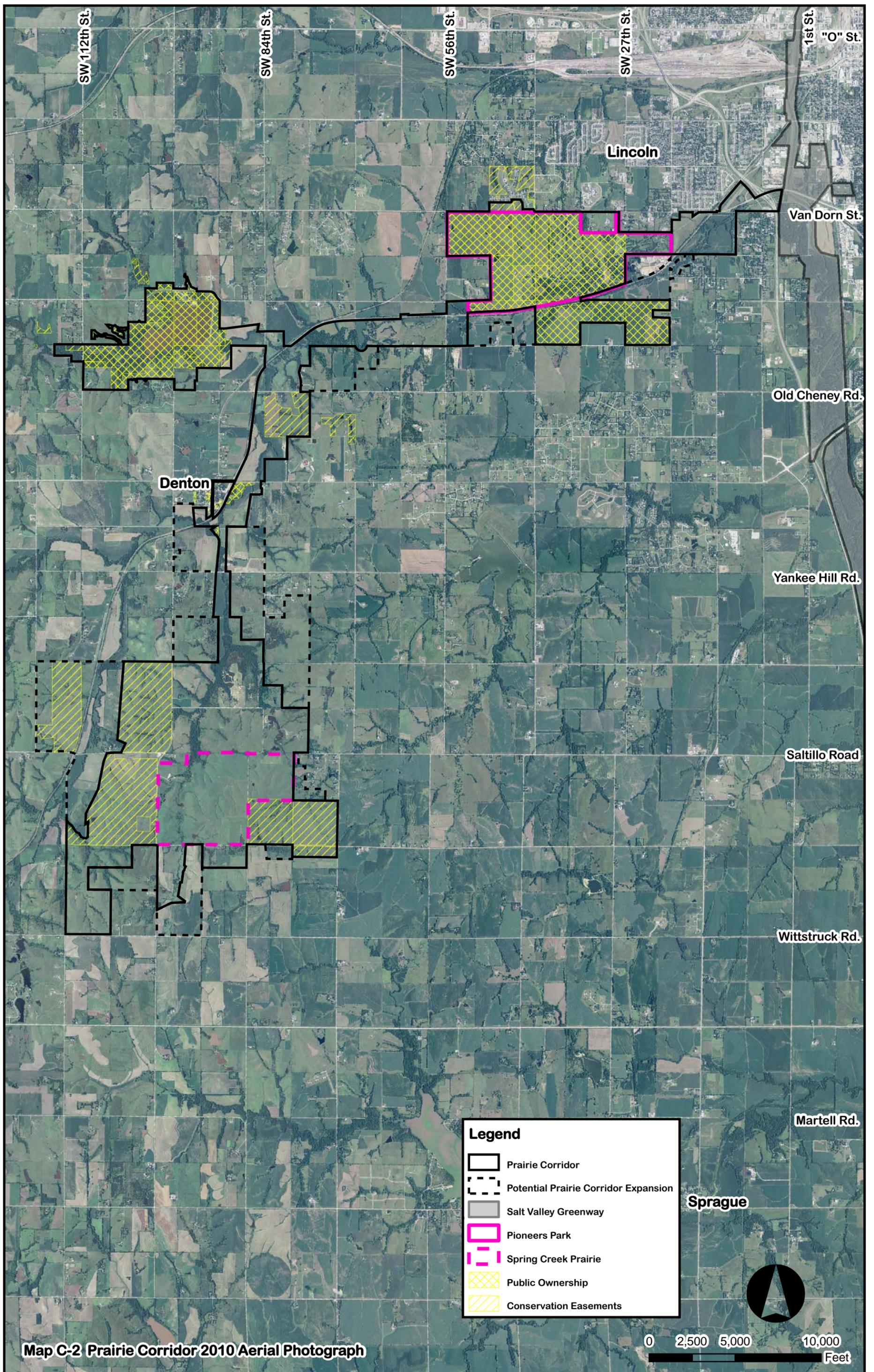
Note: Public Ownership Includes Acres under Conservation Easement and Public Lands. Total Prairie Corridor Area is 7,310ac, of which 191ac are Road and Railroad Right-Of-Way.





Map C-1 Prairie Corridor Resources

0 2,500 5,000 10,000 Feet



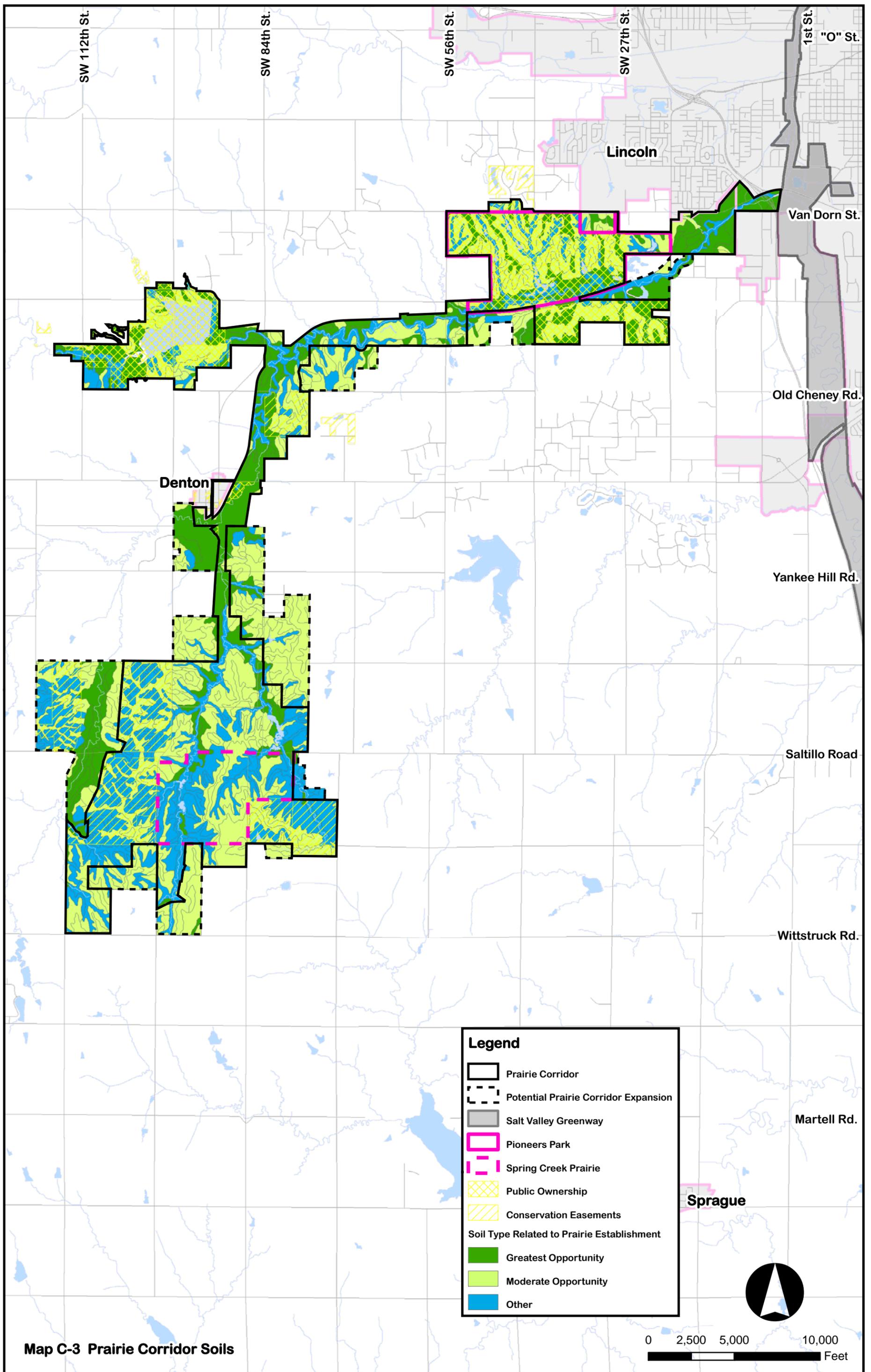
Map C-2 Prairie Corridor 2010 Aerial Photograph

Legend

-  Prairie Corridor
-  Potential Prairie Corridor Expansion
-  Salt Valley Greenway
-  Pioneers Park
-  Spring Creek Prairie
-  Public Ownership
-  Conservation Easements

Sprague





Map C-3 Prairie Corridor Soils

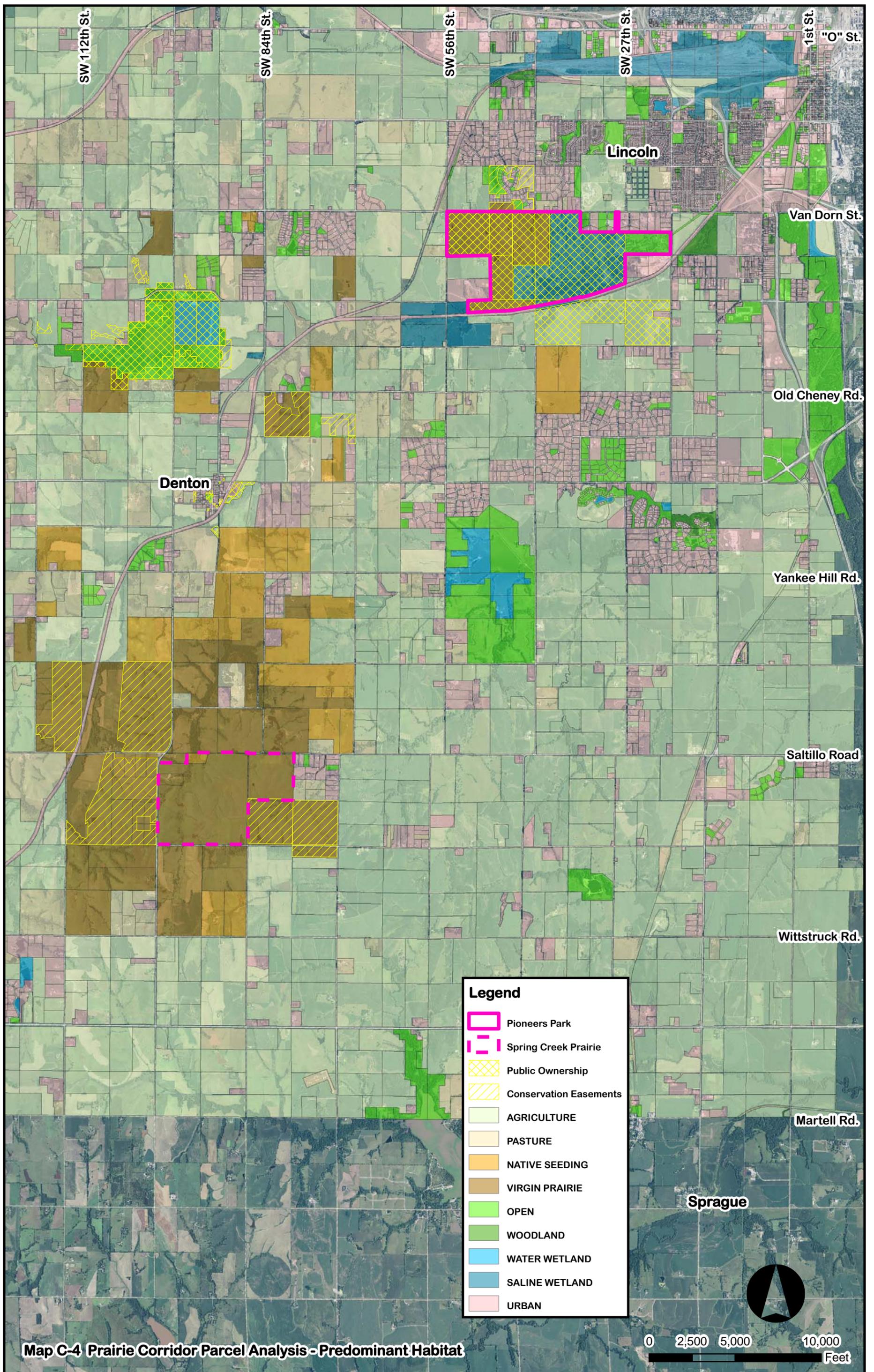
Legend

-  Prairie Corridor
-  Potential Prairie Corridor Expansion
-  Salt Valley Greenway
-  Pioneers Park
-  Spring Creek Prairie
-  Public Ownership
-  Conservation Easements

Soil Type Related to Prairie Establishment

-  Greatest Opportunity
-  Moderate Opportunity
-  Other





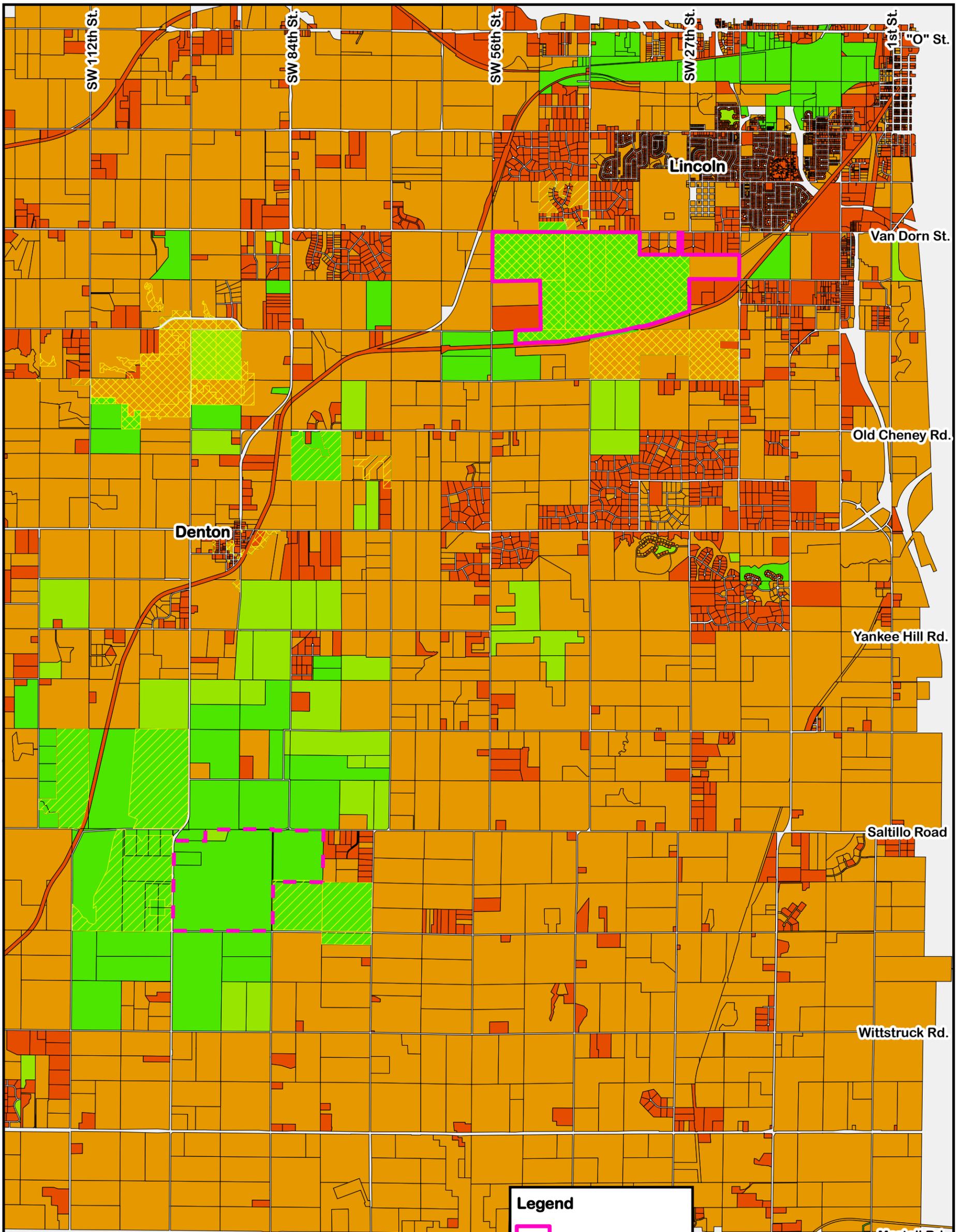
Legend

- Pioneers Park
- Spring Creek Prairie
- Public Ownership
- Conservation Easements
- AGRICULTURE
- PASTURE
- NATIVE SEEDING
- VIRGIN PRAIRIE
- OPEN
- WOODLAND
- WATER WETLAND
- SALINE WETLAND
- URBAN

Map C-4 Prairie Corridor Parcel Analysis - Predominant Habitat

0 2,500 5,000 10,000 Feet





Legend

-  Pioneers Park
-  Spring Creek Prairie
-  Public Ownership
-  Conservation Easements

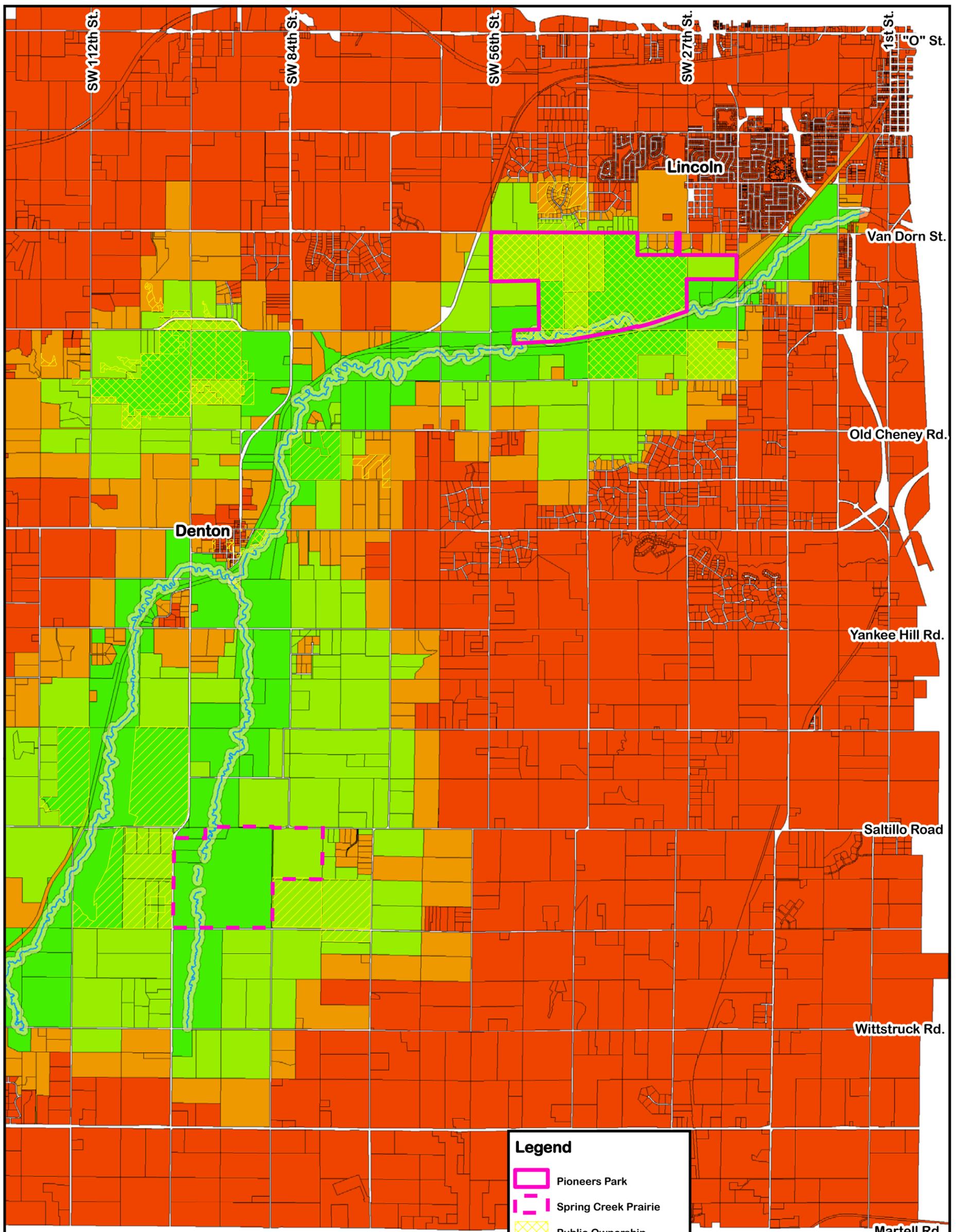
Habitat Diversity

-  1 - Highest
-  2
-  3
-  4 - Lowest

Sprague



Map C-5 Prairie Corridor Parcel Analysis - Habitat Diversity



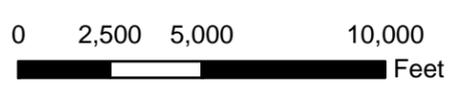
Legend

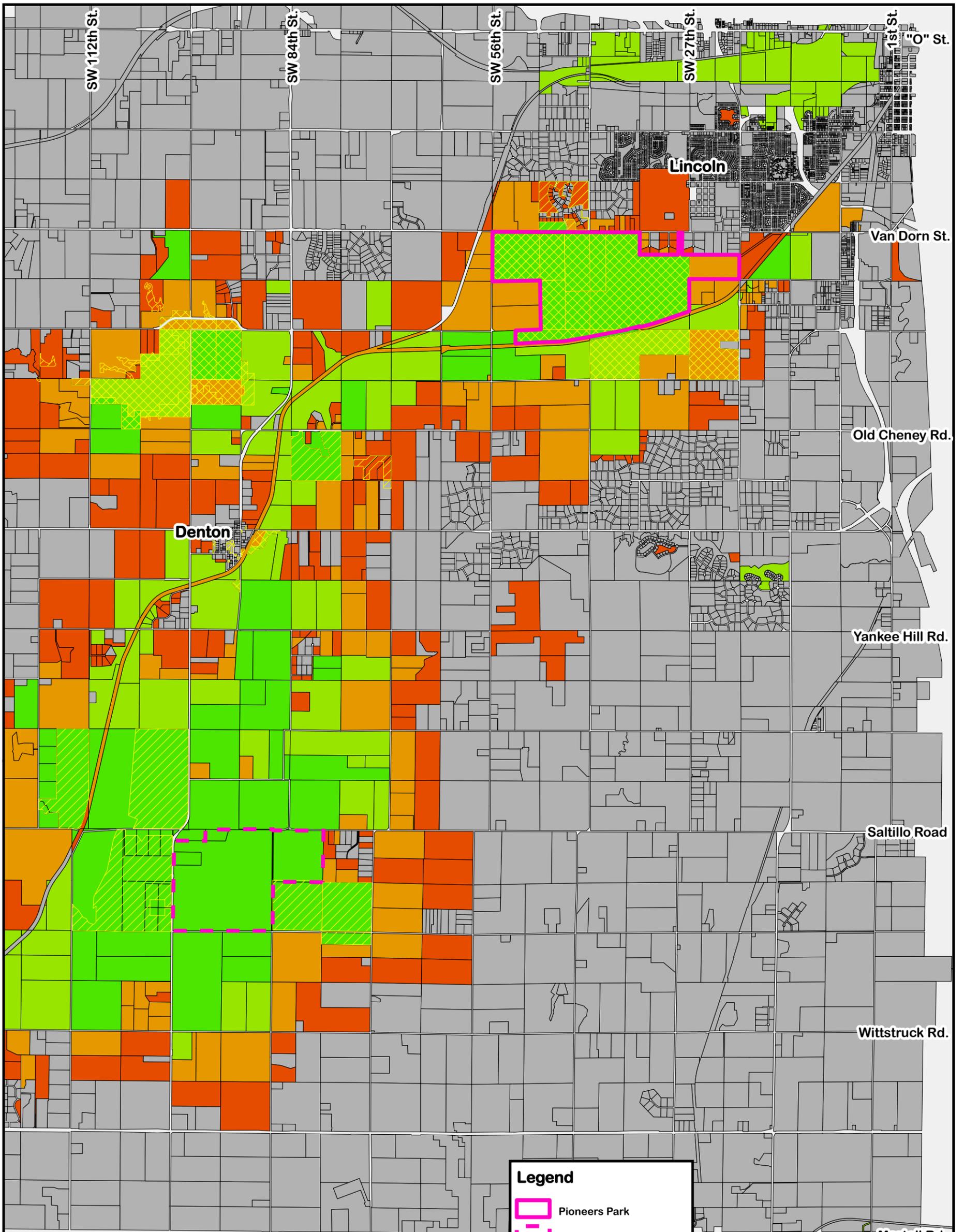
-  Pioneers Park
-  Spring Creek Prairie
-  Public Ownership
-  Conservation Easements
-  Stream Centerline
-  500' Buffer
- Habitat Connectivity**
-  1 - Highest
-  2
-  3
-  4 - Lowest

Sprague



Map C-6 Prairie Corridor Parcel Analysis - Habitat Connectivity





Legend

-  Pioneers Park
-  Spring Creek Prairie
-  Public Ownership
-  Conservation Easements

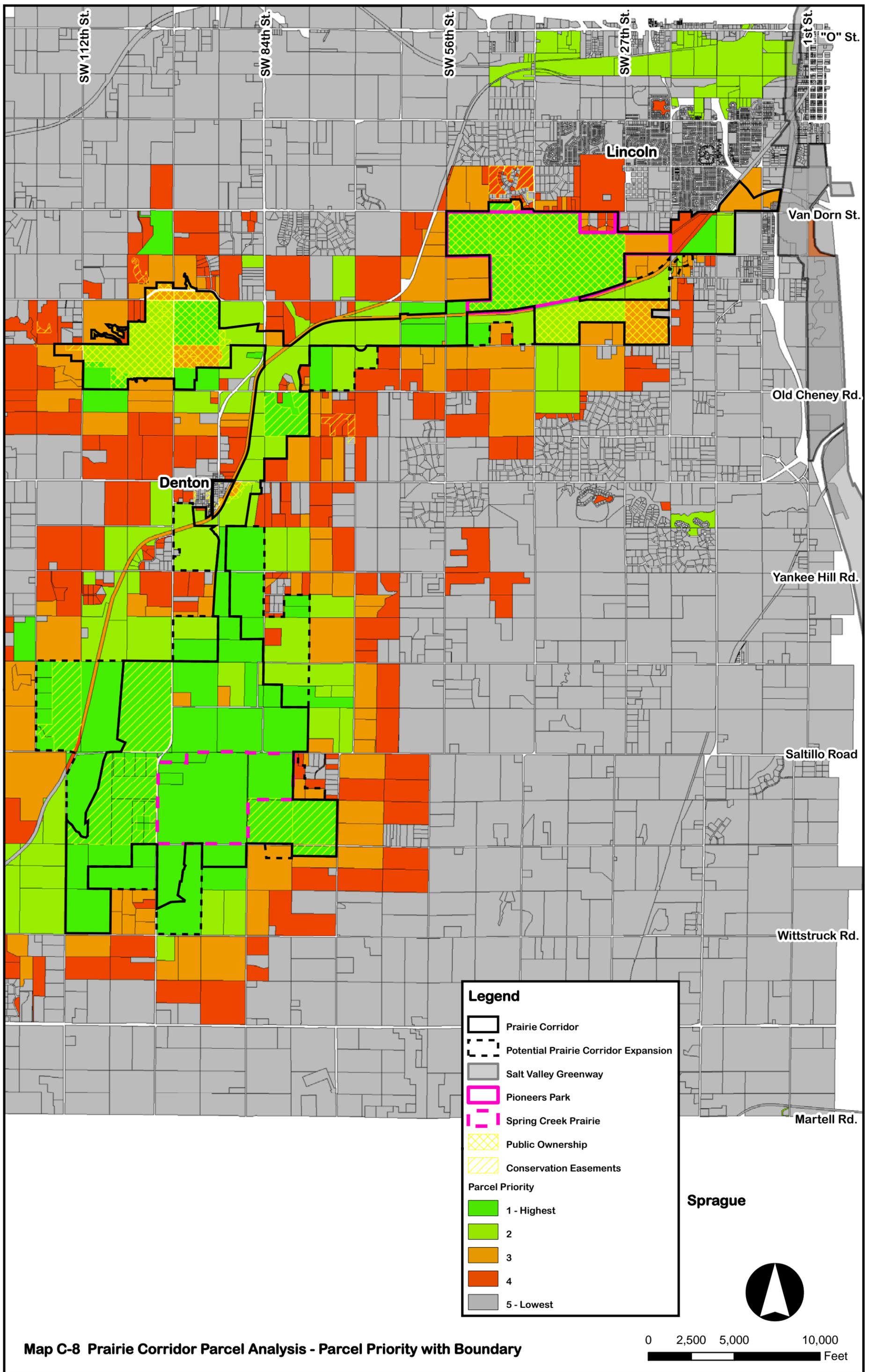
Parcel Priority

-  1 - Highest
-  2
-  3
-  4
-  5 - Lowest

Sprague



Map C-7 Prairie Corridor Parcel Analysis - Parcel Priority



Legend

- Prairie Corridor
- Potential Prairie Corridor Expansion
- Salt Valley Greenway
- Pioneers Park
- Spring Creek Prairie
- Public Ownership
- Conservation Easements

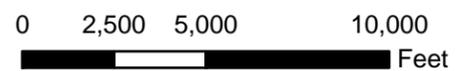
Parcel Priority

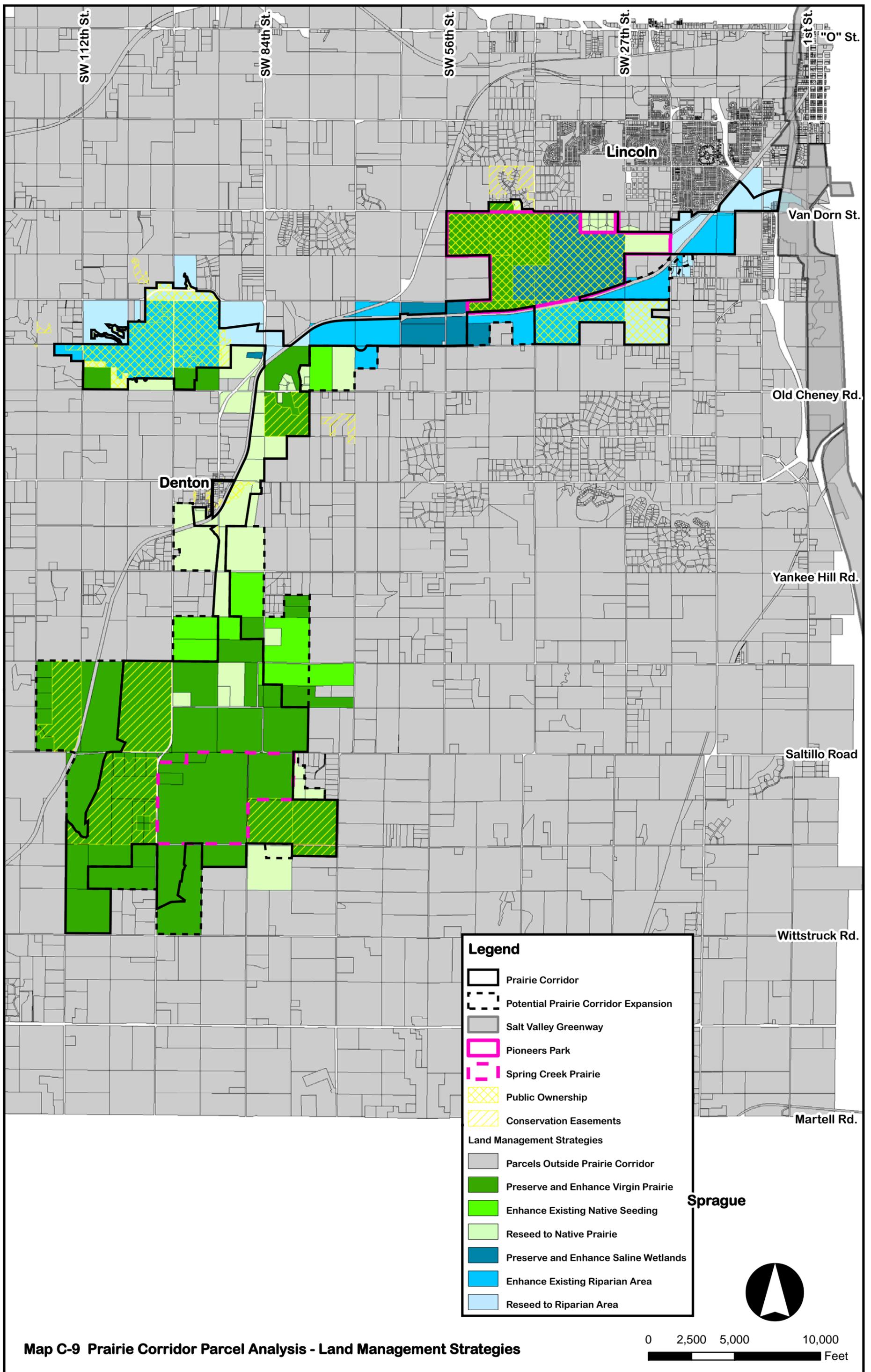
- 1 - Highest
- 2
- 3
- 4
- 5 - Lowest

Sprague



Map C-8 Prairie Corridor Parcel Analysis - Parcel Priority with Boundary





Map C-9 Prairie Corridor Parcel Analysis - Land Management Strategies

0 2,500 5,000 10,000 Feet

Legend

-  Prairie Corridor
-  Potential Prairie Corridor Expansion
-  Salt Valley Greenway
-  Pioneers Park
-  Spring Creek Prairie
-  Public Ownership
-  Conservation Easements

Land Management Strategies

-  Parcels Outside Prairie Corridor
-  Preserve and Enhance Virgin Prairie
-  Enhance Existing Native Seeding
-  Reseed to Native Prairie
-  Preserve and Enhance Saline Wetlands
-  Enhance Existing Riparian Area
-  Reseed to Riparian Area



Sprague

APPENDIX D

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Minimum Riparian Buffer Width for Maintaining Water Quality and Habitat Along Stevens Creek

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University of Nebraska at Lincoln

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MINIMUM RIPARIAN BUFFER WIDTH FOR MAINTAINING WATER QUALITY AND
HABITAT ALONG STEVENS CREEK

By

Samantha Bray

AN UNDERGRADUATE THESIS

Presented to the Faculty of
The Environmental Studies Program at the University of Nebraska-Lincoln
In Fulfillment of Requirements
For the Degree of Bachelor of Science

Major: Environmental Studies
With the Emphasis of: Natural Resources

Under the Supervision of Dr. Charles Francis

Lincoln, Nebraska

May 2010

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ABSTRACT

Riparian buffer zones are important sites of biodiversity, sediment trapping, pollutant removal, and hydrologic regulation that have significant implications for both people and wildlife. Urbanization's influence on and need for adequate water quality increases the need for careful planning in regards to riparian areas. Wildlife are key components in the ecosystem functions of riparian zones and require consideration in peri-urban planning as well. This study reviews relevant literature to determine the recommended minimum riparian buffer width for maintaining water quality and habitat along Stevens Creek in Lincoln, Nebraska. Only sources that listed a specific purpose related to water quality and habitat for their buffer width recommendations were considered. The study found that the baseline buffer width recommended for Stevens Creek that would be adequate for both water quality maintenance and basic habitat is 50 ft (15 m) per side. This number may be modified based on other factors such as slope, soil particle size, adjacent land use, the presence of certain wildlife communities, stream size, and stream order.

INTRODUCTION

The purpose of this thesis is to use a literature review to determine the necessary riparian buffer width for maintaining water quality and habitat along Stevens Creek. Riparian zones are defined as linear strips of vegetation directly adjacent to bodies of water (Whitaker and Montevecchi, 1999). They are important regulators of the flow of organic material, water, nutrients, and organisms between and within landscape elements (Vince et al., 2005). Riparian zones perform many important ecological and biological functions through the interaction of their hydrology, soils, and biotic communities, which have important social benefits as well (Klapproth and Johnson, 2009). Continuous, ecologically functioning riparian corridors have been found to positively affect water quality and habitat in addition to improving aesthetic properties of the landscape (Forman and Godron 1986). The services that riparian zones provide are numerous, but this paper will focus on water quality and habitat.

Degraded water quality poses serious threats to humans and wildlife (Changhua, 1999). Riparian buffers improve or maintain water quality by trapping sediment and debris, stabilizing stream banks and reducing erosion, and promoting the infiltration of runoff (Palone and Todd, 1998). There is substantial scientific evidence indicating that riparian buffers are cost-effective tools for mitigation of water quality problems, and can be integrated into stormwater management in urban areas (Buffleter et al., 2005; Palone and Todd, 1998). Riparian forests are able to capture, absorb, and store 40 times more rainfall than disturbed soils. Fairfax County, Virginia estimated stormwater reduction benefits of \$57 million annually from its riparian buffers. Riparian wildlife and ecosystems are also affected by water quality, as water quality is a primary determinant of the plant and animal species existing in and the ecological interactions of riparian systems (Palone and Todd, 1998). Riparian areas provide a sheltered environment for

many different species of wildlife to feed, drink, rest, and reproduce, and serve as movement corridors between larger habitats (Palone and Todd, 1998).

The Stevens Creek watershed is located immediately east of Lincoln, Nebraska, and drains approximately 55 square miles (142 sq km) to its confluence with Salt Creek (Fig. 1). It was selected as the site of this study because of the potential risk to the quality of the creek and its adjacent habitat from the significant near-future urban growth and agriculture in the basin (Fig. 2)(CDM, 2005).

The importance of riparian zones for habitat and water quality makes studying the conditions required for the provision of these services essential to riparian planning and management. It is particularly significant for Stevens Creek because of the expansion of the city of Lincoln into the Stevens Creek watershed in the relatively near future. The water quality of the creek affects not just people living within the watershed, but all water users downstream as well. If habitat is not provided for riparian species or species travelling between larger tracts of habitat, the loss or degradation of the riparian zone could result in habitat fragmentation and loss of biodiversity. This study may also be used as a model for the planning of other riparian systems for water quality and habitat.

Specific research questions addressed in this paper include 1) what are the minimum riparian buffer widths recommended in order to maintain water quality? 2) what are the minimum riparian buffer widths recommended in order to preserve adequate riparian habitat for various wildlife species guilds? and 3) what characteristics of the surrounding landscape change width requirements for water quality and habitat purposes? The study is limited by a lack of current water quality data, an inventory of wildlife species and their habitat needs, and the

inherent assumption that water quality and wildlife around Stevens Creek are important to people living in Lincoln (Koehler-Cole, 2008). It should also be noted that all buffer widths mentioned in this paper refer to buffer width on one side of the stream.

The first section of this thesis will detail the methods used to collect information, followed by a section that details and summarizes the results of the study. The discussion section will explore the variability in the results and possible adjustment factors for buffer width. Finally, the conclusion section will make recommendations for Stevens Creek and summarize the study.

METHODS

A literature search of books, peer-reviewed journal articles and publications was conducted to determine minimum riparian buffer width recommendations for habitat and water quality purposes. The recommendations were then summarized and applied to Stevens Creek as the width that would likely protect water quality and habitat based on those recommendations.

ArcGIS Version 9.0 software was used to visually represent the future land use of the watershed. The land use data layer was provided by the City of Lincoln's Planning Department. The land use data layer included the entire county, but was clipped to only include the Stevens Creek watershed. This information illustrated potential nonpoint sources of pollutants and sediments and the relative scale of impact on water quality of Stevens Creek.

RESULTS

Literature Review

Water Quality

Water temperature is important for aquatic communities and processes. Increasing temperature stimulates growth of algae, which remove oxygen that is needed by water-dwelling species. The shading of streams by forested riparian buffers decreases the temperature in the summer and lessens the temperature reduction in winter. Forested buffers as narrow as 15 ft (5 m) have been found to provide adequate shade for reducing the temperature extremes of small streams (Palone and Todd, 1998).

Large amounts of water-soluble nitrates can be intercepted by tree roots when shallow groundwater flows through the root zone. Woody plants are particularly effective at nitrogen removal through relatively aggressive nitrogen uptake and moisture retention. Leaf litter from woody plants also contributes to surface organic matter that increases infiltration. Soils high in organic matter remove nitrates through denitrification by bacteria. Studies show that nitrogen removal can be 25 to 90% effective in buffers as narrow as 35 ft (11 m) if environmental conditions for vegetative uptake, water storage, and denitrification are ideal (Palone and Todd, 1998).

Buffers of 45 ft (14 m) have been found to be effective at reduction of stream contamination by pesticides. The use of the term “pesticides” here excludes herbicides, as there is a lack of sufficient data on removal of herbicides in runoff and groundwater by riparian buffers. Most organic pesticides are subject to the processes of microbial breakdown in the surface organic material of riparian zones. Riparian buffers also help protect streams from pesticides by shielding them from chemical drift (Palone and Todd, 1998).

Phosphorous is a common water pollutant, but it is not considered separately for this study because 90% of phosphorous carried in runoff is attached to soil particles or organic matter. While many other pollutants also become adsorbed to soil particles, with phosphorous the amount is particularly high. Managing for reduction of sediments transported in runoff, therefore, would reduce the phosphorous load to streams (Palone and Todd, 1998). Sediment trapping functions of buffers must be considered by soil particle sizes: sand, silt, and clay. Research shows that a 10 ft (3 m) buffer is adequate for most sand-sized particles and 50 ft (15 m) is adequate for silt-sized particles, but smaller clay-sized particles would require a buffer that is at least 300 ft (91 m) wide (Wilson, 1967).

Wildlife

Studies of wildlife can be separated into guilds based on their use of resources (Croonquist and Brooks, 1991). This paper considered edge species, aquatic communities, large mammals, bird communities, and semi-aquatic reptiles and amphibians.

Of the guilds evaluated in this paper, edge species have the smallest requirement of 25 ft (8m) (Croonquist and Brooks, 1991). Edge species prefer the boundaries between patches or habitats of differing qualities, such as a riparian forest and a pasture (Ries and Sisk, 2004).

Aquatic communities are influenced by riparian forests in a number of ways: through effects on food availability, stream flow, light intensity, habitat diversity, and water chemistry. These factors are major determinants of the variety and productivity of plants, microorganisms, fish, and invertebrates that occur in a given stream. A riparian buffer width of 50 ft (15 m) is recommended for the benefit of aquatic communities in small streams (Klapproth and Johnson, 2001).

A study by Croonquist and Brooks (1991), as cited by Klapproth and Johnson (2009), found that large mammals require wider buffers of at least 100 ft (30 m). Klapproth and Johnson (2009) also found that many studies that have attempted to determine riparian buffer width requirements for small mammals have yielded conflicting results, and therefore small mammals are not considered in this paper. The use of riparian buffers by small mammals is possibly related to vegetation structure and habitat quality (Klapproth and Johnson, 2009). This is also an important factor influencing effectiveness of riparian buffers in addition to buffer width, and will be discussed in the following section.

In a study that evaluated bird use of riparian areas in Pennsylvania, Croonquist and Brooks (1991) found that a buffer of 82 ft (25 m) provided adequate breeding and dispersal opportunities for bird communities, including area-sensitive species (Croonquist and Brooks, 1991). Birds are also sensitive to habitat vegetation structure. Their needs vary between breeding, nesting, and other life stages, and may require a diverse species mix to create structural diversity of vegetation for different purposes (Schultz et al., 2004).

Semlitsch and Bodie (2003) performed an extensive literature review examining terrestrial habitat use by many different amphibian and reptile species associated with wetlands. This study determined that the minimum buffer width requirement that would account for the essential terrestrial life stages of semi-aquatic reptiles was 417 ft (127 m), and 522 ft (159 m) for semi-aquatic amphibians. Terrestrial habitats adjacent to wetlands and streams were used by amphibians for foraging, overwintering sites, and refuge. The study found that some amphibians only moved about 65 to 100 ft (30 m), whereas others moved 3,200 to 5,200 ft (975 to 1585 m). However, the authors believe that 522 ft (159 m) is adequate for maintaining amphibian diversity in riparian habitats (Semlitsch and Bodie, 2003).

Reptiles use terrestrial habitats adjacent to wetlands for basking, hibernating, nesting, and burrowing. Again, the distance moved from water in the study varied widely. Some reptile species rarely moved more than 100 ft (30 m), whereas others moved 415 to 950 ft (126 to 290 m) from their home wetlands. Although there is a wide range in movement and wetlands vary greatly in characteristics, the data suggests that a single minimum width of 417 ft (127 m) is sufficient to encompass the riparian areas that are biologically necessary for all reptilian life stages (Semlitsch and Bodie, 2003).

Table 1. Summary of Findings

Category	Minimum Width		Additional notes	Source
	ft	m		
Water Quality				
Water temperature	15	5	For small streams; forested	Palone and Todd, 1998
Pollutants				
Nitrates	35	11		Palone and Todd, 1998
Pesticides	45	14		Palone and Todd, 1998
Sediment				
General	25	8	On slopes <16%; Expand by 5 ft for each 1% increase in slope	Palone and Todd, 1998
Sand	10	3		Wilson, 1967
Silt	50	15		Wilson, 1967
Clay	300	91		Wilson, 1967
Wildlife				
Edge Species	25	8		Keller et al., 1993
Aquatic Communities	50	15	Depends on stream size	Klapproth and Johnson, 2001
Bird Communities	82	25	Includes area-sensitive species	Croonquist and Brooks, 1991
Large Mammals	100	30		Croonquist and Brooks, 1991
Semi-aquatic Reptiles	417	127		Semlitsch and Bodie, 2003
Semi-aquatic Amphibians	522	159		Semlitsch and Bodie, 2003

DISCUSSION

A buffer that is only wide enough for sand (10 ft; 3 m), water temperature (15 ft; 5 m), edge species (25 ft; 8 m), nitrates (35 ft; 11 m), or pesticides (45 ft; 14 m) would be inadequate for the sediment trapping function of an area with soil surface layers high in silt or clay sized particles. A riparian buffer width of 50 ft (15 m) would encompass all of the previously listed categories, as well as trapping of silt-sized sediment and habitat maintenance for aquatic communities. While it would fulfill all water quality recommendations and some of those for wildlife, the wildlife guilds not accounted for in a 50 ft (15 m) buffer are bird communities, large mammals, and semi-aquatic reptiles and amphibians. However, the benefits of a complete riparian buffer around Stevens Creek of 522 ft (159 m) so as to encompass all wildlife guilds in addition to water quality considerations would likely become uneconomical for private landowners adjacent to the creek.

It is possible that a variable width buffer design may be more effective for Stevens Creek. A variable width design includes a baseline width that is reduced or expanded based on certain landscape features or species of interest. The baseline width provides acceptable levels of all needed benefits at a reasonable cost (Dosskey et al., 1997). Actual buffer widths should be adjusted to fit the site (Schultz et al., 2009). Some bodies of water, riparian zones, and their adjacent upland areas have different characteristics that require individual consideration in order for management objectives to be met. Even along the same water body there is variability in landscape features such as presence of wetlands, width of the floodplain, slope, and soil type (Palone and Todd, 1998). Based on the fulfillment of the majority of water quality and wildlife needs, I suggest that 50 ft (15 m) would be an adequate baseline riparian buffer width for Stevens

Creek. The following is a discussion of the variables that could influence the adjustment of this baseline width.

Adjustment Variables

There may be portions of the creek along which higher clay contents exist, which according to Wilson (1967) would require a significant increase in buffer width, up to 300 ft (91 m) for clay dominated surface soils. Areas with low soil organic material would also indicate the need for a wider buffer because of reduced denitrification by bacteria in organic material (Palone and Todd, 1998). Stream size is also a factor, and it is recommended that minimum buffer width for aquatic communities be increased from 50 to 60 ft (15 to 18 m) in larger streams (Klapproth and Johnson, 2001).

The increase of impervious surfaces through urbanization could increase the pollutant or sediment loads of runoff, which may lead to more concentrated flows. Concentrated flows, in turn, will reduce the ability of riparian zones to trap the sediment and filter pollutants out of runoff before reaching the stream. Increased urban growth in the Stevens Creek watershed in coming years will require careful planning of filter strips. Additional practices such as swaths of stones to spread the runoff, and biofiltration swales and wetlands for runoff and stormwater retention which allow for greater infiltration may be required (Palone and Todd, 1998). Wetlands adjacent to streams and riparian zones are sinks for sediments, nutrients and pollutants, and sites for denitrification functions (Johnson and Buffler, 2008).

Vegetation type and design can also influence the effectiveness of buffer zones. More complex structural diversity of vegetation provides habitat for a greater range of wildlife species (Palone and Todd, 1998). Trees are important for establishment of the aquatic food web with leaf

matter as a food base (Palone and Todd, 1998). A study of 14 riparian buffer sites in Europe showed similar efficiency of nitrate removal for herbaceous and forested buffers, but after a few years of sediment build-up, grass buffers became overwhelmed and lost their effectiveness (Sabater et al, 2003).

The traditional three-zone design includes an unmanaged forest along the stream bank to provide shading, a managed forest for a nutrient sink, and a grass or grass/forb filter strip that intercepts and spreads runoff to allow sediment settling and slower movement of water through the buffer (Schultz et al., 2004). The grass filter strip is very important to buffer effectiveness. Studies show that forested buffers without filter strips exhibit gully erosion and reduced effectiveness at nutrient removal. Stiff stemmed, native grasses such as switchgrass (*Panicum virgatum*) are recommended over introduced species such as smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*) that are easily laid down and allow water to pass over. However, a filter strip of switchgrass (*Panicum virgatum*) alone does not provide bird habitat as well as a more diverse species mix. A strip of switchgrass (*Panicum virgatum*) upslope of a more diverse grass/forb mix is recommended to provide both runoff treatment and habitat functions (Schultz et al., 2004).

The most significant adjustment variable for this study is that of wildlife guilds that require buffer widths wider than 50 ft (15.2 m). In portions of the stream where such wildlife guilds or species of interest may be expected, baseline buffer width should be expanded to the width appropriate for bird communities (82 ft; 25 m), large mammals (100 ft; 30 m), and semi-aquatic reptiles (417 ft; 127 m) and amphibians (522 ft; 159 m).

Additional Considerations

Important considerations to buffer effectiveness are continuity and point source pollution. Fragmentation of riparian buffer systems reduces the pollution control ability of buffers and isolates wildlife by removing movement corridors (Schultz et al., 2009). Pollution carried by structures such as tile drains and industrial waste pipes that input water directly into the stream cannot be treated by buffers, which reduces the influence of buffers on water quality (Johnson and Buffler, 2008). In order for buffers to remain effective, point sources need to be eliminated and continuity of buffers maintained along the entire stream.

In addition to the needs of wildlife habitat and water quality functions, economic and social factors should also be considered when discussing riparian planning and management. Landowners along Stevens Creek currently use much of the land for agriculture, and it is important not to completely override their needs in favor of ecosystem functions. At the same time, the use of the land for agriculture can have adverse impacts on a wide range of ecosystem functions and services of the riparian zone, such as the provision of quality freshwater. There must be a balance between meeting the needs of the landowners and protecting ecosystem functions (DeFries et al., 2004). Riparian zones can either take some land out of agricultural production, or it can generate income through government program payments or by providing specialty crops like nuts, fruits, and woody florals (Fox et al., 2005; Dillaha et al., 1988).

The USDA (United States Department of Agriculture) Farm Service Agency offers payments to landowners enrolled in the Conservation Reserve Program for riparian buffers. This program provides economic benefits to private landowners with riparian buffers, which can offset the economic losses of keeping that land out of other kinds of production. In Nebraska, payments are determined on a site specific basis, according to soil series. Certain soil series receive higher payments than others, but all buffers receive a 20% bonus on top of the payment

recommended for soil type. An additional sign-up bonus of \$10 per acre is offered for riparian buffers, and fencing for the exclusion of livestock is also paid. All buffers are designed under the technical guidance of the NRCS (Natural Resource Conservation Service). The NRCS uses a plant species mix that includes 60% native grasses in the filter strip and always includes species for wildlife to achieve multiple benefits of the buffer (D. Weber, personal communication, 2010).

CONCLUSION

The purpose of this thesis was to evaluate minimum riparian buffer width recommendations using a literature review in order to determine a buffer width to maintain water quality and habitat along Stevens Creek. Water quality is important to the health of people and wildlife, and riparian buffers are important tools for managing water quality and providing habitat. A variable buffer width design with a baseline width of 50 ft (15 m) was recommended for Stevens Creek, to be altered according to landscape features and species of interest. Additional considerations for the implementation and effectiveness of riparian buffers include fragmentation, point source pollution, and equitable management for both natural resources and landowners.

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FIGURES

Fig. 1 Location of Stevens Creek watershed

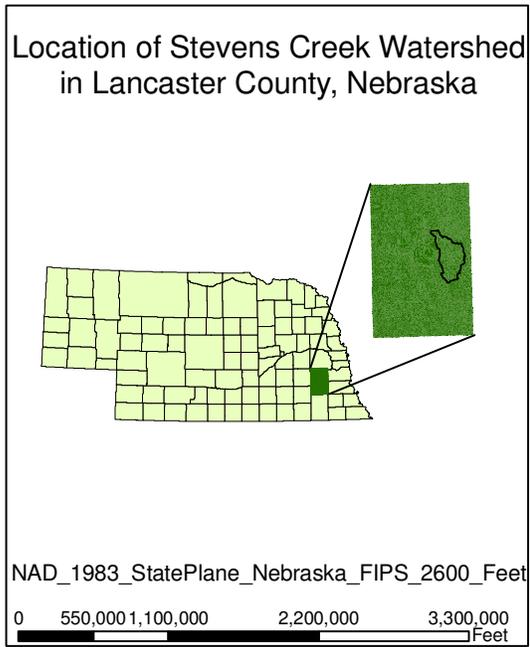
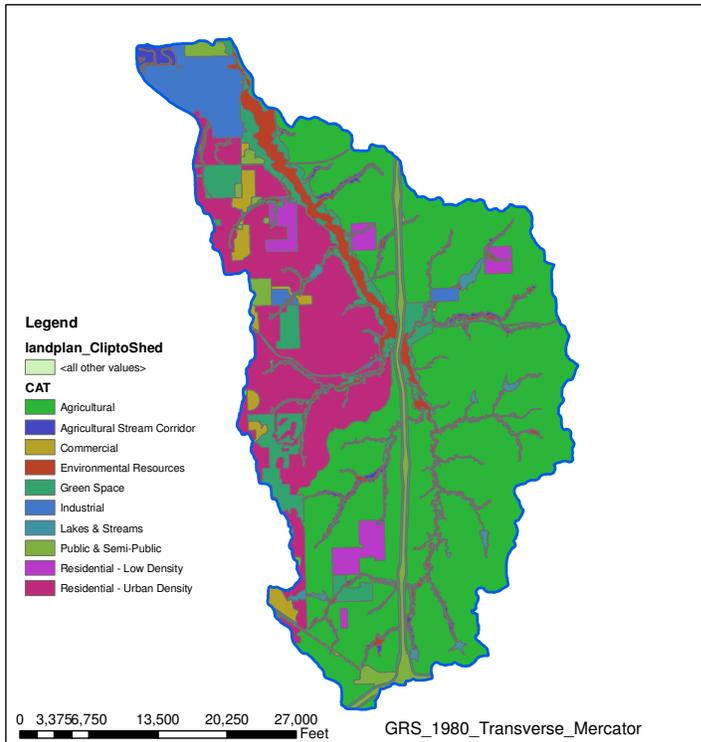


Fig. 2 Future land use plan of the Lincoln/Lancaster County Planning Department



1-1-1996

G96-1308 Management of Eastern Redcedar on Grasslands

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Management of Eastern Redcedar on Grasslands

Developing an integrated control program including prescribed burning, herbicides, and cutting may be the best way to control eastern redcedar in Nebraska, according to recent research.

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- [Eastern Redcedar in Nebraska](#)
- [Control of Eastern Redcedar](#)
- [Taking an Integrated Approach to Management](#)
- [Costs and Effectiveness of Eastern Redcedar Treatments](#)
- [General Recommendations](#)

Eastern redcedar is a serious threat to grassland productivity. Some control methods may be too expensive to use on grasslands, but in many cases, an integrated approach combining fire with more intensive follow-up methods will provide reasonable control at an acceptable cost.

Eastern Redcedar in Nebraska

Eastern redcedar (*Juniperus virginiana* L.) is one of 13 juniper species native to the United States. It is the most widespread tree-sized conifer and is native to every state east of the 100th meridian. Throughout this vast range, eastern redcedar grows on many soils and under varying climatic conditions. This adaptability has enhanced eastern redcedar's recent spread into areas where it was formerly rare or absent. Individual trees are either male or female. The small, berrylike cones are eaten by many birds and some small mammals that then spread the seed in their droppings. Digestion actually improves germination.



Figure 1. Prescribed fire alone is effective against smaller eastern redcedar trees. If properly timed, fire also benefits plant vigor and animal performance.

First accounts of Nebraska vegetation mention eastern redcedar as a native tree species, primarily along the steep valley of the Niobrara River in northern Nebraska, as a minor component in deciduous forests in eastern Nebraska, and as a dominant species on canyon sides in the rugged Loess Hills region of central Nebraska. Today, volunteer stands of eastern redcedar can be

found on most grasslands in central and eastern Nebraska. It is likely that most of the state's grasslands east and south of the Sandhills are infested or eventually could be. Since European settlement in the region, many factors have changed, allowing this minor native tree to become a serious grassland pest. Early records from the Loess Hills note that eastern redcedar were confined to the steepest canyons, usually on north-facing slopes where moisture levels were highest. The role of wildfire in confining the trees was obvious--trees near the edges of these stands displayed repeated fire damage.

The species' adaptability and hardiness made it a favorite of pioneer tree planters. Millions of eastern redcedar have been planted in Nebraska for landscaping, windbreaks, and wildlife habitat. These plantings accelerated with the conservation programs of the 1930s. Meanwhile, wildfire suppression became effective for the first time after World War II, when rural fire departments were organized and equipped with military surplus vehicles. Thus, a maturing seed source from plantings and fire control converged in time.



Figure 2. Spot-gun applications of Tordon 22K herbicide are fast and cost-effective against smaller eastern redcedar trees that survive fire.

Eastern redcedar is a problem on grasslands primarily because it reduces forage production. Because developing trees alter the microclimate, the trees also encourage a shift from desirable warm-season native grasses to introduced cool-season grasses such as Kentucky bluegrass. Heavy infestations make livestock handling more difficult. All these adverse effects can be reflected in lower rental rates or sale prices for infested grassland. Established infestations will get worse over time. On many sites complete coverage by eastern redcedar can be expected, resulting in total loss of production unless controlled. Control measures should be initiated as soon as possible, both to improve

effectiveness and reduce total costs.

Control of Eastern Redcedar

Many methods have been explored or used to control eastern redcedar. These include prescribed fire, herbicide application, and cutting. All methods have some drawbacks when used alone.

Prescribed fire. This method is inexpensive and effective against smaller trees. However, its effectiveness declines as tree size increases. Adequate fine fuel (usually, last year's dead grass) is necessary for satisfactory results. Safety also is a concern since many managers lack experience with fire and the equipment required to conduct fires.

Herbicides. Foliar sprays and broadcast soil applications of herbicides have been ineffective against eastern redcedar. The preferred treatment method is an application of undiluted Tordon 22K¹ liquid to the soil under individual trees at a rate of three or four milliliters per three feet of tree height. This method minimizes the amount of herbicide used and the exposure to non-target species. However, it still is time consuming and expensive when used on denser infestations or large tracts. Effectiveness also is variable on larger trees and label directions recommend against use on trees more than 15 feet tall. (Always read and follow pesticide label directions.)

Cutting. This method is even more time consuming than herbicide application. It is effective because eastern redcedar is a non-sprouter. Trees cut below the lowest foliage will not regrow. Larger trees require a chain saw or tractor-mounted shears, but trees less than three feet tall can be quickly cut with hand shears. Tractor-mounted shears may not be able to safely operate on steep slopes. Sawing is potentially dangerous because all

lower branches of larger trees should be removed before cutting the main stem. Otherwise, the operator can be injured when the tree falls.



Figure 3. Cutting may be the best option for larger eastern redcedar trees that survive fire because this species does not resprout. However, if trees are cut by hand, cutting is time-consuming because lower limbs should be removed before the main stem is cut to prevent operator injury when the tree falls.

Cutting alone also fails to remove all of the problem because felled trees continue to occupy space. Oklahoma research found that the durable skeletons of felled trees occupy 70% of the space of living trees. This area is lost to production for years because livestock are reluctant to graze among the sharp branches. In addition, removing large trees often releases a flush of tree and weed seedlings within the former canopy dripline. Removal of one large tree can result in hundreds of small trees in its place that soon can merge into a nearly impenetrable thicket.

Taking an Integrated Approach to Management

As described, Nebraska's eastern redcedar infestations have developed over several decades. Likewise, management of these infestations is best viewed as a long-term effort, both to reduce the initial infestations and prevent them from redeveloping to economically damaging levels. It is best to begin treatment as soon as possible, once treatment has begun considerable time is gained to continue long-term management. The emphasis should be on **management** of the infestation, rather than **eradication**. Eradication is not economical, and probably not physically possible in most cases. Instead, it should be recognized that some remaining larger trees, which are the most difficult and expensive to kill, do little damage. In fact, at low levels, eastern redcedars can be viewed as a potential resource, providing livestock shelter, wildlife habitat, timber products, and aesthetic values. Most important, long-term selective management is considerably less expensive than a more intensive, short-term approach.

While single-method approaches all have drawbacks, recent research in Nebraska and elsewhere has shown that integrating prescribed burning with herbicides or cutting combines the strengths of each method while overcoming their disadvantages.

Prescribed fire. The controlled use of fire is a large subject in itself. It is beyond the scope of this publication to provide detailed instruction on conducting prescribed fires. Two other Nebraska Extension publications provide information on the use of fire in general and on how to safely conduct fires. They are *NebGuide G88-894, Grassland Management with Prescribed Burning*, and *Extension Circular 90-121, Conducting a Prescribed Burn*. A fire plan should be prepared and a prescribed-burning permit obtained from the local fire jurisdiction, as required by state law. Specialized fire equipment can be purchased. Two sources are the Ben Meadows Company, 3589 Broad St., Chamblee, GA 30341; and Forestry Suppliers, Inc, Box 8397, Jackson, MS 39284-8397.

Regarding eastern redcedar specifically, prescribed fire is important both to initially reduce infestations and to maintain trees at economically tolerable levels. Research indicates that prescribed fires used primarily to control eastern redcedar should be conducted earlier than previously recommended, about April 1. Foliage is drier then and ignition of large trees is more likely. Fires should be conducted under conditions which are as warm and dry as is consistent with safety. Lower windspeeds, in a range of 5 to 10 mph, will increase the duration of high temperatures and damage to larger trees. In some cases fire alone may be adequate. In other cases supplemental treatment may be necessary. Fortunately, a number of treatment options are available to fit different circumstances. These include selective treatment by height and reducing herbicide rates for

smaller trees.

Several variables should be weighed when considering options. These include location within the state, difficulty of burning the area in question, age and density of trees, the density of surviving trees that can be tolerated, kind of grassland vegetation, and the availability of labor or capital.

Location. Eastern Nebraska lies within the tallgrass prairie region, while central Nebraska, including the Loess Hills, is in the mixed prairie region. The tallgrass region potentially produces greater fine-fuel loads, and thus more intense fires and higher eastern redcedar mortality. Fire can be used more frequently here with less risk of adverse effects to the other vegetation, such as can occur when drought follows spring fire. This means that fire alone on a short rotation, perhaps even annually, may suffice in the east. In the mixed prairie region fine-fuel loads tend to be lower and control from fire alone may be less, while arid post-fire conditions also are more likely. In central Nebraska fire should be used more conservatively, at intervals of several years. This makes it more likely that limited supplemental treatments will be necessary to achieve management goals.

Difficulty of burning individual units. Lighting a prescribed fire often carries some risk of it escaping. Eastern Nebraska pastures more often are isolated by roads, cultivated lands, and other firebreaks that will confine the fire and minimize risk. This means that fire may be safely used more often and under more favorable burning conditions. In central Nebraska, pastures often are located within large blocks of rangeland, making escape more likely and serious. This argues for a more sparing use of fire and reduces the chance that fire alone will suffice.

In some cases, the difficulty and risks of burning in areas of extensive grasslands can be greatly reduced by conducting "landscape-scale" fires, rather than burning pastures individually. Under the landscape-scale concept, the fire boundary is extended until adequate existing firebreaks are encountered. These may be roads, watercourses, cultivated lands, stands of broadleaf trees, relatively non-flammable canyon bottoms, or areas of short or green vegetation. Such large areas frequently contain the holdings of multiple landowners. Obviously, all landowners and managers within the area must be in agreement about the proposed burn.

Age and initial density of trees. Eastern Nebraska infestations tend to be younger and more dispersed. This will improve control levels achieved by fire alone. In the rugged Loess Hills, where eastern redcedar is native, infestations include dense stands, usually on north-facing slopes, and larger trees. These stands are less susceptible to fire and may require supplemental treatment. In fact, some dense stands may be better left alone because little vegetation remains under the canopy and the danger of soil erosion is great on steep slopes if trees are removed. Management efforts may be better concentrated on developing stands that are easier to attack and threaten future productivity much more.

Density of surviving trees that can be tolerated. This factor depends on manager preference. Low numbers of surviving trees will have little effect on future productivity. Most surviving trees will be the largest and oldest in the population. These may have a near-term value, for example as fence posts, and so pay for their own removal. Low numbers of such trees also furnish livestock shelter, and improve habitat for popular game animals such as deer and wild turkey.

Kind of existing vegetation. Most research on prescribed fire in grasslands relates to warm-season native grasses, either in rangeland or planted pastures. Much less is known about the use of fire on cool-season grasslands. For planted cool-season pastures, fires would have to be conducted as much as six to eight weeks earlier than on warm-season grasses, probably no later than mid-March to minimize damage to the grass.

The situation on degraded, cool-season dominated range is more complex. Fires conducted early will encourage the cool-season grasses at the expense of the remnant warm-season grasses. Fires conducted around May 1, at the optimum time to favor warm-season grass growth, will damage the cool-season grasses. While that often is desirable, a manager may have come to depend on early production from a cool-season

range. Much of this production will be lost if fire is used. Total production also may be temporarily reduced if the remnant warm-season grasses are too scarce or weakened to take advantage of the suppression of the cool-season grasses.

Use of fire should be carefully considered on all lands. Ideally, fire should be incorporated as part of a long-term pasture-management plan designed both to reduce eastern redcedar infestations and improve range condition while maintaining or improving productivity.

Availability of labor vs. capital. Nebraska research indicates that the costs and effectiveness of cutting and herbicide application are similar for trees less than 10 feet tall. However, the sources of those costs are different. Labor accounts for most of chain sawing costs. Shearing costs include purchase or rental costs of the shears plus considerable labor, or payment to a contractor. For Tordon 22K application, the purchase price of the herbicide accounts for most of the cost. Cutting and herbicide application both are rational choices, but managers should choose based on their own circumstances.

Costs and Effectiveness of Eastern Redcedar Treatments

Recent Nebraska research has provided detailed information on the results and costs that can be expected when a variety of eastern redcedar control measures are applied under realistic conditions. The values in *Table I* were generated on a site in the Loess Hills in Custer County. The eastern redcedar population on the site had developed since about 1960 and had reached a density of about 250 trees per acre. Trees were mostly less than six feet tall, indicative of a still-expanding infestation, and were growing mostly as single trees or in small groups. Tordon 22K was applied at a rate of four milliliter per three feet of tree height. It was apparent that there were some misses, and some trees were treated twice. When herbicides are used, some form of marking should be used to prevent this. Sprinkling a few kernels of popped popcorn by each tree as it is treated is fast and inexpensive. The cutting treatments used hand tools and chain saws. Supplemental treatments were applied one to two months after the fires. Actual costs and effectiveness achieved will depend on initial tree density and fire intensity.

The main points in *Table I* are:

1. the total costs and effectiveness for trees less than 10 feet tall are about equal for fire plus Tordon 22K and fire plus cutting;
2. burning first reduced the time requirement by half for both Tordon 22K and cutting treatments, and
3. burning first reduced total costs by nearly half for both treatments. It should be noted that supplemental treatment is a one-time expense that can be spread over a number of years. This is true only if fire is used periodically to prevent reinfestation.

These costs do not include charges for changes in grazing management. For example, if grazing is reduced by 0.25 animal unit month (AUM) per acre in the year before fire to accumulate fine fuels, and an AUM's value is \$16, then an additional \$4 per acre should be charged to the fire cost. However, this cost likely will be recovered in reduced supplemental treatment costs if a more effective fire is achieved.

Table I. Effectiveness and costs of eastern redcedar control treatments as measured one year after treatment.

Treatment	Mortality					To Apply Supplemental Treatments	
	By Height Class						
	0-3 ft	3-6.5 ft	6.5-10 ft	>10 ft	Total ¹	Time	Costs
	------(%)-----					(hours/acre)	(\$/acre)
Fire alone	94	71	63	29	81	0.00	2

Fire+Tordon	98	95	93	60	95	0.25	20 ²
Fire+Cutting	95	99	100	94	96	1.25	16 ²
Tordon Alone	82	83	60	66	79	0.50	37
Cutting Alone	84	97	97	95	88	2.50	25
¹ Weighted means, based on different numbers of trees in each height class.							
² These costs include the estimated \$2 per acre fire cost.							

Treatment options. The Nebraska research also indicated that treatment strategies can be modified to further reduce costs. It was found that:

1. some trees that at first appeared to survive the initial prescribed fire will die during the following year;
2. surviving large trees, which make up a small percentage of an expanding population, will make a negligible contribution to future production losses; and
3. herbicide rates for trees less than 10 feet tall may be reduced to two milliliter per three feet of height without significant loss of effectiveness. Reducing rates will, however, void the manufacturer's warranty. *Table II* shows estimated costs of fire plus herbicide application based on these findings.

Table II. Estimated costs per acre of fire followed by Tordon 22K application under combinations of delaying treatment after fire, reducing the rate by half, and selective treatment by tree height. Costs include estimated \$2 per acre fire cost.				
Treatment Option	Treatment Date	Herbicide Rate	Trees Treated	Cost
	(time after fire)	(ml/3 ft)		(\$/acre)
1	3 weeks	4	All	20
2	1 year	4	All	14
3	3 weeks	2	All	12
4	1 year	2	All	9
5	3 weeks	4	<10 ft	13
6	1 year	4	<10 ft	9
7	3 weeks	2	<10 ft	9
8	1 year	2	<10 ft	7

The assumptions regarding delaying treatment for one year after fire and selectively treating only smaller trees also can be made for cutting and could be expected to reduce these costs as well. A further refinement would be to focus supplemental control on seed-producing females to reduce reinfestation.

General Recommendations

If at all possible, prescribed fire should be incorporated into long-term eastern redcedar management on grasslands. Periodic fire is required both to reduce the cost and improve effectiveness of treatments, and to prevent reinfestation. If necessary, grazing management should be changed to ensure adequate fine fuel loads before the initial and subsequent fires. To prevent reinfestation, fire should be used no less than every eight years in central Nebraska, and no less than every four years in eastern Nebraska where eastern redcedar growth rates are higher. Alternately, fire can be applied whenever newly established trees are approaching three feet in height, the size above which significant numbers can survive fire.

The need for supplemental treatment should be assessed after the initial fire, in light of the variables discussed previously in the *Taking an Integrated Approach* section. Supplemental treatment should be delayed at least one year after the initial fire to take advantage of delayed mortality. The supplemental methods should be those best suited to individual circumstances. Selective treatment, based on tree height, should be considered to reduce costs.

¹Use of tradenames is not an endorsement by the authors or the University of Nebraska-Lincoln.

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Patch-Burn Grazing for Biological Diversity

May 2011

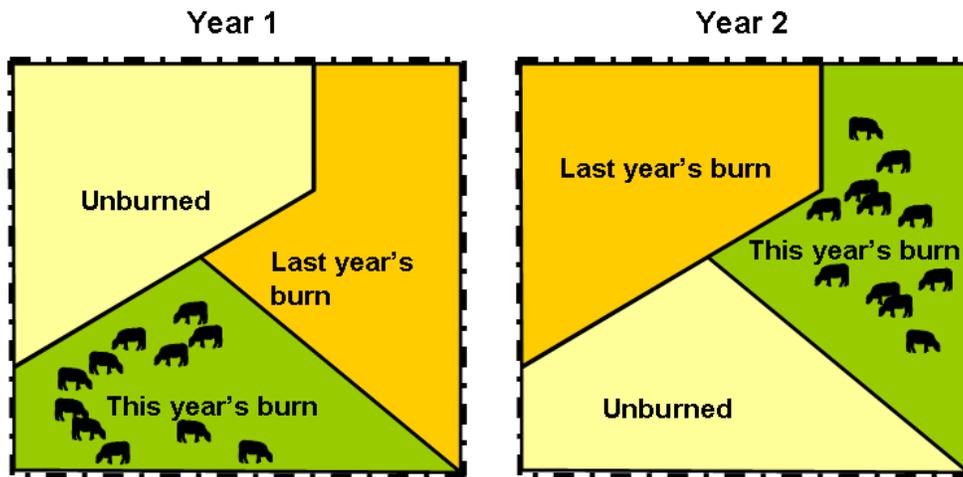
By Chris Helzer
The Nature Conservancy – Nebraska



INTRODUCTION

Patch-burn grazing is a grassland management strategy in which a portion of prairie is burned to attract grazing animals. Those animals concentrate their grazing in that burned “patch” even though they have access to the entire prairie. As new patches are burned, grazers shift their grazing to the most recent burned patch, allowing previously-burned patches to recover (Figure 1). Today’s methods evolved from early efforts by The Nature Conservancy and others to manage large grasslands with a combination of prescribed fire and bison grazing. The bison in those grasslands showed strong grazing preference for grasses (as opposed to forbs, aka wildflowers), and that selective grazing led to increases in plant diversity in recently grazed portions of those grasslands.

Figure 1. The Basic Patch-Burn Grazing Model. Cattle concentrate their grazing within the most recently-burned patch, even though they have access to the entire prairie. When a new patch is burned, cattle shift their grazing to that patch, allowing older burned areas to recover.



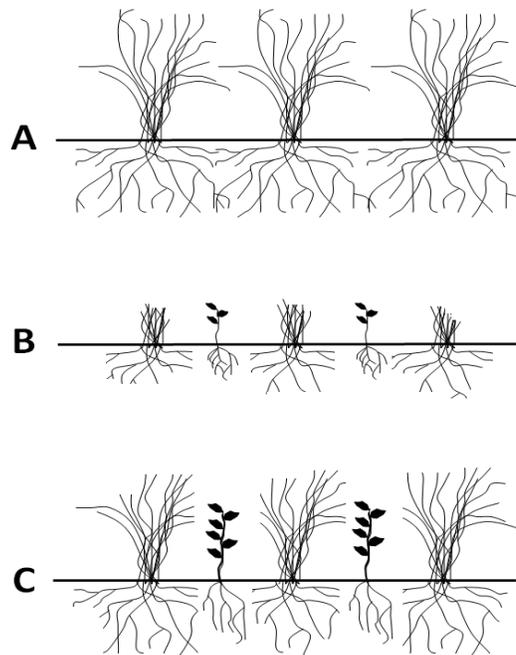
Most of today's applications of patch-burn grazing are designed to improve wildlife habitat quality of rangeland by increasing the heterogeneity of habitat structure – as compared to many traditional cattle grazing systems that try to avoid grazing extremely low or high intensities. Researchers from Oklahoma State University have led the effort to test patch-burn grazing's applicability to rangelands, and have documented many benefits to wildlife species and plant/insect diversity. More importantly, ranchers can typically obtain these results without compromising either stocking rate or weight gains. Because of OSU's positive findings, a variety of agencies, universities, and landowners are now testing patch-burn grazing in their local landscapes to see whether or not they can obtain the same kind of results. Currently, patch-burn grazing shows great potential for improving habitat quality in privately-owned agricultural grasslands, something that could have profound impacts on many at-risk grassland wildlife species.

In contrast to the vast majority of patch-burn grazing studies, however, our work along the central Platte River in Nebraska is not focused on altering management in production-oriented grasslands, but rather was specifically designed to increase and maintain floristic quality in prairies. During the last two decades, we invested significant resources into creating diverse prairie restorations (reconstructions), using seed mixes of between 150 and 230 plant species, as a way to enlarge and reconnect fragmented native prairies. As those restored prairie plant communities became established, we needed a way to maintain that plant diversity. In restored prairies (and many native prairies as well) dominant grasses tend to monopolize many of the resources, decreasing plant diversity. The Nature Conservancy's experience with bison/fire management had shown us that selective grazing by bison temporarily suppressed grass vigor and allowed other plants to become more abundant – increasing plant diversity. We hoped we could get similar results in our restored prairies by substituting cattle for bison and applying patch-burn grazing at much smaller scales (e.g. 80-400 acre prairies). While we are targeting plant diversity, we are also using that as one indicator of our larger goal of overall biological diversity,

much of which depends heavily on plant diversity as a foundation. Other studies have documented impacts of patch-burn grazing on other taxa (birds, small mammals, insects, etc.) so we are focusing mainly on plant species and community responses.

OUR APPROACH

Because we were not constrained by the need to design a management system that would be acceptable to ranchers or farmers, we were able to think about stocking rate, grazing season, and the timing and frequency of fire purely from the standpoint of what we thought would best achieve our primary objective – to prevent dominant grass species from reducing overall plant diversity. We started with the knowledge the intense defoliation of grasses reduces their vigor substantially. Those grasses lose aboveground stems and leaves, allowing more light to hit the ground around them. More importantly, the aboveground defoliation reduces the ability of grasses to support their massive root system, and they have to abandon many roots – leaving soil moisture and nutrients for other plants. Opening up space around dominant grasses allows other plant species to spread by seed and/or rhizome into territory formerly held by grass plants, increasing overall plant diversity. We hoped to get cattle to graze grasses hard and long enough to significantly weaken them, but then allow those grasses to rest and recover their vigor before the next grazing bout. At the same time, we wanted grazing pressure on forbs to be as light as possible to allow them to take advantage of the temporarily weakened grasses and increase (or at least maintain) their abundance.



An illustration of how grazing can influence dominant grasses in a prairie. In A, dominant grasses are monopolizing above and belowground resources. Other plant species have little opportunity to obtain light, moisture, or soil nutrients. In B, intensive defoliation has removed the leaves and stems, which has led to the abandonment of much of the root system. This opens up resources for other new plants to start. In C, those new plants are growing stronger as the grasses recover their vigor.

Over the last 10 years or so, we have experimented with various modifications of the basic patch-burn grazing system on about a half dozen prairies. Those prairies include lowland and upland sites, and restored and remnant (unplowed) prairies. We have been employing cow/calf pairs as our grazers because that is what our neighbors have, and we lease our pastures to those neighbors, who bring in cattle based on our plans for timing, duration, and stocking rate each season.

GENERAL RESULTS

Our early experiments confirmed that cattle followed the grazing pattern we hoped they would – spending the vast majority of their time in the most recent burned patches, and grazing very little in unburned areas. More importantly, we have found that under light stocking rates the cattle in our prairies graze very selectively – eating almost exclusively grasses. (The patch-burn grazing system seems to help facilitate that selectivity, but we’ve also seen it occur under light stocking rates in other grazing systems.) Increasing the stocking rate increases the amount of grazing on forbs within the burned patch and also increases the amount of grazing that occurs outside the most recent burned patch.



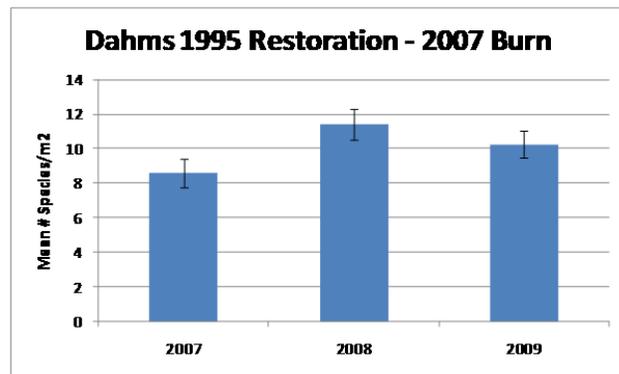
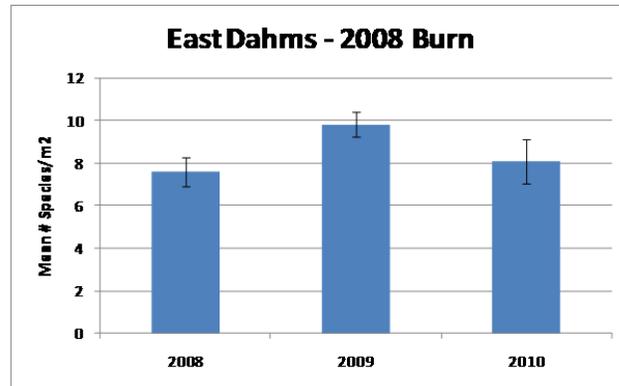
Selective grazing in a restored prairie under a light stocking rate. Most grasses have been grazed but few forbs have, including Maximilian sunflower, purple prairie clover (blooming) and rosinweed (blooming).

Stocking rates are difficult to translate from site to site because of differences in annual rainfall, soil types, vegetation composition, etc. In general, our patch-burn grazing stocking rates are about half to three-quarters of what the Natural Resources Conservation Service (NRCS) would recommend to a livestock producer on the same site. In addition, we alter stocking rates annually based on the previous year's rainfall and the results we see on the ground.

It's been fascinating to watch cattle select which plants to graze on, and to see how that changes through the season. During the early spring, their favorite plant in our prairies is smooth brome, an invasive species that we target for suppression. We try to get cattle into our pastures as early in April as we can so that the cattle can start grazing it (and stressing it) while it is still relatively short. At that time of year, cattle can generally "get ahead" of the grass in the burned patch, meaning that they can graze it all down faster than it can regrow, so they also spread out and selectively graze patches of smooth brome elsewhere across the prairie. As soon as the burned patch starts growing faster, however, they refocus their grazing there. As the season progresses into warmer weather, cattle tend to focus primarily on big bluestem and indiangrass – our most dominant native grasses during the summer. Other grass species, such as switchgrass, tall dropseed, Canada wildrye, and others are also grazed, but the grazing intensity on those species increases with stocking rate. At lower stocking rates, cattle tend to stick with their favorite species most of the time. When we do see grazing on forbs, cattle have favorites among them as well. Their absolute favorite forb is sweet clover – another species we're happy to let them suppress for us – but they also like native legumes such as Illinois bundleflower and Canada milkvetch. As a result of knowing the grazing preferences of our cattle, we can easily gauge our stocking rate by whether or not species like switchgrass and Illinois bundleflower are being grazed. Again, the "appropriate" stocking rate changes from year to year based on our objectives for each prairie.

To date, we've primarily evaluated two different aspects of plant community changes under patch-burn grazing. First, we've examined short-term changes in the plant composition as a direct result of the fire/grazing/rest cycle in the patch-burn grazing system. Second, we've tracked long-term changes in the plant community (up to 9 years so far) as prairies have gone through repeated cycles of fire/grazing and rest. In both cases, we measure changes by identifying and counting plant species within numerous 1m² plots spread across each site. We can then look at changes in the species diversity at both small (1m) and large (prairie) scales. In addition, we can calculate the floristic quality (see Swink, F. and G. Wilhelm, 1994, *Plants of the Chicago Region*, 4th ed.) at the 1m scale and average it across the entire prairie to look for change over time.

In both restored and remnant prairies, we generally see about a 20-30% increase in plant species density at small scales (1m²) after a season of fire/grazing. In other words, within a burned patch, the number of plant species per square meter is about 20-30% higher in the year after intensive grazing than the previous year. Many of those "new" plants are opportunistic species such as ragweeds, annual sunflowers, maretail, and others that are quick to take advantage of the grazing-weakened grasses. However, we also see seedlings of plants like purple prairie clover, Illinois bundleflower, perennial sunflowers, and many other perennial native wildflowers that are taking advantage of the same open space. Many of those same plants are also spreading through rhizomes. That bump in species density drops off again the following year as the grasses recover most of their vigor. Sometimes the density drops back to pre-burn levels, but in other cases it retains some of the "new" species. We've not yet been able to predict why species densities sometimes remain higher, but it does seem to be at least somewhat related to weather patterns.



Two graphs showing changes in the average number of plant species per meter in burned patches. The top graph shows a burned patch within a degraded remnant prairie over three years, starting with 2008 when the patch was burned. The bottom graph shows the same pattern in a 2007 burned patch within a restored prairie. In both cases, the species density increases in the year after the fire but drops again the subsequent year. Error bars indicate 95% Confidence.

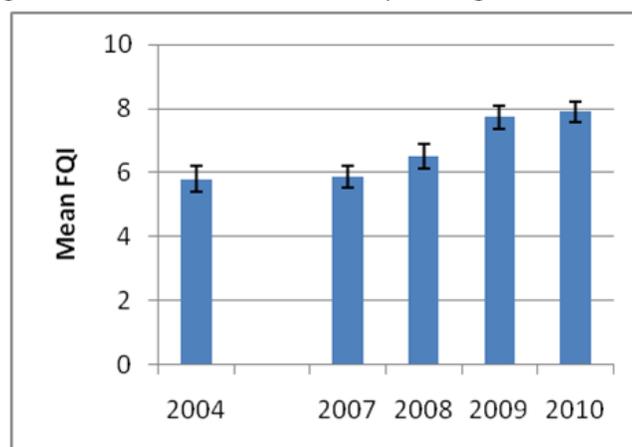
In terms of long-term (9 year) data on changes in plant species composition in prairies, we've certainly seen changes, but most seem more strongly linked to weather patterns than our fire/grazing work. Most of our remnant prairies have relatively degraded plant communities, dominated by grasses (native and non-native) and with fairly low numbers of forb species. Those prairies have tended to increase in mean floristic quality during our patch-burn grazing experiments, but for the most part we're not seeing increases in the abundance of perennial forb species that are largely missing from those prairies. In addition, those increases in mean floristic quality corresponded with a return to wetter years following a drought that lasted from about 2000 through 2006.



In many of our degraded remnants, plant species such as Maximilian sunflower (left) and purple prairie clover (right) are uncommon. However, even when they have nowhere to hide, they are rarely grazed within our patch-burn grazing system when we employ a light stocking rate, giving us hope that they will increase in abundance over time.

On the one hand, an increase in floristic quality in those degraded remnants is positive, and it doesn't appear that our fire/grazing is having detrimental impacts. On the other hand, we don't yet know how much our management influenced the change relative to the influence of weather. For the most part, we feel that we're not seeing perennial forb species increase in abundance because they're simply not there anymore. A few, especially Maximilian sunflower, are increasing over time, but our next job is to reintroduce other species to the site. We've been experimenting with overseeding those species within the patch-burn grazing system – with some success – but it's too early to know how well that will work.

Changes in Mean Plot-wise Floristic Quality in a Degraded Remnant Prairie

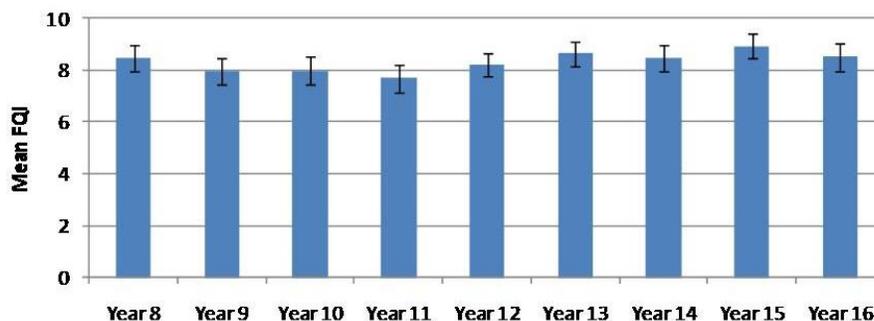


Data were collected from approximately 100 1m plots each year. Within each plot, all plant species were listed and the floristic quality (FQI) was calculated for that plot. Those values were then averaged across the site. Error bars indicate 95% Confidence.

In contrast to our degraded remnant prairies, our restored prairies already have about what we want for plant species composition, and our objective is simply to maintain that. We introduce patch-burn grazing to restored prairies when they establish to the point where most species are present, but before grasses begin to become overly dominant. So far, our data show that we are maintaining mean floristic quality in those restored prairies over time – through both drought years and wet years. Some individual plant species increase and decrease over time, but none show a steady drop (excepting a few non-native annuals). Most species are either relatively stable or bounce around in abundance as a result of the combination of our fire/management and weather. In one site, only two plant species have steadily increased over time – *Carex brevior* (a native sedge) and Kentucky bluegrass (a non-native invasive grass). We’re glad to see the sedge increase in abundance but wary of the bluegrass. Bluegrass is now found in about 75% of our annual data plots, but has not had any visible impacts on species diversity, so we’re wondering whether or not we can keep it suppressed enough (like other grasses) that it simply joins the plant community instead of dominating it as it does in nearby degraded prairies.

We don’t collect data from every prairie in every year, but in the case of one restored prairie, we have nine years of annual data, dating back to when we first started implementing patch-burn grazing at the site (2002). As with other restored prairies, the site has maintained its mean floristic quality and has not lost any plant species that we’re aware of. In this prairie, though, we also have a couple of fairly large (2-4 acre) exclosures that have gotten similar fire management to the rest of the site, but have not had any grazing. The prairie plant communities within those exclosures are significantly lower in mean floristic quality and species diversity – and are dominated by warm-season grasses and a few forb species. We have installed exclosures at other restored prairies during the last couple of years but don’t know if we will see similar differences at those sites or not. At this point, it appears that grazing is an important component in our attempt to maintain species diversity in our restored prairies, but we will continue to learn over the coming years.

Changes in Mean Plot-wise Floristic Quality in a 1995 Prairie Restoration Seeding During Nine Years of Annual Patch-Burn Grazing



Data were collected from approximately 100 1m plots annually. Within each plot, all plant species were listed, and the floristic quality (FQI) was calculated for that plot. Those values were then averaged across the site. Error bars indicated 95% Confidence Intervals.

Year 8 – Year 16 on the X axis indicate the age of the seeding.

MODIFICATIONS FOR SPECIAL CIRCUMSTANCES

The standard patch-burn grazing template we use consists of a three year fire frequency, meaning that we burn a third of each site annually. However, in reality, we don't stick with that frequency - and to meet objectives for individual prairies, we constantly manipulate other aspects of the model as well, including length of grazing season, season of fire, stocking rate, and others. In addition, on most sites, we don't use the same burn units each time around, choosing instead to mow firebreaks around the portions of the prairie that contain the most fuel (dry grass) for burning. In this way, we avoid creating permanent edges between patches, but also help regulate the fire frequency based on the recovery needs of the prairies. In other words, portions of the prairie that recover more slowly after fire/grazing will get burned less often than those portions that recover faster. For example, locations with sandy/gravelly soils tend to recover more slowly than those with richer soils because soil nutrients are lower - so they get less frequent fire. On the other hand, we tend to burn Kentucky bluegrass-dominated portions of our remnant more frequently (sometimes every other year) than we burn other portions because cattle often don't graze bluegrass as hard as other species, so it recovers quickly - and the fire may be a better agent of bluegrass suppression than grazing.

The following is a set of examples of the kinds of modifications we make to the basic patch-burn grazing system to meet specific objectives.

Season of Fire

We try to alter the season of fire as much as we can to ensure that we're not falling into a set pattern of consistently burning at the same time of year. This seems important in terms of impacts to both plant and animal species - we don't want to negatively impact the same species over and over. In deciding what time of year to burn, we consider the impact of both the fire and grazing intensity on plants and animals. For example, a dormant season (late fall or early spring) burn - before cattle come into the prairie - means that when cattle are brought in they'll immediately begin grazing that recently-burned patch, and the remainder of the prairie will get very little grazing. By contrast, if we do a late-spring burn (May) but bring cattle into the pasture in April, the cattle will be grazing cool-season grasses throughout the site - but especially in the previous-year's burn - until the May burn greens up. The late-spring burn can be helpful when we are fighting cool-season invasive grasses because both the fire and spring grazing will target those grass species.

We've also begun experimenting with summer fires (July/August) as a way to have a greater impact on dominant warm-season grasses and to release a different set of forbs from competition than we do with spring fires. Ordinarily, a summer fire with no subsequent grazing will favor fall-growing plants (including smooth brome and Kentucky bluegrass), but when cattle are present to graze the fall regrowth following the fire, the vigor of cool-season grasses are suppressed, leaving forbs with less competition. Our limited experience with summer fires so far has shown us that short-lived species that overwinter as rosettes are particularly favored by the treatment, but that many other forb species benefit as well. At this point, we consider summer fires to be a treatment that supplements our larger management with something a little different, so we tend to consider burning perhaps one-fifth or less

of the prairie with a summer fire. That helps to minimize impacts to the many insect and wildlife species that are active in the summer, but still provides a patch of different wildlife habitat and opportunities for plant species that might not otherwise be favored by dormant season or late spring burns. The other impact of a summer burn is that it pulls grazing pressure off of the remainder of the prairie during the fall green-up of that summer-burned patch. One of the advantages of that is that we often see cattle ranging outside the recent burned patch during the fall when warm-season grasses are dormant and the cool-season grasses in the same patch are still weak from the spring grazing (or late spring fire). Since there's not much for cattle to eat in the burned patches, they start looking elsewhere, sometimes causing us problems (discussed below). A summer fire can concentrate that fall grazing into a smaller area, allowing large parts of the prairie to remain ungrazed or lightly grazed.

Stocking Rate and Grazing Season Length

Following up on the last thought, we're still debating the idea of how long to leave cattle in our prairies during the fall. Because they tend to start foraging outside spring-burned patches in the late summer and early fall, we've had years where fall-grazing cattle have significantly knocked down vegetation height and density in the portion of the prairie we were hoping to burn the next spring. Sometimes that's helpful because it reduces the intensity of the fire, but other times it prevents us from being able to burn – or to burn with enough intensity to kill eastern red cedar trees. Removing cattle from the prairie in the early fall can help remedy that. On the other hand, fall grazing on cool-season invasive grasses can be very helpful in suppressing them, and we've noticed that smooth brome that was grazed in the fall often appears very sluggish and weak the next spring.

There is a period starting in mid-late August when warm-season grasses are of low forage quality for cattle and cool-season grasses aren't growing much when we see cattle graze on forbs more than at other times of the season. That usually entails grazing the tops of plants, as opposed to grazing them down to the ground, but many flowers are nipped off during that period. For perennial plants, this probably has a negligible impact if it only happens once in a while, but if those plants are never allowed to flower and produce seed, it can clearly have more serious consequences. As we continue to experiment with fall grazing, we sometimes put up an electric fence in the late summer around the portion of prairie we plan to burn the next year – both to build fuel and to reduce grazing on forbs. In addition, if we do keep cattle in the prairie until late fall one year we don't tend to do the same the next year.

On the other end of the season, we tend to try to put cattle into the prairies as early as we can in the spring because most of our sites either have an abundance of cool-season invasive grasses or are at risk from an invasion. Putting cattle into the prairie in early April often means that our late spring burns occur while cattle are in the prairie – which has never led to any issues. (Cattle tend to retreat to the far side of the prairie to watch the fire.) In sites where not much is greening up in early April, we'll bring cattle in later, but that's a rare situation for us. Ordinarily, the biggest challenge of early spring grazing is convincing the owner of the cattle that there is enough grass to sustain grazing needs. Balancing our desire for early season intense grazing against the livestock owner's worries about running out of grass is an annual event.

As discussed earlier, stocking rate can have a tremendous impact on the selectivity of grazing cattle. As stocking rate increases, both the amount of total grazing outside the burned patch and the amount of forb grazing inside the burned patch increase as well. At extremely light stocking rates, almost no grazing occurs outside the burned patch and very patchy grazing occurs inside the burned patch. Conversely, at very heavy stocking rates, cattle will quickly run out of grass in the burned patch and graze the majority of the prairie.



This July photo shows the burned patch of a restored prairie under patch-burn grazing management with a light stocking rate. Most grasses are grazed – but not uniformly – while the majority of forbs are ungrazed. In the photograph are opportunistic species such as black-eyed Susan and hoary vervain that typically respond well to grazing pressure, but also Canada milkvetch and compass plant that are often seen as plants that do poorly under cattle grazing.

There is no single “perfect” stocking rate for patch-burn grazing because the appropriate rate depends upon objectives – which can change over time. A lighter stocking rate will leave more flowers ungrazed, but will also have much less impact on the vigor of dominant grasses. In fact, light grazing on grasses often leads to increased rhizome development, helping those grasses to spread horizontally. On the other hand, a heavy stocking rate can more strongly suppress dominant grasses but will also lead to more forb grazing. It’s important to remember that even if a perennial forb is grazed down to the ground for an entire season (more typically, much of the plant is left ungrazed) it will recover its vigor during the subsequent year if that grazing doesn’t continue. In other words, periodic defoliation of forbs does not necessarily have a negative impact on those species or their relative abundance within the prairie.

Stocking rate decisions can be made annually, based on weather and objectives. In our case, we typically lower stocking rates after dry years to compensate for what was heavier-than planned grazing during that year. Conversely, we usually increase stocking rates after wet years to make up for an “excess” of grass coming out of that season. We can’t predict the coming season’s weather, but we can at least adjust to compensate for the prior year. In addition to weather, though, we also look at the

vigor of invasive and native grasses, our desire to create certain kinds of wildlife habitat structure, and objectives related to forbs and other plants and insects as we determine annual stocking rates.

There is no rule that stocking rates have to stay constant through the season. Historically, bison grazing was likely most concentrated in burned patches of the landscape during the early part of the summer, before herds broke up into smaller wandering groups in the late season. More importantly, our desire for a certain intensity of grazing often varies by season, depending upon our objectives for a prairie. An advantage of using yearling cattle instead of cows/calves is that reducing stocking rates as the season progresses can sometimes fit well into a marketing plan for yearling cattle. It rarely makes sense to sell cow/calf pairs in mid-summer, however, so when we reduce stocking rates of cow/calf pairs in our prairies mid-season, we or the livestock owner have to find another place for those extra cattle to graze. Regardless, we have been experimenting more and more with stocking rate changes during the season.

In many of our prairies, the ideal stocking rate regime might call for a high number of cattle in the early spring, somewhat fewer animals in the early summer, and then no cattle, or just a few, in the fall (maybe just enough to “clean up” any brome that is growing strongly, but not enough to knock down fuel for the next year’s fire). An early high stocking rate helps to suppress invasive cool-season grasses, but rarely has much impact on forbs because most forbs at that season are either dormant or so short that they escape notice by cattle. With a dormant season fire, cattle will suppress cool-season grasses most in the burned patch, but with a high enough stocking rate, they will also graze across much of the rest of the prairie – searching out those grasses as well. With a late-spring fire, a high number of cattle in the early spring (before the fire) can knock down cool-season grasses in the previous year’s burn, and then the late spring fire can suppress cool-season grasses within the current year’s burn patch.

Reducing the number of cattle on the prairie in late May, as warm-season grasses and forbs are starting to hit their growth spurts, can help ensure that cattle will focus more narrowly on dominant warm-season grasses, leaving forbs largely ungrazed and poised to take advantage of weakened grasses. Again, the appropriate summer stocking rate depends on objectives... In any given year, we tend to have some prairies that have a (relatively) high stocking rate in the summer and others with a low rate.

Exclosures/Seasons of Rest

In smaller prairies (a couple hundred acres or less in size) it may be beneficial to provide seasons of complete rest from grazing to ensure that no plant species are being perennially grazed by cattle. Most of our grazed prairies range from between 80 and 400 acres, and we haven’t seen any plant species disappear from annual patch-burn grazing. However, in some prairies (why it varies by prairie, I don’t know) there are some forb species that can get grazed – at least their flowers – nearly every year. Sometimes that appears to happen because the plants are blooming at a time when grass growth typically slows (e.g. late summer). In other situations, the relative forage value of the most dominant prairie plants may be low enough (especially in prairies dominated by Kentucky bluegrass and switchgrass) that cattle are looking for other plants to supplement their diet. Regardless of the reason, smaller prairies are easy for cattle to search fairly thoroughly for the plants they need to meet their dietary needs, and if some plant species are repeatedly grazed year after year, they are unlikely to

persist. Sometimes, the repeated grazing of forb species – even outside burned patches – can be greatly reduced by simply lowering stocking rates. Other times, periodic total exclusion of grazing may be important.

We have experimented with a couple different ways of periodically excluding prairies from grazing. In some cases, we simply give the prairie complete rest from grazing every few years. In other cases, we'll put cattle in during the spring to hit cool season grasses and then pull them all out in late May or early June. We have one restored prairie where we've increased our stocking rate and burned close to half of the prairie each year, but then only graze that prairie every other year. We're also experimenting with "moving window" exclosures by putting up electric fence around a different portion of the prairie each year so that all portions of the prairie will get some complete rest from grazing while still grazing other portions. In the case of the moving window exclosures, we don't adjust stocking rates because we tend to exclude the area least likely to be grazed anyway, and all we're really doing is preventing "drive by" grazing of favored forbs that don't add much quantity to the forage being taken by the cattle anyway.

We still have a lot to learn about the grazing/rest needs of many plant species, but as discussed earlier, we've not seen any plant species disappear, or even decline precipitously from any of our prairies – even without rest periods or exclosures. The resilience of prairie plants seems to be high, but the lifespan of many plants is also very long, so it may take many years before repeated grazing shows serious impacts. It seems prudent to play it safe by providing complete rest periods now and then when there is a question about what impacts might become important in the long-term.

CONCLUSION

Patch-burn grazing (or any kind of grazing) is not appropriate for all prairies – especially those under 20 acres or so. In our case, we feel that the kind of fire and grazing combinations we're employing are providing benefits, especially in terms of grass suppression, that benefit both plant diversity and habitat quality. At this point, rather than attempting to find a grazing system on our land that would also work for our agricultural neighbors, our approach is to try to optimize biological diversity first. If we can figure out how best to do that, we and others can then focus on how to modify and translate those strategies to fit the needs of private landowners, public land managers, and others working toward a variety of other objectives. In the meantime, we continue to experiment and evaluate the potential impacts of patch-burn grazing – including a multitude of variations on the basic system – on the wide range of species and ecological processes that drive diverse prairie ecosystems. We hope others will conduct similar experiments with fire and grazing combinations that might fit their individual prairie management objectives, and that they will share their results with us and others. There are too many challenges facing prairies not to test all of the tools that could help us ensure that diverse prairies exist far into the future.

Chris Helzer is the author of *The Ecology and Management of Prairies in the Central United States* and blogs at <http://prairieecologist.com>.

APPENDIX E

Soils Data and Analysis

GIS data for soils was compiled in March of 2012 to assist in informing the development of the Master Plan and future implementation efforts. The data and maps referenced on the next six pages of this appendix are comprised of a subset of soils from the NRCS Soil Survey Geographic (SSURGO) Database, representing soil formation, slope, ease of establishment for prairie plantings, and erosion potential. Attributes were applied by the City-County Planning Department based upon input from Jim Culver from the Lancaster County Ecological Advisory Committee, as follows:

a. Ease: Ease of establishment for prairie plantings

- 1** = Greatest opportunity
- 2** = Moderate
- 3** = Other

b. Alluv: Soil formation

- 1** = Soils formed in alluvial soils
- 2** = Soils formed in alluvial soils and glacial till
- 3** = Soils formed in glacial till

c. Erode: Erosion potential of soil types

- 1** = Low
- 2** = Moderate
- 3** = Moderately high
- 4** = High
- 5** = Very high

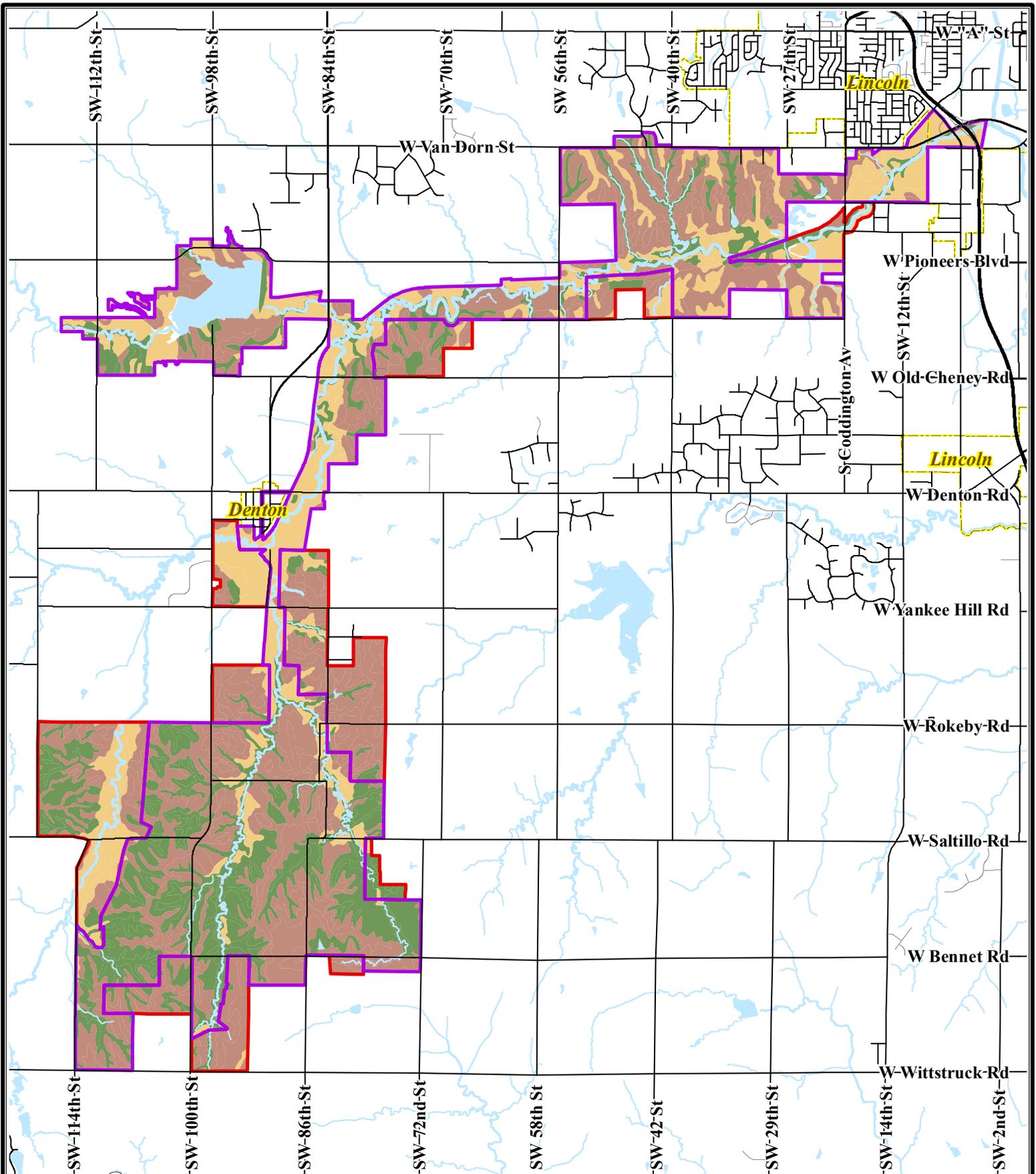
d. Slope:

- 1** = 5% or lower and/or flooded
- 2** = 6% to 11%
- 3** = 12% to 17%
- 4** = 18% or higher

A list of hydric soils for Lancaster County provided by NRCS is also included in this appendix.

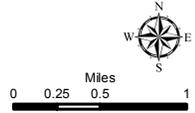
MUNAME	EASE	ALLUV	ERODE	SLOPE
Lamo silty clay loam, occasionally flooded	1	1	1	1
Crete silt loam, terrace, 0 to 1 percent slopes	1	0	1	1
Butler silt loam, terrace, 0 to 1 percent slopes	1	0	1	1
Crete silty clay loam, terrace, 1 to 3 percent slopes	1	0	1	1
Crete silt loam, 0 to 1 percent slopes	1	0	1	1
Hedville sandy loam, 7 to 30 percent slopes	3	0	5	4
Salmo silty clay loam, channeled, frequently flooded	3	1	1	1
Salmo silty clay loam, occasionally flooded	2	1	1	1
Kennebec silt loam, occasionally flooded	1	0	1	1
Zook silty clay loam, occasionally flooded	1	1	1	1
Aksarben silty clay loam, 2 to 6 percent slopes	1	0	2	2
Aksarben silty clay loam, 6 to 11 percent slopes	2	0	3	2
Burchard-Nodaway complex, 2 to 30 percent slopes	3	2	5	4
Burchard clay loam, 6 to 11 percent slopes	2	3	3	2
Burchard clay loam, 11 to 17 percent slopes	3	3	4	3
Judson silt loam, 2 to 6 percent slopes	1	0	1	2
Judson fine sandy loam, 2 to 6 percent slopes	1	0	1	2
Dickinson fine sandy loam, 6 to 11 percent slopes	2	0	2	2
Dickinson fine sandy loam, 6 to 11 percent slopes, erod	2	0	3	2
Malcolm silt loam, 6 to 11 percent slopes	2	0	3	2
Morrill clay loam, 6 to 11 percent slopes	2	0	3	2
Morrill clay loam, 11 to 17 percent slopes	2	0	4	3
Morrill clay loam, 6 to 11 percent slopes, eroded	2	0	4	2
Otoe silty clay, 6 to 11 percent slopes, eroded	2	0	4	2
Pawnee clay loam, 3 to 6 percent slopes, eroded	2	3	3	2
Pawnee clay loam, 6 to 11 percent slopes, eroded	2	3	4	2
Pawnee clay, 3 to 6 percent slopes, severely eroded	3	3	5	2
Shelby clay loam, 6 to 11 percent slopes	2	3	3	2
Steinauer clay loam, 6 to 11 percent slopes, eroded	2	3	4	2
Steinauer loam, 6 to 11 percent slopes	2	3	4	2
Steinauer loam, 11 to 30 percent slopes	3	3	5	4
Steinauer clay loam, 20 to 40 percent slopes	3	3	5	4
Yutan silty clay loam, 6 to 11 percent slopes, eroded	2	0	3	2
Yutan silty clay loam, 11 to 17 percent slopes, eroded	2	0	4	3
Mayberry silty clay loam, 3 to 6 percent slopes, eroded	2	3	3	2
Mayberry silty clay loam, 6 to 11 percent slopes, erode	2	3	4	2
Wymore silty clay loam, 0 to 1 percent slopes	1	0	1	1
Wymore silty clay loam, 1 to 3 percent slopes	1	0	2	1
Wymore silty clay loam, 3 to 6 percent slopes, eroded	2	0	3	2
Wymore silty clay loam, 6 to 11 percent slopes	2	0	4	2
Nodaway silt loam, occasionally flooded	1	1	1	1
Colo silty clay loam, occasionally flooded	1	1	1	1
Colo-Nodaway silty clay loams, frequently flooded	2	1	1	1
Nodaway silt loam, channeled, frequently flooded	3	1	1	1
Zook silt loam, occasionally flooded	1	1	1	1
Arents, earthen dam	3	0	5	4

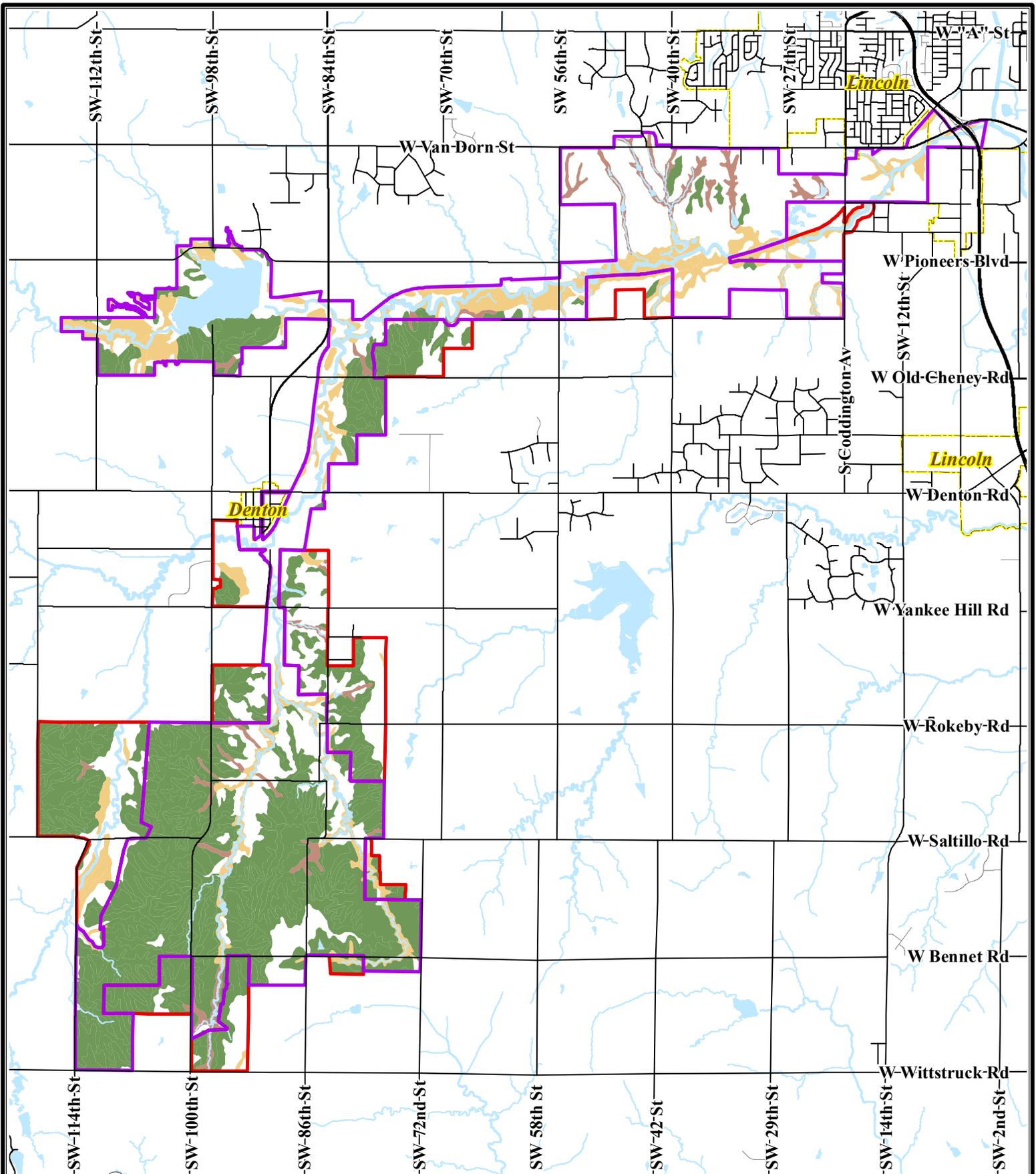
Mine or quarry	3	0	5	4
Miscellaneous water, sewage lagoon	3	0	1	1
Water	0	0	1	1



EASE OF ESTABLISHMENT FOR PRAIRIE PLANTINGS

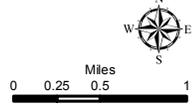
- | | |
|--|---|
|  Greatest Opportunity |  Prairie Corridor Tier A |
|  Moderate |  Prairie Corridor Tier B |
|  Other |  Corporate Limits |

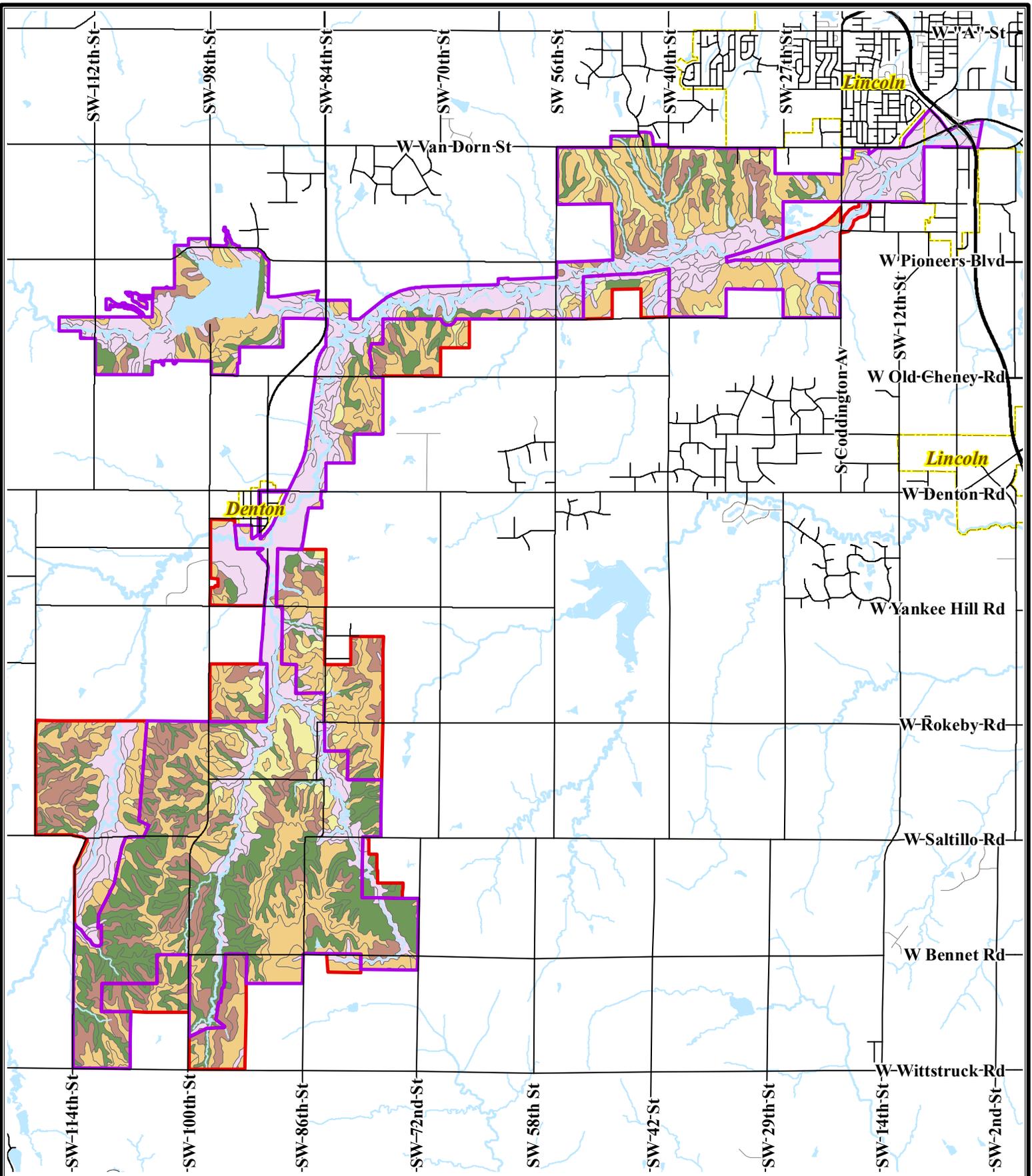




PRAIRIE CORRIDOR SOIL FORMATION

- Alluvial Sediments
- Alluvial Sediments and Glacial Till
- Glacial Till
- Prairie Corridor Tier A
- Prairie Corridor Tier B
- Corporate Limits



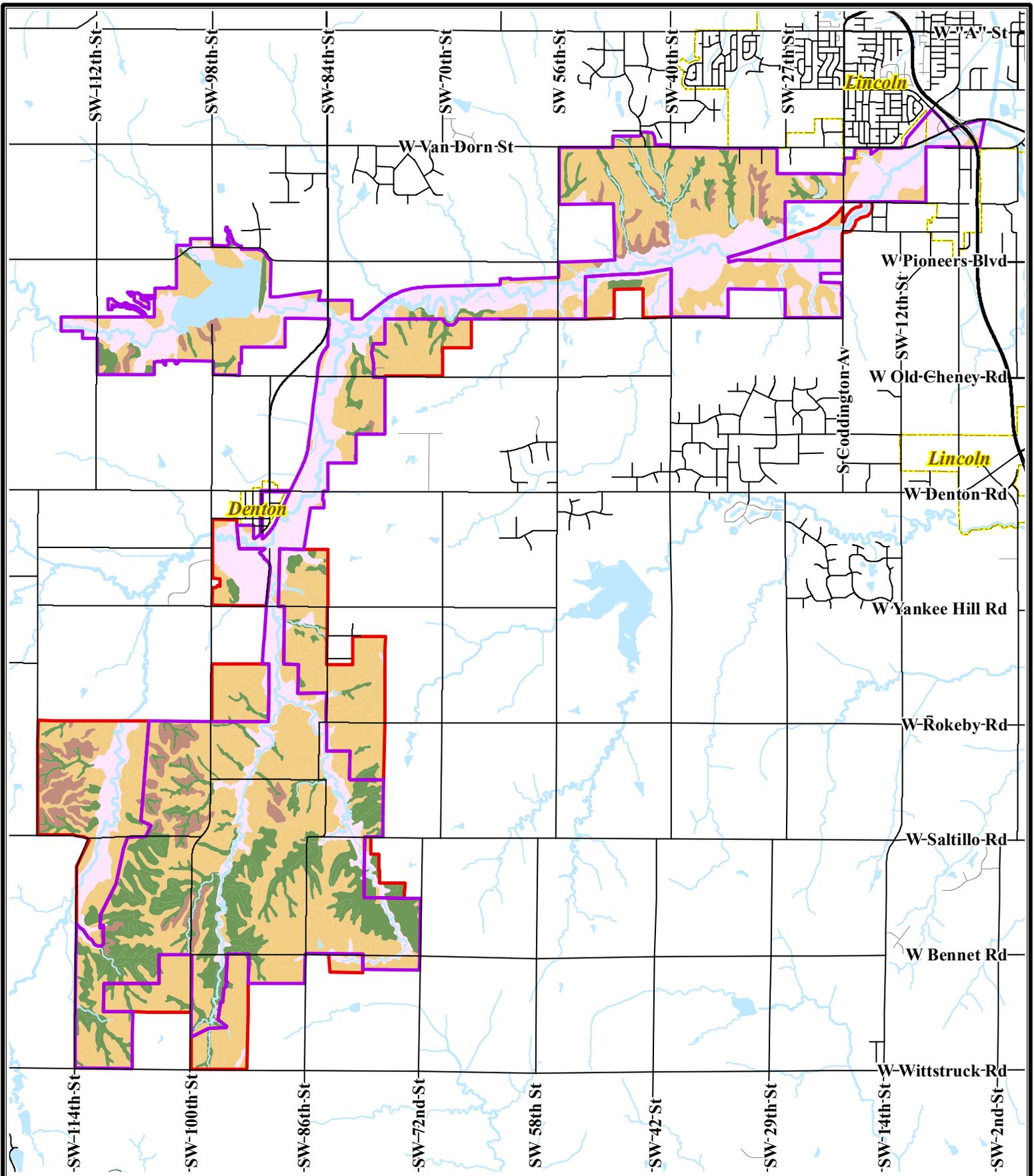


PRAIRIE CORRIDOR SOIL EROSION POTENTIAL

- | | | |
|---------------------------|-----------------|-------------------------|
| Erosion Potential: | Moderately High | Prairie Corridor Tier A |
| Low | High | Prairie Corridor Tier B |
| Moderate | Very High | Corporate Limits |

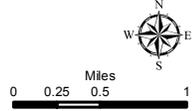
0 0.25 0.5 1 Miles

LINCOLN - LANCASTER COUNTY
 PLANNING DEPARTMENT



PRAIRIE CORRIDOR GENERALIZED SLOPE CLASSES

- Slope 5% or Lower and/or Flooded (Low)
- Slope 6% to 11%
- Slope 12% to 17%
- Slope 18% or Higher (High)
- Prairie Corridor Tier A
- Prairie Corridor Tier B
- Corporate Limits



Hydric Soils

Lancaster County, Nebraska

Map symbol and map unit name	Component	Percent of map unit	Landform	Hydric rating	Hydric criteria
3518: Lamo silty clay loam, occasionally flooded	Salmo, occasionally flooded	2	Flood plains	Yes	2B3
3561: Hobbs silt loam, occasionally flooded	Ponded soils	1	Depressions	Yes	2B3
3640: Kezan silt loam, frequently flooded	Kezan	99	Flood plains	Yes	2B3
	Ponded soils	1	Depressions	Yes	2B3
3641: Kezan silt loam, channeled, frequently flooded	Kezan, channeled, frequently flooded	85	Drainageways	Yes	2B3
	Kezan, occasionally flooded	10	Drainageways	Yes	2B3
	Fluvaquents, frequently flooded	3	Drainageways	Yes	2B3, 3
3709: Crete silt loam, terrace, 0 to 1 percent slopes	Fillmore	2	Playas, Stream terraces	Yes	2A
3713: Butler silt loam, terrace, 0 to 1 percent slopes	Fillmore	4	Playas, Stream terraces	Yes	2A
	Zook, occasionally flooded	1	Flood plains	Yes	2B3
3820: Butler silt loam, 0 to 1 percent slopes	Fillmore	5	Divides, Playas	Yes	2A
3824: Crete silt loam, 0 to 1 percent slopes	Fillmore	2	Closed depressions	Yes	2A
	Olbut	1	Playas	Yes	2A
3952: Fillmore silt loam, frequently ponded	Fillmore	99	Playas, Stream terraces	Yes	2A
	Ponded soils	1	Depressions	Yes	2B3
7015: Salmo silt loam, occasionally flooded	Ponded soils	1	Depressions	Yes	2B3
	Wt at 0-1 foot	1	Swales	Yes	2B3

Hydric Soils

Lancaster County, Nebraska

Map symbol and map unit name	Component	Percent of map unit	Landform	Hydric rating	Hydric criteria
7016: Salmo silty clay loam, channeled, frequently flooded	Salmo, channeled, frequently flooded	99	Flood plains	Yes	2B3
	Ponded soils	1	Depressions	Yes	2B3
7017: Salmo silty clay loam, occasionally flooded	Salmo, occasionally flooded	99	Flood plains	Yes	2B3
	Ponded soils	1	Depressions	Yes	2B3
7049: Kenridge silty clay loam, occasionally flooded	Obert, occasionally flooded	2	Flood plains	Yes	2B3, 3
7050: Kennebec silt loam, occasionally flooded	Wabash	3	Flood plains	Yes	2B3
	Colo	2	Flood plains, River valleys	Yes	2B3
7067: Saltillo silt loam, occasionally flooded	Saltillo, occasionally flooded	85	Flood plains	Yes	2B3
	Fluvaquents, frequently flooded	9	Depressions, Flood plains	Yes	2B3, 3
7091: Wabash silty clay, occasionally flooded	Wabash, occasionally flooded	99	Flood plains	Yes	2B3
	Ponded soils	1	Depressions	Yes	2B3
7094: Zoe silty clay loam, occasionally flooded	Zoe, occasionally flooded	100	Flood plains	Yes	2B3
7099: Zook silty clay loam, occasionally flooded	Zook, occasionally flooded	100	Flood plains	Yes	2B3
7205: Aksarben silty clay loam, 0 to 2 percent slopes	Fillmore	2	Broad interstream divides, Playas	Yes	2A
7231: Judson silt loam, 2 to 6 percent slopes	Flooded soils	1	Flood plains	Yes	2B3, 4
7446: Morrill-Malmo, eroded, complex, 3 to 11 percent slopes	Wt at 0-1 foot	1	Swales	Yes	2B3

Hydric Soils

Lancaster County, Nebraska

Map symbol and map unit name	Component	Percent of map unit	Landform	Hydric rating	Hydric criteria
7669: Mayberry clay loam, 3 to 11 percent slopes	Wt at 0-1 foot	1	Swales	Yes	2B3
7695: Wymore silty clay, 3 to 6 percent slopes, eroded	Perched wt	1	Swales	Yes	2B3
7750: Nodaway silt loam, occasionally flooded	Colo, occasionally flooded	5	Flood plains	Yes	2B3
7770: Colo silty clay loam, occasionally flooded	Colo, occasionally flooded	100	Flood plains	Yes	2B3
7773: Colo-Nodaway complex, frequently flooded	Colo, frequently flooded	50	Flood plains	Yes	2B3
	Zook	5	Flood plains	Yes	2B3
7774: Colo-Nodaway silty clay loams, frequently flooded	Colo, occasionally flooded	60	Flood plains	Yes	2B3
7867: Nodaway silt loam, channeled, frequently flooded	Colo, occasionally flooded	4	Flood plains	Yes	2B3
	Ponded soils	1	Depressions	Yes	2B3
7868: Nodaway silt loam, channeled, occasionally flooded	Kezan, occasionally flooded	2	Flood plains	Yes	2B3
7890: Zook silt loam, occasionally flooded	Zook, occasionally flooded	100	Flood plains	Yes	2B3

Explanation of hydric criteria codes:

1. All Histels except for Folistels, and Histosols except for Folist.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
 - A. are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
 - B. are poorly drained or very poorly drained and have either:
 - 1.) a water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
 - 2.) a water table at a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or
 - 3.) a water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.
3. Soils that are frequently ponded for long or very long duration during the growing season.