Engineered ecologies: Addressing energy infrastructure impacts on wildlife habitat & movement

by

Logan A. Baker

A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

Landscape Architecture and Regional and Community Planning
College of Architecture, Planning and Design

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2020

Approved by:

Major Professor
Dr. Timothy D. Keane

Abstract

As the worldwide demand for energy continues to grow, vast amounts of energy infrastructure are required to support the expanding energy production industry. This infrastructure, taking the form of high-voltage transmission lines, pipelines, and wind farm installations, threatens the movement patterns and native habitat of many terrestrial and avian wildlife species. By utilizing the concepts of Public/Private Partnerships (P3s) and Social Capital, this study aims to address the energy infrastructure-induced habitat degradation and movement impacts experienced by wildlife within Kansas, Oklahoma, and Northern Texas.

Building upon the research, management strategies, and stakeholder structure of existing conservation-based public/private partnerships, this study asks two main questions:

how can wildlife habitat within existing and proposed energy corridors and installations be better conserved to prevent wildlife habitat degradation and barrier effects?

and

how can public/private partnerships utilize stakeholders to form design guidelines and policies for the conservation of habitat within existing and proposed energy corridors and installations?

A review of literature on successful conservation-based public/private partnerships suggested that, while the concept of social capital has been successfully applied in P3s concerned with wildlife habitat preservation, there has not been a direct application of social capital or public/private partnerships to energy infrastructure and installation design and management. Case studies conducted on three conservation-based P3s, the Sage Grouse Initiative, the Lesser Prairie Chicken Initiative, and the Wyoming Migration Initiative, revealed that many of the same conservation planning policies and stakeholder composition strategies used in wildlife habitat conservation P3s could be easily adapted to existing and proposed energy infrastructure and installations.

Case study analysis of precedential P3s aimed at identifying stakeholder composition, structure, and innovative or successful use of conservation strategies led to the formation of a series of design guidelines and policies for existing and proposed energy infrastructure corridors and installations. In addition, conservation planning and management guidelines focused on education and training for design professionals, energy infrastructure maintenance personnel, and practicing ecologists, biologists, and conservationists were developed.

To test the effectiveness and applicability of the newly developed design guidelines and policies, two test sites were chosen that clearly exhibited signs of wildlife habitat degradation and barrier effects on wildlife movement resulting from the presence of energy infrastructure or installations. These two sites, located in Northeastern Texas and Western Kansas, served as

testbeds for projective site designs, where design guidelines and policies for existing energy infrastructure corridors and installations were applied at two different site scales, and with two different types of energy infrastructure present (below-grade pipeline and wind turbine arrays, respectively).

The results of these projective site designs indicated that the design guidelines and policies developed during the course of this study were successful in creating additional wildlife habitat for two target avian species, the Lesser Prairie Chicken and Northern Bobwhite. Umbrella species, specifically Mule Deer, were able to indirectly benefit from habitat creation as well. Additionally, it was determined that the design guidelines and policies developed within this report were infinitely scalable, allowing many of the same guidelines and policies to be adapted to industries as large as worldwide transportation, or as small as the horizontal directional drilling utilities installation industry. It is suggested that additional future research be conducted toward developing design guidelines and policies specific to the extreme Eastern and Western portions of the United States, as many of the guidelines and policies within this report are best suited for the Midwestern grasslands of the U.S.

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LOGAN BAKER | 2020

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As the worldwide demand for energy continues to grow, vast amounts of energy infrastructure are required to support the expanding energy production industry. This infrastructure, taking the form of high-voltage transmission lines, pipelines, and wind farm installations, threatens the movement patterns and native habitat of many terrestrial and avian wildlife species. By utilizing the concepts of Public/Private Partnerships (P3s) and Social Capital, this study aims to address the energy infrastructure-induced habitat degradation and movement impacts experienced by wildlife within Kansas, Oklahoma, and Northern Texas.

Building upon the research, management strategies, and stakeholder structure of existing conservation-based public/private partnerships, this study asks two main questions:

1) How can wildlife habitat within existing and proposed energy corridors and installations be better conserved to prevent wildlife habitat degradation and barrier effects?

2) How can public/private partnerships utilize stakeholders to form design guidelines and policies for the conservation of habitat within existing and proposed energy corridors and installations?

A review of literature on successful conservation-based public/private partnerships suggested that, while the concept of Social Capital has

been successfully applied in P3s concerned with wildlife habitat preservation, there has not been a direct application of social capital or public/private partnerships to energy infrastructure and installation design and management. Case studies conducted on three conservation-based P3s, the Sage Grouse Initiative, the Lesser Prairie chicken Initiative, and the Wyoming Migration Initiative, revealed that many of the same conservation planning policies and stakeholder composition strategies used in wildlife habitat conservation P3s could be easily adapted to existing and proposed energy infrastructure and installations.

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The results of these projective site designs indicated that the design guidelines and policies developed during the course of this study were successful in creating additional wildlife habitat for two target avian species, the Lesser Prairie Chicken and Northern Bobwhite. Secondary species, specifically Mule Deer, were able to indirectly benefit from habitat creation as well. Additionally, it was determined that the design guidelines and policies developed within this report were scalable, allowing many of the same guidelines and policies to be adapted to industries as large as regional transportation, or as small as the horizontal directional-drilling utilities-installation industry. It is suggested that additional future research be conducted toward developing design guidelines and policies specific to the extreme Eastern and Western portions of the United States, as many of the guidelines and policies within this report have only been studied within the grasslands of the Midwestern U.S.

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ACKNOWLEDGMENTS

First, I would like to thank my family for their continued support and encouragement through the entirety of my education. Without their support, the opportunities and experiences I've gained the past five years would not have been possible. An extended thank you to my grandparents, friends, and peers for their continued encouragement, stress-relief, and positivity.

I would also like to extend my gratitude and appreciation to my committee members, Dr. Kimberly With and Dr. Daniel Sullins, for their excellent feedback and contributions.

Finally, to the endless dedication of my Major Professor, Dr. Tim Keane. Thank you for answering my countless questions to the best of your ability, and encouraging me to explore new and interesting avenues, whether those avenues be academic or professional.

INTRODUCTION & BACKGROUND

1.0

BACKGROUND

As the worldwide demand for energy continues to grow, new technologies for affordable and efficient energy production are on the rise. Energy infrastructure corridors- the access roads, rights-of-way, and transmission lines associated with energy production, negatively impact the habitat of many mammals and migratory bird species. These corridors are typically linear patches that differ in composition and quality from surrounding habitat, and often inhibit wildlife migration patterns, fragment habitats, and promote the establishment of non-native edge species (Echevveria et al. 2007).

RESEARCH QUESTIONS

How can we better conserve habitat in existing and proposed energy corridors to prevent barrier effects on wildlife movement?

Secondly, how can a public/ private partnership obtain and utilize stakeholders to form design guidelines and regulatory policies for the conservation of habitat within existing energy corridors and the design of new energy corridors?

PROJECT OVERVIEW

To reduce the ecological footprint of currently existing and newly proposed energy infrastructure corridors, a system of public/private partnerships and projective design and management strategies was employed to aid in the creation of a future energy infrastructure corridor design model.

The first step, a case study on public/private partnerships (P3), serves to establish a framework for the engagement of stakeholders interested in the common goal of energy corridor best management and design practices (BMDPs). Research was conducted on public/private partnerships, namely research on how P3's are structured, how partners may be selected, and how policy and guidelines are developed within a partnership. From this case study, a selection of theoretical stakeholders then took place, consisting of private landowners, federal agencies, non-profit government organizations, researchers from universities and private practice, and private energy corporations. This case study aided in the establishment of a framework for community-led conservation efforts, utilizing the application of scientific inquiry and data collection and stakeholder input for the development of regulatory and geospatial policies. The result of this approach established a set of design guidelines and best practices for not only the conservation of existing energy corridors, but also the implementation of new energy corridor networks and systems.

The second step in the development of a future corridor design model involves precedent research of existing ecological succession and landscape ecology models. This research, coupled with landscape design knowledge, geomorphological factors, and regulatory and geospatial frameworks, led to the development of a site-specific projective corridor design model that utilizes newly formed design guidelines and regulatory policies. This model represents the potential implementation of prototype energy corridors and associated best management and design practices.

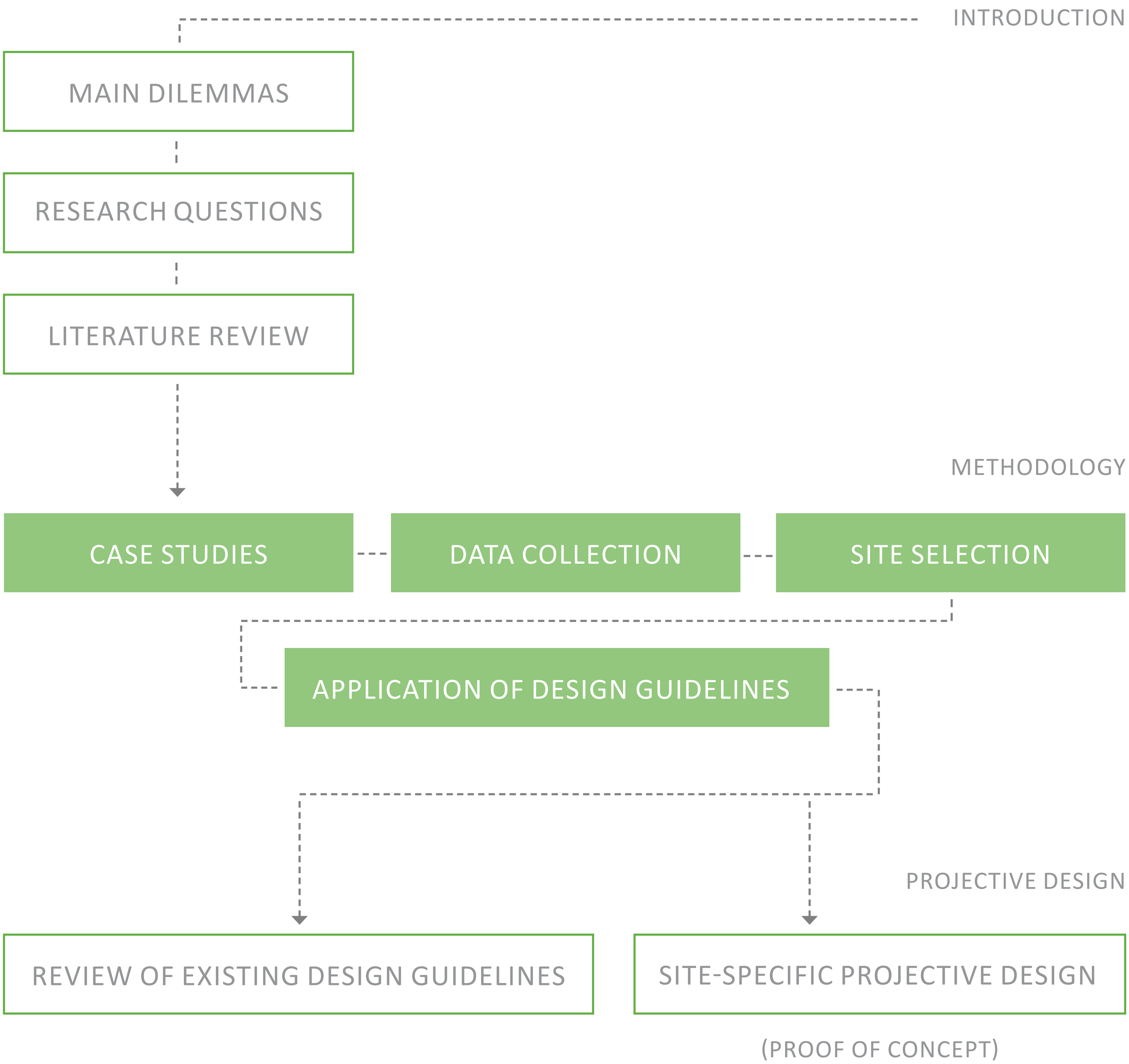
Collaboration between partnership stakeholders and design professionals allows for the formation of design guidelines and regulatory policies that are intended to better inform landowners, energy corporations, and designers on the conservation of existing energy corridors and better implementation of proposed corridors. Together, partnership stakeholders and design professionals can identify key implications of energy infrastructure as they relate to wildlife, land use, and future development.

PURPOSE & SIGNIFICANCE

This report serves to identify common goals and facilitate collaboration between public/private partnership stakeholders and design professionals, ultimately developing a set of regulatory policies and design guidelines for the conservation of wildlife habitat in existing energy infrastructure corridors and installations, and the implementation of future energy infrastructure corridors.

While previous studies have begun to examine the impacts to wildlife and habitat of energy corridors and installations, few have focused their efforts on the establishment of regulations and guidelines for the prevention of ecosystem damage at the outset. The result of this research will be a projective design model for the ecologically sensitive, environmentally sound implementation of energy infrastructure corridors. This model will be unique, in that its application is not limited to energy infrastructure corridors. Rather, there is potential for this model to be applied to a wide range of corridor types, including roadways, rail lines, and communications-infrastructure networks.

Figure 1.00
PROJECT DIAGRAM (BAKER 2020)



DILEMMA

Energy infrastructure corridors and installations, or the pipelines, access roads, rights-of-way, wind farms, and transmission lines associated with energy production, negatively impact the habitats of many mammals and bird species across Kansas, Oklahoma, and Texas (Arnett & Baerwald 2013). These infrastructure systems inhibit native wildlife movement patterns, fragment habitats, and promote the establishment of non-native edge species (Echevveria et al. 2007).

THESIS

By forming a theoretical partnership with key entities including large energy-production corporations, State and Federal agencies, NGOs, and private landowners, the development of government-administered regulatory policies and design guideline frameworks can lead to better design and implementation of energy infrastructure corridors. These guidelines can then serve as a 'checklist' of best management practices toward the responsible design of energy infrastructure, providing insight on the successful mitigation of negative ecosystem impacts. In addition, stakeholder incentives can help encourage oil, gas, and wind energy corporations to adopt these guidelines and implement energy infrastructure corridors that reduce negative impacts to wildlife species composition and habitat destruction, while private landowners can benefit from decreases in sprawling infrastructure development and associated damages. It should be noted that the theoretical nature of this partnership is necessary given the timeline available to complete this report, as the formation, selection of stakeholders, and collaboration required to effectively establish a partnership can take five to ten years.

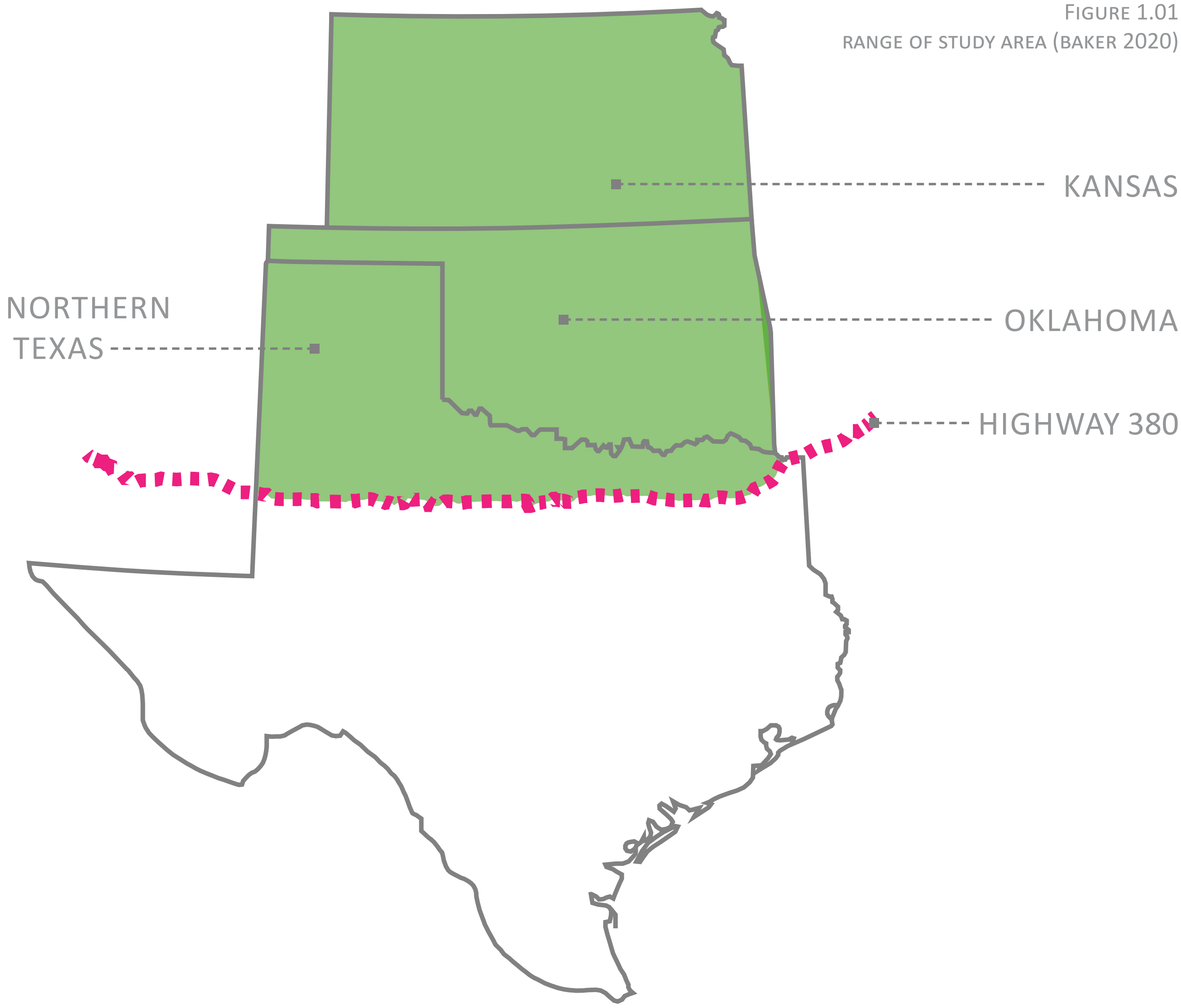


FIGURE 1.01
RANGE OF STUDY AREA (BAKER 2020)

STUDY AREAS

Infrastructure related to energy production impacts many locations across the United States. While many forms of renewable and non-renewable energy production are employed at varying scales, this report will focus on oil, gas, and wind energy production in the Northern Texas, Oklahoma, and Kansas regions. This range was chosen for its overall contribution to total gas, oil, and wind energy production in the United States. State lines serve as study area boundaries for both Kansas and Oklahoma, while Highway 380 in Texas defines the southern border of the study area.

As of 2018, Texas was the leading U.S. producer of both crude oil and natural gas, responsible for 37% of crude oil production and 24% of natural gas production (EIA 2018a). Additionally, one-quarter of U.S. wind energy is produced in Texas (EIA 2018a). Oklahoma is also a large contributor to U.S. oil and natural gas production. A total of five petroleum refineries process roughly 3% of daily national oil production, while 8.6% of the total U.S. natural gas market production originates from Oklahoma (EIA 2018b). Oklahoma also ranks second in wind energy production, falling slightly behind Texas (EIA 2018b). Finally, Kansas was the 10th largest producer of U.S. crude oil and natural gas as of 2018, with 1% of total production. Nearly 36% of electrical energy that originates from Kansas is produced through wind generation (EIA 2018c).

Previous research indicates that as production capacity increases, the amount of infrastructure required to produce and transport energy products increases as well (Kiviat, 2013). The three states within the Study Area produce large amounts of energy, requiring a significant presence of infrastructure corridors throughout the entire Northern Texas, Oklahoma, and Kansas range. These infrastructure corridors intersect the habitat of many species of wildlife, primarily large mammalian ungulates and grassland bird species, where the habitat loss, fragmentation and general increase in noise levels associated with energy corridors directly impacts these species (Khalil 2019, Winder et al. 2015, Lautenbach et al. 2017).

DELINEATION OF TARGET AND SECONDARY SPECIES

It is important to note that the beneficial impacts of energy corridor and installation conservation and design are not distributed evenly across all species discussed within this report. Rather, the concept of target and umbrella species is utilized to identify the primary beneficiaries of energy corridor and installation conservation and design. Though there are five primary target species identified within this report, the benefits and impacts of energy corridors and installations will vary from species to species. For example, while the inclusion of above or below-grade wildlife crossings would benefit migratory ungulates within the study area, it would have little to no beneficial impact upon grassland and territorial avian species.

For this reason, it was determined that to prevent the development of 'one size fits all' design guidelines and policies, it would be necessary to define key candidate species for each projective design proposal. These candidate species, referred to as 'target species' (Maslo et al. 2016) are intended to be the primary beneficiaries of each projective site design proposal; however, they are not the only species to receive potential benefit. Secondary beneficiaries, referred to as 'secondary species', consist of all other wildlife species who occupy habitat within the projective site design study area.

Distinction between target and secondary species is not meant to serve as a metric for quantifying each projective site design's habitat benefits for specific wildlife species. Rather, it is meant to acknowledge the fact that, though it would be best practice to provide uniform habitat improvements for every species present within the study area, external ecological factors and differing wildlife habitat requirements make this unfeasible.   A list of species this report focuses on follows. From this list, two target species were selected as primary beneficiaries of the projective site designs developed within this report: the Northern Bobwhite and Lesser Prairie Chicken.

Figure 1.02

NORTHERN BOBWHITE
(COLINUS VIRGINIANUS)

Figure 1.03

LESSER PRAIRIE CHICKEN
(TYMPANUCHUS PALLIDICINCTUS)

Figure 1.04

GREATER PRAIRIE CHICKEN
(TYMPANUCHUS CUPIDO)

Figure 1.05

MULE DEER
(ODOCOILEUS HEMIONUS)

Figure 1.06

PRONGHORN ANTELOPE
(ANTILOCARPA AMERICANA)

NORTHERN BOBWHITE (COLINUS VIRGINIANUS)

Northern bobwhite populations have significantly declined throughout the northern and southern portions of their habitat range, though they are commonly found across Northern Texas, Oklahoma, and Kansas. Anthropogenic disturbances from energy corridor development have been found to disturb the ecotone habitats used by bobwhite and can be attributed to the shrinkage of the bobwhite's habitat range (Audubon 2019b).

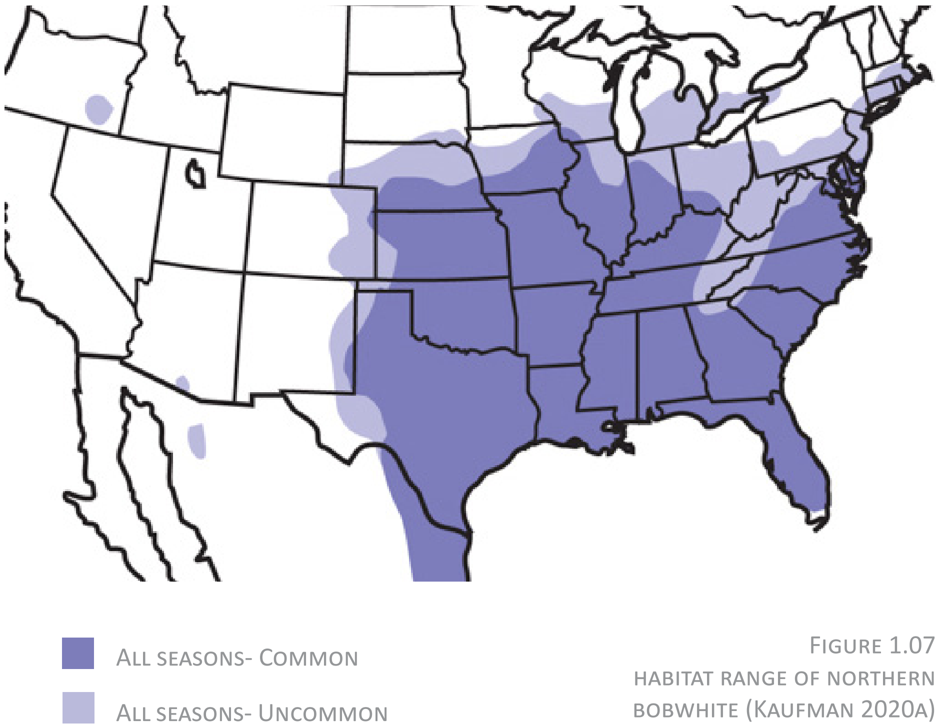
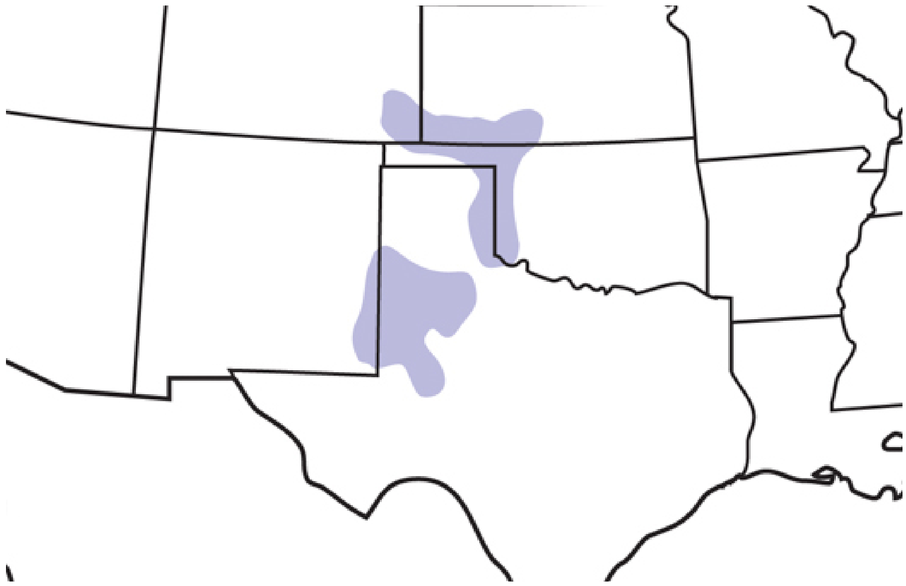


Figure 1.07
habitat range of northern bobwhite (Kaufman 2020a)

LESSER PRAIRIE CHICKEN (TYMPANUCHUS PALLIDICINTUS)

The Lesser Prairie Chicken has disappeared from much of its native rangeland, and was listed as a threatened species in 2014. Threatened species are those species that experience significant declines in population, though they are not yet considered endangered (Audubon 2019a). Habitat loss due to land-use change is the primary threat to this species, with nearly two-thirds of the estimated Lesser Prairie Chicken population occurring in undeveloped areas of western Kansas. Despite continued habitat degradation and loss, the Lesser Prairie Chicken has since been removed from the threatened species list by a Texas federal district judge (LPCI-NRCS 2010).



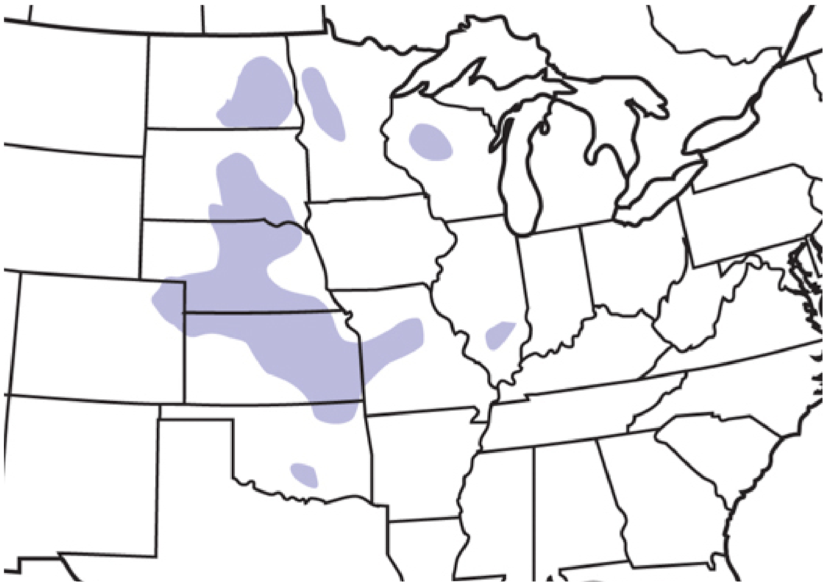
All seasons- Common

All seasons- Uncommon

Figure 1.08
habitat range of lesser prairie chicken (Kaufman 2020b)

GREATER PRAIRIE CHICKEN (TYMPANUCHUS CUPIDO)

Once a common sight across central and Eastern North America, the Greater Prairie Chicken is now very localized in the grasslands of the Midwest. Similar to the Lesser Prairie Chicken, the loss of habitat resulting from land-use change continues to threaten the greater prairie chicken. Though it is not yet listed as a threatened species, the habitat range of the greater prairie chicken is primarily located in the Great Plains region of Kansas, Nebraska, and the Dakotas (Audubon 2019c).



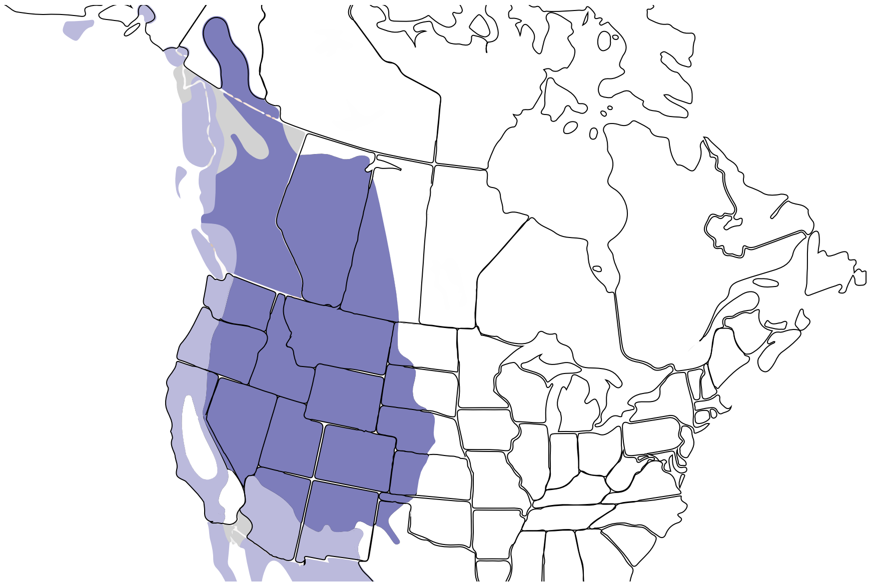
All seasons- Common

All seasons- Uncommon

Figure 1.09
habitat range of greater prairie chicken (Kaufman 2020c)

MULE DEER (ODOCOILEUS HEMIONUS)

Mule deer populations have declined by as much as half in certain geographic regions of the western United States. External pressures including land-use change, agriculture development, and oil and gas development threaten mule deer populations (NRCS 2005, FHSU 2018). Northern Texas, Oklahoma, and western edges of Kansas are included within the current mule deer habitat range, though increased encroachment of white-tailed deer resulting from the expansion of woody vegetation into former habitats is becoming an increasing threat to mule deer populations (FHSU 2018).



All seasons- Common

All seasons- Uncommon

Figure 1.10
habitat range of mule deer
(baker 2020)

PRONGHORN ANTELOPE (ANTILOCARPA AMERICANA)

Threats to pronghorn include habitat loss resulting from increased urban and rural development. Migration barriers such as roads, highways, and fences in open rangeland also impact the movement of pronghorn populations (Howard 1995, Duquette et al. 2015). The habitat range of the pronghorn primarily extends from northern Mexico to Montana and extreme southern Canada, though portions of Northern Texas and Oklahoma are home to pronghorn. While pronghorn have been observed in portions of southwestern and central Kansas, their population numbers are fewer than 2000 individuals. Less than 50 individuals remain within the Flint Hills region of Kansas (KDWPT n.d., Sullins 2019).

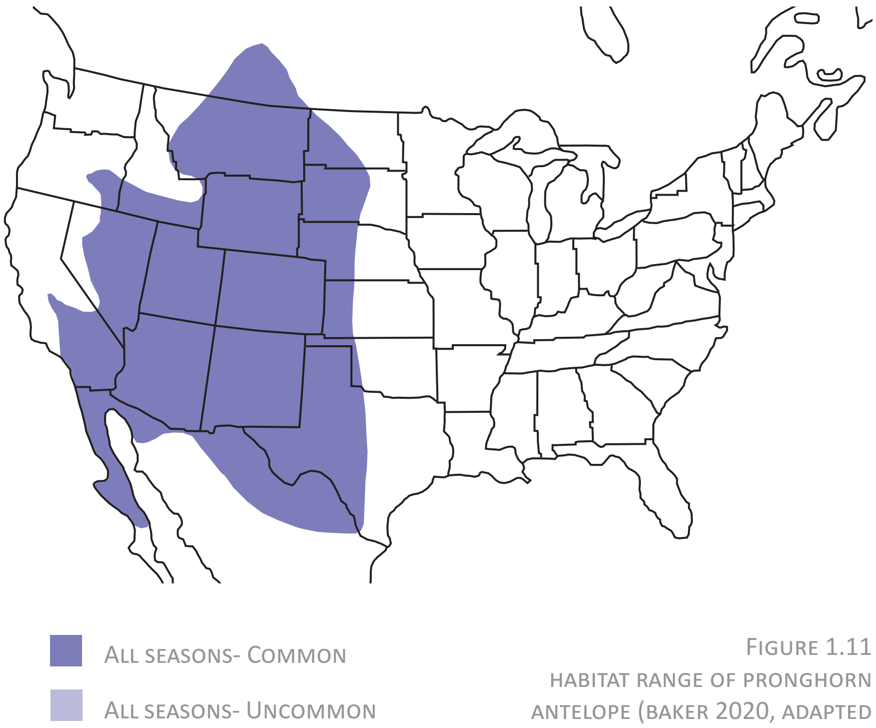


Figure 1.11
habitat range of pronghorn antelope (baker 2020, adapted from Hygnstrom 2017)

KEY TERMS

Energy Infrastructure Corridor:

A linear patch that differs from its surroundings. Contains some type of energy-related infrastructure, such as pipelines, transmission lines, or access roads.

Energy Infrastructure Installation:

Areas that contain large-scale energy production infrastructure or facilities. Typical examples can include wind farms (Burton et al. 2011), large oil and gas metering stations and tank farms (Mokhatab & Lamberson 2009), and solar arrays.

Edge Species:

Species that occur at the interface between different biological communities, which may negatively impact habitat-interior species… through increased competition, predation, disease, or parasitism (With & Pavuk 2012).

Species Composition:

The number and types of species present in an area. Species composition is an important indicator of ecological processes and is commonly determined during the inventorying or monitoring of specific habitats or ecosystems (Barbour et al. 1980, Jacoby 1989).

KEY TERMS (CONTINUED)

Public/Private Partnership:

A non-profit, long-term initiative between stakeholders, usually providing a public asset or service. Stakeholders can include private parties, government entities, or corporations (PPPLRC 2019).

Social Capital:

Features of social life, such as networks, norms, and trust that enable participants to act together more effectively to pursue shared objectives (Putnam 1995, Musoke 2017).

Social Capital Proxy:

A measure of Social Capital using ‘indicators’ or ‘proxies’ that are theoretically linked to Social Capital (Claridge 2017). Essentially, proxies are terms used to quantify the typologies of Social Capital. See Figure 2.09 in Chapter 2 for examples of these proxies.

NGO:

Any non-profit, voluntary group which is organized on a local, national, or international level. NGOs are often task-oriented and driven by members with a common interest, and provide concerns, analysis, and expertise to local, state, and federal governments (NGO Special Interest Area n.d.)

LITERATURE REVIEW

2.0

LANDSCAPE CORRIDOR IMPLICATIONS FOR WILDLIFE

Animals, plants, water, materials, and energy are spatially distributed and move throughout their ecosystems in predictable ways (Dramstad et al. 1996). Landscape corridor structure, or the physical and biological characteristics that make up wildlife and riparian corridors, have many impacts on species composition, diversity, and distribution.

Because wildlife and riparian corridors are often composed of many layers of vegetation, from the rich organic matter of the forest floor to the tree canopy, these corridors provide vital habitat for wildlife (Dramstad et al. 1996). This habitat is threatened by land-use change and changes in development patterns. The introduction of energy infrastructure into existing corridors, or the establishment of new energy infrastructure corridors that did not previously exist, can significantly alter the habitat of the wildlife species that encounter them. Because it is not uncommon for corridors to serve as transitional habitats for larger migrating species, the introduction of infrastructure can pose challenges during seasonal migration, contributing to what is known as the 'barrier effect' (Sangiorgi & Irali 2012). Physical infrastructure is not the only barrier associated with corridors, however. According to Forman and Godron (1986), certain corridors can act as barriers for wind, sub-surface and surface water, and sediment. These barriers can prevent not only the physical movement of bird and terrestrial species, but also the movement of genetics, impacting the overall species diversity of habitat within and adjacent to corridors. This is especially evident when disturbance from human-induced or natural processes occurs within corridors. Post-disturbance successional trajectories often show the presence of invasive species, which compete with native species for food, water, and shelter (Christensen 2014).

DISTURBANCE CORRIDORS

Energy infrastructure corridors fall into the category referred to as 'disturbance' corridors. Disturbance corridors are created by disturbances, either human-induced or natural, and can often prove detrimental to native species habitat (NRCS 2004). Disturbance corridors may result in the displacement of native species and suppress overall population levels in habitats adjacent to the corridor itself. Species that remain are forced to occupy small, densely populated, leftover habitat patches, where competition from other species for food and shelter is drastically increased. In the case of energy infrastructure corridors, both habitat quality and quantity are reduced.

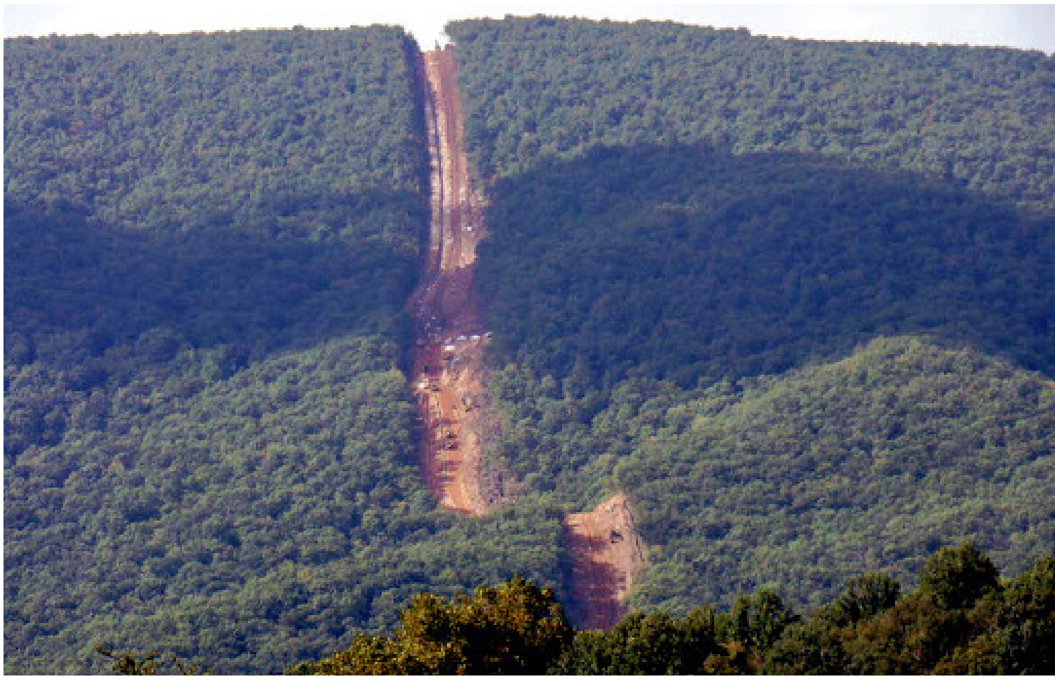


Figure 2.00
Example of a pipeline right-of-way corridor through the Appalachian mountains (Webb 2020).

To date, few studies examine the impact of energy-infrastructure related noise on wildlife species. The noise and invasive species that accompany the introduction of energy infrastructure brings with it many challenges for the avian and terrestrial communities that previously inhabited the area (Khalil 2019). A study conducted by Warrington et. al (2017) suggests that the responses of wildlife species to energy-related noise intrusion are often dynamic and complex. This indicates that adapting to increased levels of infrastructure-related noise can place significant external stressors on wildlife species. It should be noted that all energy infrastructure discussed within this report (pipelines, power lines, and wind energy infrastructure) contribute varying levels of noise intrusion into wildlife habitats. Compressor and pump stations associated with oil and gas production, acoustic frequencies generated by large wind turbines, and flat, static buzzing signals from high voltage power lines all contribute to the noise pollution of wildlife habitat (Warrington et al. 2017). Additionally, the large, vertical structures associated with energy infrastructure corridors can provide vantage points for predatory species, further impacting native species populations (Sullins, 2019).

Review of previous literature reveals that disturbance by the introduction of infrastructure is a common theme. Though the infrastructure can vary in type, the most common forms are roadway and power line rights-of-way. It is clear that the type of infrastructure plays an important role when regarding the species types impacted. Avian species, for example, may not be subject to the physical impacts of the 'barrier effect' (Sangiorgi & Irali 2012); however these species are indirectly impacted through habitat loss and encroachment and increased competition from invasive species (Echeverria et al. 2007, Sangiorgi & Irali 2012, Warrington et al. 2017). Physical impacts to mammalian ungulates are more clearly observed.

Infrastructure within disturbance corridors is often linear in arrangement, with few breaks to allow the passage of terrestrial wildlife. According to a study by Bissonette & Adair (2008), the ideal distance between infrastructure breaks for the passage of most ungulate species is roughly one mile. This figure varies based upon population density and established migration routes; however, it serves as an exemplary 'rule of thumb' when considering the best management and design practices (BMDPs) of energy corridor conservation and implementation.

Figure 2.01
Excavator installing portions of pipeline (Pentin 2019).

Figure 2.02
High-voltage electric transmission lines (Boicu 2019).

Figure 2.03
Access road for high-voltage transmission line maintenance and operations (Hosova 2019).

SUCCESSIONAL STAGES WITHIN DISTURBANCE CORRIDORS

The anthropogenic nature of disturbance corridors formed by energy infrastructure creates unique trajectories for successional sequences that would not otherwise occur following natural disturbances (NRCS 2004). Referred to as 'ecological drivers', these natural disturbances occur in regular return frequencies, and serve to maintain the ecological function of ecosystems (Askins 2007, Sullins 2019). High monetary values placed on infrastructure, especially energy-related infrastructure, greatly alter the level of natural succession allowed to take place within infrastructure corridors. This is largely due to the concern of damage to infrastructure by natural successional trajectories and ecological drivers. For example, ecosystems such as tallgrass prairie that rely on disturbance by fire are severely impacted by the introduction of energy infrastructure. The suppression of fire disturbance has been proven to alter the vegetative composition in these ecosystem types, resulting in the encroachment of invasive woody species such as the eastern red cedar and honeysuckle (Reichman 1987).

ECOLOGICAL BENEFITS OF LANDSCAPE CORRIDORS

The presence of landscape corridors within the landscape is not always detrimental to the ecosystems in which they reside. In many cases, if corridors are devoid of infrastructure (i.e. not considered disturbance type corridors), many benefits can stem from the natural processes that occur within them and along their edges (Forman 1995). Non-riparian corridors, such as conservation buffers and easements, have been shown to cleanse air through carbon sequestration, and even serve as productive agricultural land (Lovell & Sullivan 2005), while riparian corridors are excellent examples of corridor types that offer many ecological benefits to terrestrial and aquatic species alike. Riparian corridors along wetlands and floodplains provide water storage capacity and slow high velocity flows, mitigating potential downstream damage (Binford & Buchenau 1993). In addition, the incorporation of riparian buffer corridors can reduce sediment deposition, increase stream channel bank stability (Alldredge et al. 2014), and provide shelter and forage for wildlife (Reichman 1987).

Figure 2.04
Wetlands adjacent to stream channels reduce stream flow velocity and mitigate potential downstream flood damages. Photo by Kevin Ortiz (2019).

Figure 2.05
Riparian corridor along stream channel (Sakhibgareev 2019).

The importance of preserving both riparian and non-riparian corridors and limiting development, infrastructure or otherwise, within these ecosystems is paramount. Many ecological benefits stem directly from these corridor types, and the destruction of these ecosystems will likely result in increased flooding occurrence and frequency, reduced air and water quality, increased erosion and sediment deposition, and the general decline of overall corridor habitat (Lovell & Sullivan 2005, Rosgen & Silvey 2009). Though the likelihood of energy infrastructure development along long-distance stretches of riparian corridors is relatively low, it is probable that energy infrastructure will cross perpendicular to riparian corridors and within non-riparian corridors or conservation easements to a limited extent. In this case, extreme care must be taken to preserve the integrity of these riparian and non-riparian ecosystems. This issue will be addressed in the projective design section of this report.

Additionally, habitat loss is an issue of increasing concern for many species of wildlife. According to Noss (1991), “[wildlife] corridors, even narrow ones, provide habitat in which some kinds of organisms will live and reproduce”. Though corridors primarily serve as transitional zones, wider corridors can provide habitat for a variety of species.

ECONOMIC BENEFITS OF LANDSCAPE CORRIDORS

Current literature reveals significant gaps in the economic contributions of non-infrastructural corridors. Some research has been conducted regarding the economic benefits of conservation buffers, such as the NRCS CRP program, though this research is primarily directed toward farmers and agricultural production, specifically focused on the reduction of soil erosion (Lovell & Sullivan 2005, Nassauer 2002). Additional research is suggested on the monetary contributions (in terms of annual dollars in production) of energy corridors within the study area.

Figure 2.06
NRCS Conservation Easement Boundary Sign (Moseley 2009).

Figure 2.07
NRCS conservation buffer along Bear Creek in Story County, Iowa (Betts 2012).

SOCIAL BENEFITS OF LANDSCAPE CORRIDORS

Corridors without the presence of infrastructure can present opportunities for recreation, education, and aesthetic beauty. The linear structure of corridors makes them suitable for many forms of recreation, especially if they are located on public property. Hiking, walking, biking, hunting, and bird watching are but a few of many recreational opportunities offered by corridors. In addition, corridors that are diverse in vegetation can offer scenic views and an abundance of native wildlife (Lovell & Sullivan 2005). Education and research are another valuable contribution of corridors. Stable reaches of riparian corridors can provide valuable insight on vegetative successional trajectories (NRCS 2004).

Densely vegetated corridors, especially those comprised of a mix of woody and herbaceous plant types, can offer significant visual characteristics. These corridors can provide an overall sense of visual and spatial structure and scale to sprawling, open landscapes common in the Midwest (NRCS 2004). Given the vast scale of infrastructure corridors, their presence can often impose upon and reduce the visual quality of the landscape. By incorporating native vegetation along infrastructural corridors, the textural diversity and seasonal color of otherwise visually insignificant spaces can lessen this imposing character.

SOCIAL CAPITAL

The social aspects of landscape corridors extend far beyond aesthetic beauty and recreation. By integrating people into the preservation and responsible management of landscape and energy corridors, the opportunity for collaborative and intentional engagement presents itself. The following section explores the concept of Social Capital, where groups of people who share a common interest work together in the form of a public/private partnership to promote energy corridor conservation and develop design guidelines and regulatory policy.

According to Van Ham & Koppenjan (2001), “there is no uniform blueprint for a successful public/private partnership”.

The most successful public/private partnerships require mutual agreement between partners, and typically require partners and stakeholders to share a common or central goal. Determining who will participate in any public/private partnership is often a challenging matter. Dale & Newman (2010) and Musoke (2017), suggest that “ideal partnerships are formed with a combination of local organizations, leaders, various levels of government, the private sector, and other pertinent organizations”.

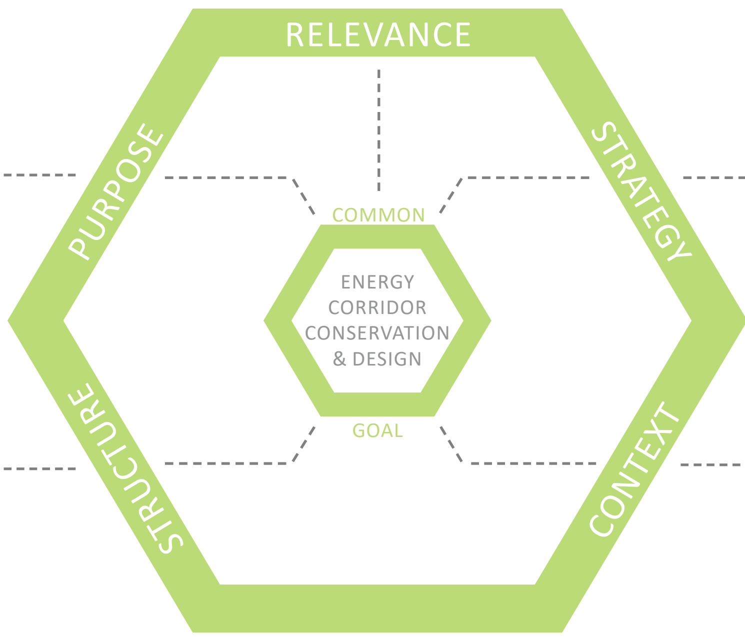
Defined broadly, social capital is “the features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions” (Putnam et al. 1993). In recent years, the concept of social capital has become increasingly common, utilized in many science-based disciplines by economists, sociologists, architects, landscape architects, and designers.

Figure 2.08
basic concepts of social capital (Baker 2020)

Through the use of Social Capital, a group of like-minded individuals can be assembled. This team then develops strategies to achieve a common goal -Energy Corridor Design & conservation- through collaborative engagement.

An essential aspect of social capital is the sharing of a common goal (Musoke 2017). In this case, the common goal is energy corridor conservation and design.

Three proxies of social capital drive the guideline and policy formation strategy within this report: Groups & Networks, Collective Action & Cooperation, and Information & Communication.



Ideal partnerships are formed with a combination of local organizations, leaders, various levels of government, the private sector, and other pertinent organizations (Dale & Newman 2010).

Social Capital can be utilized across many scales. Examples include local government committees, regional conservation partnerships, and large corporate/government joint initiatives (Dudwick et al. 2006).

PROXIES OF SOCIAL CAPITAL

Six proxies (see Key Terms section on pages 19 and 20) can be used to describe social capital: groups and networks; trust and solidarity; collective action and cooperation; information and communication; social cohesion and inclusion; and empowerment and political action (Dudwick et al. 2006). For the purpose of this pilot study, focus will be placed upon three proxies: groups and networks; collective action and cooperation; and information and communication.

1. GROUPS & NETWORKS

Social interactions are the foundation of social capital. Reciprocity of knowledge and information exchanges through interactions between local community members, natural resource agencies, and resource-based organizations serve to increase trust among communal partners and stakeholders.

Securing the trust and cooperation of individuals can be accomplished through three typologies of social capital: bonding, bridging, and linking capital (Musoke 2017, Pretty 2003). Bonding social capital reinforces ties between groups of similar people. These people may be linked by similar backgrounds, social classes, or ethnicity (Putnam 2001). Contrasting bonding capital, bridging capital secures ties between groups of people who do not share common interests, have different backgrounds or upbringings, or exist within different social classes (Putnam 2001). Finally, linking capital refers to connections between community groups and external entities (Musoke 2017), including corporations, natural resource agencies, or governmental groups.

2. COLLECTIVE ACTION & COOPERATION

What do groups, networks, and collective action within social capital mean for the establishment of a wildlife and habitat-conservation based public/private partnership? Trust between the potential volunteers or members of any conservation-based partnership and the partnership itself is critical to a successful conservation partnership. By establishing connections through similar and dissimilar community groups and exchanging knowledge, information, and ideas reciprocally, a sense of trust can be formed, resulting in greater public participation rates throughout the community.

3. INFORMATION & COMMUNICATION

The ability for communities to collect and receive information regarding public services, market conditions, or other community events plays a large role in the social capital of these communities (Dudwick et al. 2006). Information may be disseminated through the media (print media, radio, television broadcasts), or through other sources (conversations, posters, brochures).

For a community to be aware of emerging conservation-based partnerships, information must be available to it. By capitalizing on available forms of distribution, whether that be media or print, and making it available to citizens of the community, the awareness of these partnerships will increase.

Figure 2.09
Six Proxies of social capital
(baker 2020)

SYNTHESIS OF LITERATURE

Relevance of social capital to conservation-based P3s

Natural resource conservation, management, and community development have become key areas for the application of social capital, where community stakeholders initiate partnerships, often through 'grassroots' efforts (Ballet et al. 2002). Through organized social capital, groups and networks of people gather specific information, create a series of formal and informal rules and guidelines, and reciprocate ideas that lead to a collective action (Musoke 2017, Adler & Kwon 1999). Simply stated, the concept of social capital serves as the basis for many conservation-based partnerships, where volunteers collaborate and contribute information, experiences, and time to benefit a goal that is commonly held between other volunteers and stakeholders.

Relevance of social capital to energy infrastructure corridor partnerships

Given the specific nature of conservation-based public/private partnerships, especially those pertaining to the preservation of habitat and wildlife within energy corridors, it is likely that bonding capital, or the common similarities and ties between individuals, will be the primary type of social capital used in the formation of this theoretical partnership. The volunteers who comprise the stakeholders and partners of this public/ private partnership will all share the common goal of preserving wildlife habitat and improving the design and implementation of proposed energy infrastructure corridors. These volunteers will consist of private landowners, agencies, universities, non-profit government organizations (NGOs), or corporations at the local, state, and national levels.

Below, a proposed list of stakeholders and partners can be found. Derived through the examination of existing conservation-based P3s (public/ private partnerships) and study of Social Capital concepts, this list will serve as a basis for the creation of a theoretical public/ private partnership that aims to connect stakeholders with design professionals. This collaboration will lead to the creation of design guidelines that can inform the creation and implementation of future energy corridors, and the conservation of existing energy corridors. Additionally, the development of regulatory policy will serve as a framework for guiding energy corporations along a more sustainable approach to energy corridor implementation through federal and state legislation.

PROPOSED P3 PARTNERS & STAKEHOLDERS

PRIVATE LANDOWNERS WITHIN STUDY AREA	RESEARCHERS (ACADEMIC OR PRIVATE)	DESIGN PROFESSIONALS
RANCHERS	ECOLOGISTS	LANDSCAPE ARCHITECTS
FARMERS	RANGE CONSERVATIONISTS	RURAL COMMUNITY PLANNERS
OTHER LARGE LANDOWNERS OR AGRICULTURAL PRODUCERS	WILDLIFE BIOLOGISTS	CIVIL, BIO-AGRICULTURAL, AND ENVIRONMENTAL ENGINEERS
	CIVIL & BIO-AGRICULTURAL ENGINEERS	
	HYDROLOGISTS & ECO-HYDROLOGISTS	

STATE CONSERVATION AGENCIES	FEDERAL AGENCIES	NGOS	PRIVATE CORPORATIONS
KANSAS DEPARTMENT OF WILDLIFE & TOURISM	NATURAL RESOURCE CONSERVATION SERVICE	WYOMING MIGRATION INITIATIVE	3M PRODUCTIONS (OIL AND GAS ENERGY)
TEXAS PARKS & WILDLIFE DEPARTMENT	U.S. FISH & WILDLIFE SERVICE	THE NATURE CONSERVANCY	XTO ENERGY (OIL AND GAS ENERGY)
OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION	U.S. BUREAU OF LAND MANAGEMENT	LESSER PRAIRIE CHICKEN INITIATIVE	VESTAS (WIND ENERGY)
	U.S. FOREST SERVICE	NORTH AMERICAN GROUSE PARTNERSHIP	
	U.S. GEOLOGICAL SURVEY	RANCHLAND TRUST OF KANSAS	

Table 2.01
Proposed P3 partners & stakeholders (Baker 2019)

METHODOLOGY

3.0

OVERVIEW

The methodology within this report serves to clearly define the selection process of the case studies, data, and sites for the application of a projective design. By developing a four-step process, a clear framework for the creation of energy corridor conservation and design strategies was developed.

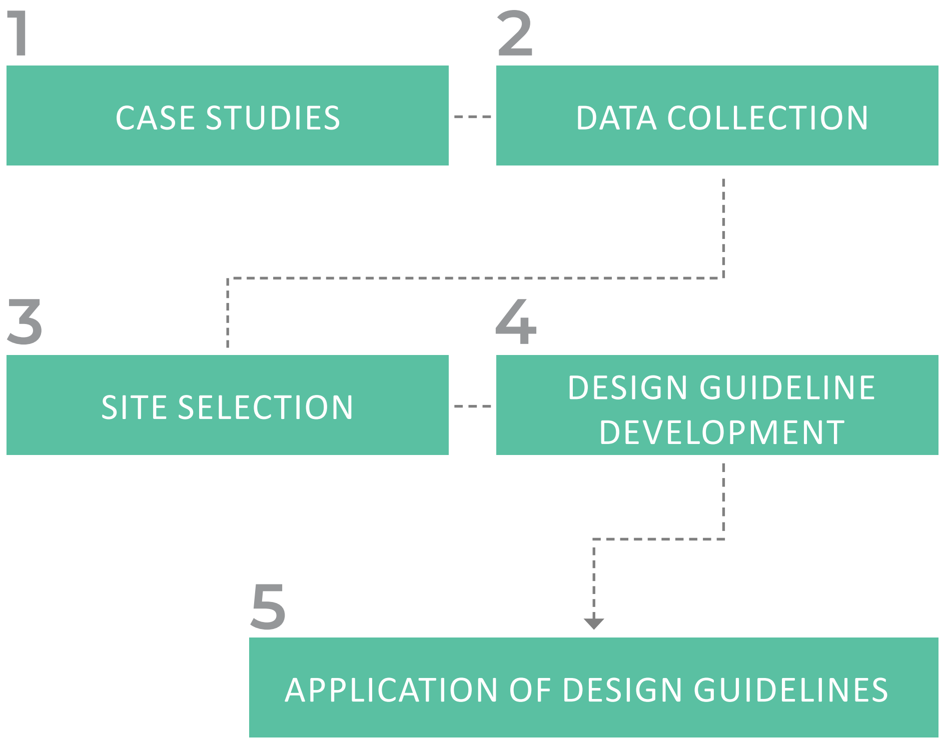


Figure 3.00
Methodology process diagram (Baker 2019)

CASE STUDY SELECTION

In order to effectively understand the structure and organization of public/private partnerships, a series of case studies was employed. These case studies were selected by utilizing an adaptation of the methodology within Mark Francis's A Case Study Method for Landscape Architecture (1999). This organizational strategy served to aid in the selection of relevant case studies that feature wildlife species, study areas, and overall purposes that match those discussed within this report.

Case studies were then divided into two primary categories: terrestrial wildlife and avian wildlife. From this broad division, a series of criteria were utilized to further refine the selection of case studies. These criteria include the overall purpose of the public/private partnership, the specific target species the partnership is concerned with, and, finally, the location or study area that the partnership operates within.

A breakdown of case study selection criteria can be found in Figure 3.01 on page 49.

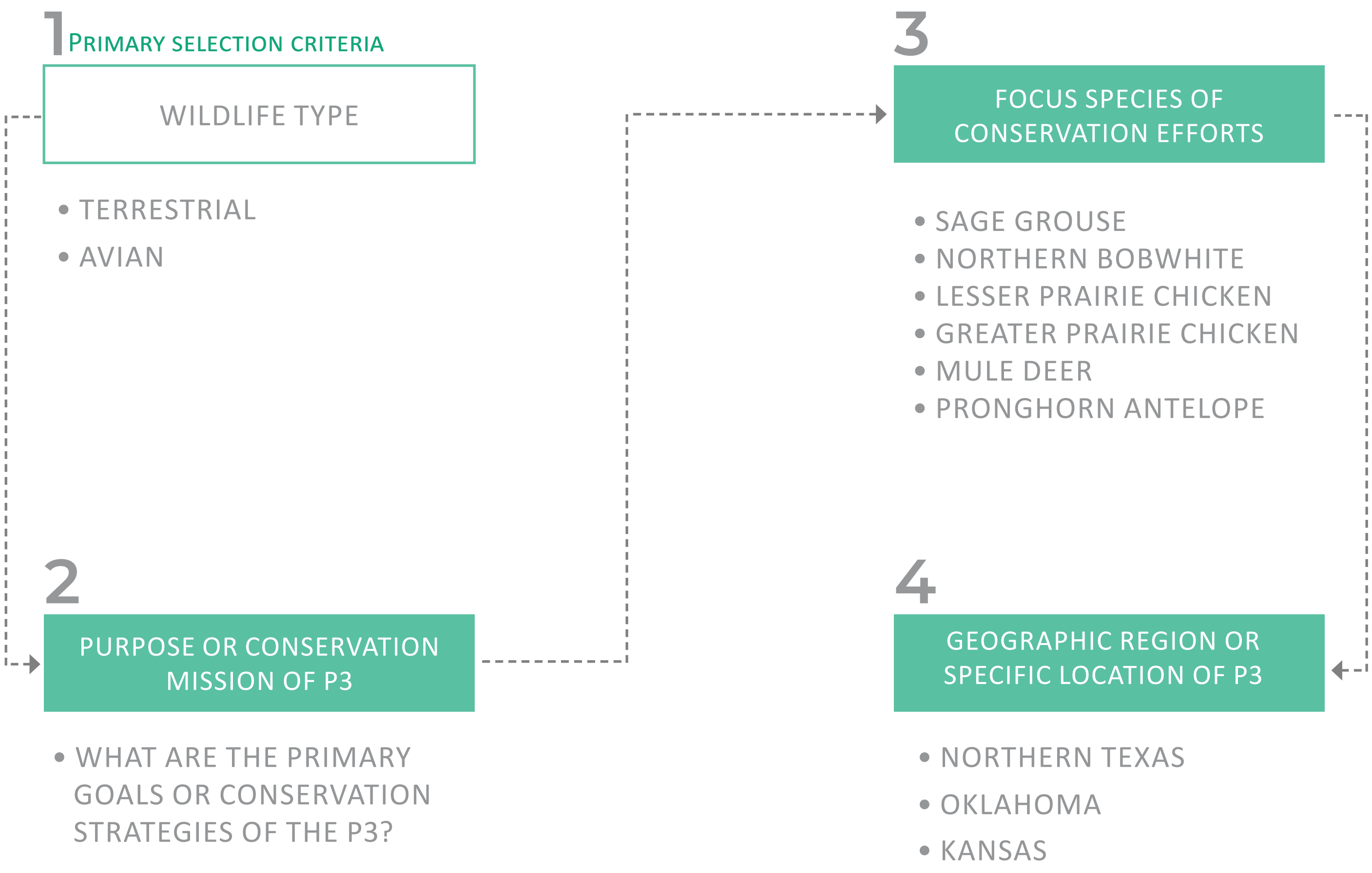


Figure 3.01
Case study selection criteria diagram (Baker 2020)

TERRESTRIAL WILDLIFE

Purpose

The selected case studies will demonstrate how terrestrial wildlife are impacted by circumstances or disturbances outside their control, and how initiatives or partnerships have formed with the common goal of conserving these species of terrestrial wildlife. Common examples may include topics such as climate-change impacts on wildlife (WWF 2019), or forest management and species diversity (NAFO 2019).

Type

The selected case studies should focus on large mammals or ungulates. Ideal case studies would focus on species including mule deer and pronghorn antelope (Keane 2019a).

Location

Ideally, the selected case studies will be located within the study area of this report (Northern Texas, Oklahoma, and Kansas). Location exceptions were made if the case study criteria meet the Type and Purpose requirements above.

AVIAN WILDLIFE

Purpose

The selected case studies will demonstrate how avian species of wildlife are impacted by disturbances including land-use change, the alteration of development patterns, and habitat loss. Similar to case studies concerning terrestrial wildlife, the case studies selected here must focus on the goal of conserving those avian species impacted by external disturbance.

Type

The selected case studies will focus on avian grassland species. The greater prairie chicken (Audubon 2019c), lesser prairie chicken (SGI 2019), and northern bobwhite (ArcGIS 2019) are the primary species being considered.

Location

These case studies will focus on the grassland regions of Northern Texas, Oklahoma, and Kansas. Again, exceptions regarding location were made if case studies fit with the Purpose and Type requirements above. Other exceptions may occur if the case studies present significant information on the overall structure and organization of the partnership.

DATA COLLECTION

The procurement of map data on energy corridors across the study area was required in order to understand the vast spatial scale of energy infrastructure. Aerial photographs and GIS data were also employed to more precisely determine the location of oil and gas infrastructure systems, wind energy infrastructure systems, and the energy corridors that connect them.

SITE SELECTION

Employing the aerial imagery and GIS data above, coupled with Environmental Impact Statements, two sites were chosen that most clearly exhibit the negative impacts of energy corridors and installations. Common indicators of energy corridor and installation impacts on habitat quality included the removal of woody vegetation, the alteration of natural systems like stream channels or riparian corridors, long spans of infrastructure without provisions for wildlife crossing, and the presence of access roads, fencing, or other physical barriers to wildlife movement. These two sites then became the primary location for the implementation of the design guidelines and regulatory policies implemented through the theoretical partnership created in this report.

APPLICATION OF DESIGN GUIDELINES

The introduction of design guidelines for energy corridors and installations brings with it many ecological considerations. When designing stable energy corridors rich in diversity, it is important to consider the dynamic nature of the shape, size, and composition of these corridors. Because wildlife corridors serve as primary conduits for migration and gene flow, the width of a corridor can have a significant effect on the presence of invasive edge species. In general, wider corridor widths decrease the threat of invasive species, reduce competition among species populations, and increase overall biodiversity within the corridor (Forman & Godron 1986, Dramstad et al. 1996). By designing energy infrastructure corridors and installations that provide ample width and crossing points to accommodate migratory species, the likelihood that animals will complete their journey through or across the corridor will increase.

FINDINGS

4.0

PUBLIC/ PRIVATE PARTNERSHIP INITIATIVES

The goal of the case study reviews was intended to examine how existing public/private partnerships and initiatives are operated, organized, and structured. From these case studies, a framework or model for the establishment of a theoretical public/private partnership was developed. The intention was to identify exemplary or innovative design and conservation strategies employed by each case study and determine how these strategies may be applied toward the goal of energy corridor conservation and design. This model served to aid in the selection of stakeholders, and the devising of stakeholder incentives to increase participation in the partnership. It was intended that collaboration between stakeholders and design professionals within the partnership would result in the development of projective design guidelines and policies for the conservation and design of energy corridors.

Figure 4.00
Theoretical P3 establishment framework development (Baker 2020)

CASE STUDY 1: SAGE GROUSE INITIATIVE

Background & History

Launched by the NRCS in 2010, the Sage Grouse Initiative is a partnership-based, science-driven effort that is part of Working Lands for Wildlife, a USDA-led initiative that aims to conserve the habitat range of the sage grouse (SGI 2019). The majority of SGI's focus is based on privately owned lands, many of which are large ranches covering thousands of acres. By utilizing federal grants issued through the Farm Bill, SGI encourages landowners and public conservation groups to systematically target sage grouse conservation efforts. As an integral component to the overall success of SGI, the Farm Bill provides technical and financial assistance to stakeholders of the SGI partnership (WLF 2018). In exchange for technical and financial assistance, stakeholders must agree to make improvements to their land that increases the amount, quality, and connectivity of sage grouse habitat range. Three specific goals led to the founding of SGI. By working with partners and stakeholders, SGI strives to catalyze the design of physical projects that work for wildlife and communities, communicate successful conservation efforts and learn from these achievements, and gather stakeholders to accelerate effective and lasting conservation (SGI 2019).

Partnership Structure

SGI partners with public land councils, federal agencies, private corporations, state wildlife agencies, and colleges and universities across the United States. These partners and stakeholders work collaboratively with the Bureau of Land Management and private landowners to develop conservation practices that set the stage for sage grouse protection through sustainable agriculture practices, the management of healthy sagebrush ecosystems, ecological research, and grant funding. These research, agricultural and financial contributions are then used to develop site-specific sustainability, management and conservation designs that can be applied to key areas within privately owned lands. See Figure 4.01 for a list of SGI's key partners.

KEY PARTNERS

U.S. FISH & WILDLIFE SERVICE	COLORADO STATE UNIVERSITY
CONOCOPHILLIPS	VARIOUS STATE WILDLIFE AGENCIES
U.S. BUREAU OF LAND MANAGEMENT	PRIVATE LANDOWNERS
NATIONAL CATTLEMENS BEEF ASSOCIATION	DESIGN PROFESSIONALS

Figure 4.01
Key partners and stakeholders of the Sage Grouse Initiative (Baker 2020, SGI 2019)

Relevance

Though the sage grouse species' range does not overlap the study area of this report, the structure of the partnership and organization of stakeholders are excellent examples of how an energy corridor partnership could be structured. SGI's array of partners and stakeholders represent a diverse working group that my research efforts can draw from and expand upon, while the application of the Farm Bill exemplifies how government policy and funding can influence and foster creative solutions to the conservation of specific habitats and specific species types. In addition, in 2015, the U.S. Fish and Wildlife Service determined that the sage grouse would not be listed as a threatened species, largely due to the large-scale collaborative conservation efforts employed through SGI. This further supports the theory behind partnership and initiative-based conservation (SGI 2019).

Figure 4.02
(Wick n.d.)

Figure 4.03
SGI focuses conservation efforts on preserving greater sage grouse habitat, educating landowners, and developing innovative conservation and land management strategies (USDA 2015).

Figure 4.04
Increased development and unsustainable agricultural practices contribute to the rapid degradation and destruction of lesser prairie chicken habitat (Emerson 2015)

Figure 4.05
LPCI promotes sustainable agriculture practices geared toward lesser prairie chicken habitat conservation. Training programs are available to private landowners throughout the entirety of the Lesser Prairie chicken habitat range (USDA n.d.)

CASE STUDY 2: LESSER PRAIRIE CHICKEN INITIATIVE

Background & History

Established in 2010 to assist private landowners and ranchers in preventing the lesser prairie chicken from being listed as an endangered species. Like the Sage grouse initiative, the LPCI utilizes the power of the Farm Bill to preserve lesser prairie chicken habitat through the promotion of sustainable agricultural practices (LPCI-NRCS 2010). Once abundant throughout Kansas, Colorado, Texas, New Mexico and Oklahoma, the lesser prairie chicken population has been reduced by more than 85% due to habitat loss. The primary goal behind the LPCI is the conservation and increase of existing lesser prairie chicken populations and habitat. As an additional incentive to these strategies, LPCI strives to make lands in which these birds reside more resilient to disturbances including wildfire and climatic extremes. Federal grant funding and research from universities across the nation allow LPCI to aid ranchers and private landowners in introducing fire and sustainable ranching practices, removal of invasive woody species, and recreate the historic grassland habitat of the lesser prairie chicken. Since 2010, the LPCI has restored half a million acres of lesser prairie chicken habitat by focusing on four key threats to the bird: degraded rangeland health, invasive red cedar and mesquite trees, cultivation of grazing lands, and lack of fire in grassland habitats (LPCI-NRCS 2010).

Partnership Structure

Nearly 95% of lesser prairie chicken habitat is located on private lands. Because of this, the voluntary participation of private landowners and ranchers is key to the success of the LPCI. Research and experience gained through ongoing conservation efforts by NRCS has guided the selection of many partners and stakeholders in the corporate, federal, and state sectors. These partners pool funding collected through private donations and research grants to hire range conservationists and wildlife biologists, who work with private landowners to develop and implement site-specific habitat restoration and conservation plans (LPCI-NRCS 2010). Though similar to the structure of SGI, there are a few key differences between the two initiatives. While SGI focuses primarily on the conservation of sage grouse populations, less emphasis is placed upon implementing sustainable agriculture practices that coincide with population conservation. This may be a result of the differing habitat ranges between the sage grouse and lesser prairie chicken, where lesser prairie chicken are able to inhabit grassland-dominated landscapes interspersed with smaller amounts of cropland and other agricultural lands. See Figure 4.07 on page 64 for a list of LPCI's key partners.

Figure 4.06
Conflicts arise when lands that previously served as habitat for lesser prairie chicken are converted to strictly agricultural uses. LPCI strives to create a balance between productive agricultural practices and maintaining lesser prairie chicken habitat (baker 2020)

KEY PARTNERS

- FARM SERVICE AGENCY
- VARIOUS STATE WILDLIFE AGENCIES
- KANSAS FOREST SERVICE
- PRIVATE LANDOWNERS
- U.S. BUREAU OF LAND MANAGEMENT
- DESIGN PROFESSIONALS
- PARTNERS FOR FISH AND WILDLIFE
- KANSAS STATE UNIVERSITY

Figure 4.07
Key partners and stakeholders of the Lesser prairie chicken Initiative
(baker 2020, LPCI-NRCS 2010)

Relevance

Because the habitat range of the lesser prairie chicken directly coincides with the study area of this report, this renders many of the conservation strategies employed by the LPCI useful for the development of the projective design guidelines within this report. Many of the LPCIs partners and stakeholders work in conjunction with Kansas State University, with much of the research supporting the LPCI conducted at Kansas State University by professors of the Biology department. Additionally, the structure of the initiative's partnerships and stakeholders is much like that of SGI, furthering the validity of utilizing public/private partnerships as a catalyst for energy corridor conservation efforts.

Figure 4.08
(parker/Kansas Cooperative Fish & Wildlife research Unit 2020)

Figure 4.09
Kansas State University contributes valuable research and studies toward lesser prairie chicken conservation through Conservation Biology and Landscape Ecology courses, as well as the wildlife & Outdoor Enterprise Management department (Duncan 1974)

Figure 4.10
WMI's migration mapping tracked Mule Deer landscape-corridor use across the Greater Yellowstone Ecosystem (Riis/Wyoming Migration Initiative 2013)

Figure 4.11
Collar-Like tracking devices were utilized to analyze movement patterns. This mule deer doe is being released after placing the tracking collar (Nickerson/ Wyoming Migration Initiative 2016)

CASE STUDY 3: WYOMING MIGRATION INITIATIVE

Background & History

Dedicated to studying the migration patterns of ungulates in the western regions of the United States, the Wyoming Migration Initiative conducts in-depth research on species including mule deer, elk, and pronghorn. Created within the Department of Zoology and Physiology at the University of Wyoming, a landmark study completed in March 2016 mapped mule deer migration corridors across the eastern boundary of the Greater Yellowstone Ecosystem. This study utilized collar-like tracking devices placed on mule deer to better understand how disturbance and landscape corridors can act as threats or opportunities to the deer themselves. For the purpose of the study, disturbance corridors were identified as roadways, fences spanning large distances across rangelands, and even linear patterns of development (Wyoming Migration Initiative 2016).

Partnership Structure

Emerging at the confluence of academia, state, and federal wildlife research, the Wyoming Migration Initiative was formed through the Wyoming Cooperative Fish and Wildlife Research Unit. As part of the U.S. Geological Survey system, the Wyoming Migration Initiative collaborates with thirty related USGS programs at universities across the United States. In addition, WMI works with the National Forest Service and the Bureau of Land Management at the federal and state agency levels. Funding is primarily allocated through private partnerships, where person-to-person relationships are developed with key players of major wildlife conservation groups. These groups may include entities such as the Rocky Mountain Elk Foundation, who offer grant programs that support conservation research, or the Nature Conservancy, where research and migration data compiled by WMI is employed to target and secure funding for conservation easements (Staff of WMI, 2019).

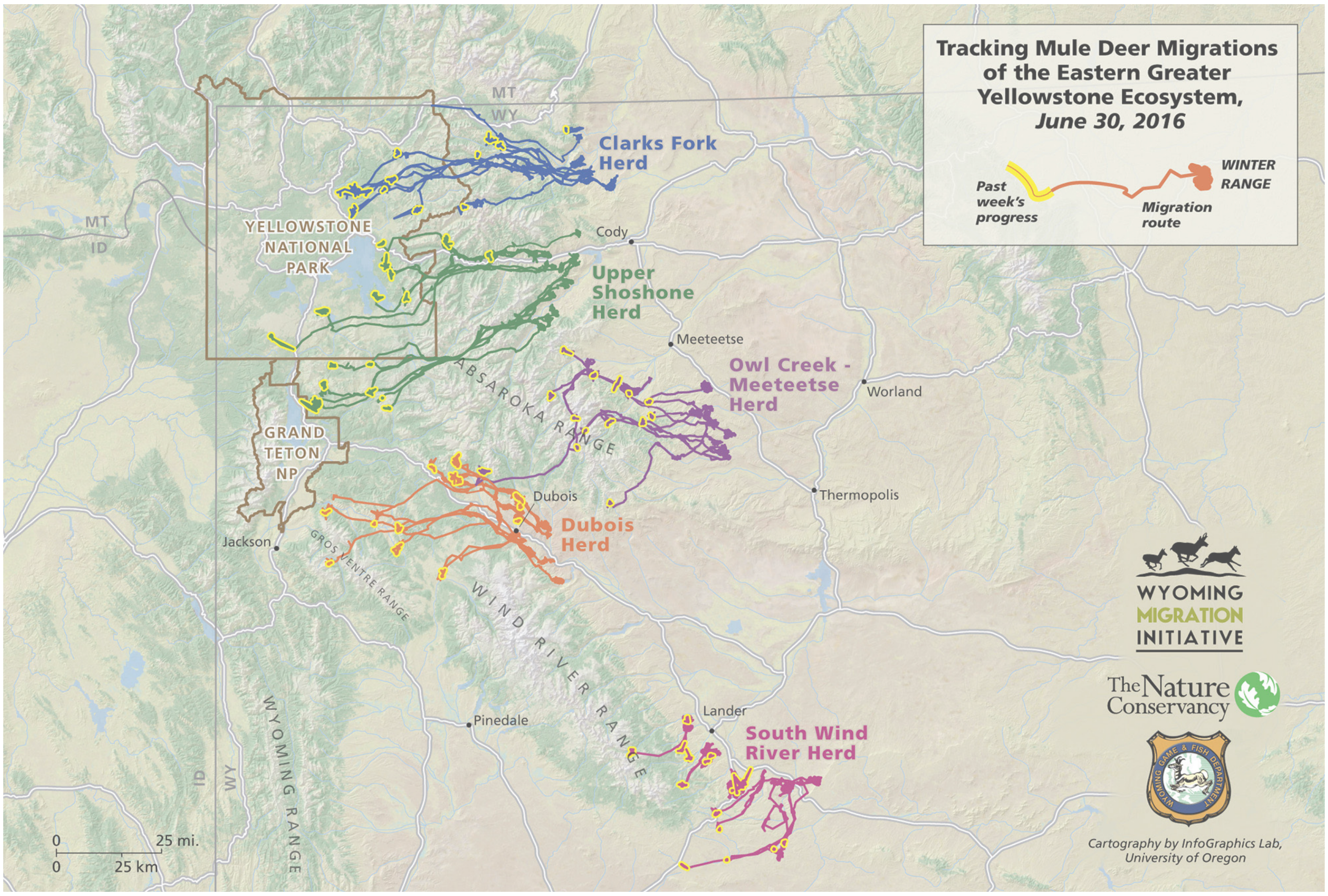


Figure 4.12
Migration routes taken by various Mule Deer herds across portions of Wyoming (Nickerson/ Wyoming migration initiative 2016).

Relevance

Though the study range used by WMI is outside the study area of this report, the species types and conservation strategies utilized align perfectly with this report's study topics. The research and studies conducted by WMI deal with external implications on the migration patterns of mule deer and pronghorn, many of which can be directly applied to energy corridors across varying scales. Another benefit of utilizing the Wyoming Migration Initiative as a key case study is the credibility of research conducted within the initiative. Largely comprised of leading professors of Zoology and Physiology, the sheer amount of research and literature available on the migration patterns of wildlife species is a great asset to this report. The limited amount of information available on the structure of partners and stakeholders is a slight setback, though the well-defined organization and framework of the Sage Grouse and Lesser Prairie chicken initiatives contributes a solid knowledge base toward how my theoretical public/private partnership could be structured for the best possible conservation outcomes.

Figure 4.13
(Baumeister 2015)

Figure 4.14
Conducted through the University of Wyoming, top zoologists and physiologists dedicate their time toward fostering a better understanding of the benefits and impacts associated with landscape corridors (Nickerson/Wyoming migration initiative 2019)

POLICY & GUIDELINE DEVELOPMENT

5.0

ESTABLISHMENT OF THEORETICAL STAKEHOLDERS

An in-depth review of case studies indicated that partners and stakeholders are key to successful initiative and partnership-based conservation (SGI 2019, NRCS-LPCI 2010). This report utilizes a framework for stakeholder selection similar to the Sage Grouse and Lesser Prairie chicken Initiatives. These specific partnerships have demonstrated that by assembling large corporations, research institutions, federal and state conservation agencies, and private landowners into a collective-based upon a common goal, large advancements toward the goal can be achieved. Perhaps the biggest challenge in assembling public/private partnerships is the allocation of funds. By applying federal funds derived through the Farm Bill, both SGI and LPCI can implement effective, research-based conservation strategies and designs at site-specific scales. Bridging the gap between large entities like corporations and federal agencies is accomplished through the direction of federal funds into a hiring pool of practicing ecologists, range conservationists, and wildlife biologists (NRCS-LPCI 2010). This ensures that federal dollars are spent toward achieving conservation goals and preserving wildlife habitat, rather than simply being dissolved through a complex matrix of corporate partners, state agencies, and stakeholders.

ESTABLISHMENT OF DESIGN GUIDELINES & POLICIES

While it is generally acknowledged that P3s can benefit communities and individuals by actively involving stakeholders in the decision-making processes of partnerships, the role that community stakeholders play in policymaking efforts is often difficult to interpret. Policymaking through partnership is challenging, as the desired outcome of regulations and guidelines is often poorly defined throughout the structure of the partnership. This means that for a partnership to successfully form policy, it is critical to delegate what is expected of each stakeholder within the partnership. These responsibilities should be delegated appropriately among all levels of stakeholder structure within the partnership, from private landowners, to design professionals and conservationists, to private corporations (McLaughlin & Osborne 2000).

Dialogue and collaboration between the proposed stakeholders in this report is intended to act as a catalyst for the creation of design guidelines and regulatory policies for energy corridor conservation and development. By analyzing Environmental Impact Statements submitted to the United States Environmental Protection Agency (EPA) that concern pipelines, transmission lines, and access roads, stakeholders can identify key areas of concern, and work toward developing a set of criteria for potential strategies to mitigate the impact of proposed energy development activities (NEPA 2017). The creation of these criteria and identification of key issues can then be utilized to inform policymakers at the local, state, and even federal levels of government. Traditionally, a distinct separation between policy formulation and policy implementation has existed in public/private partnerships. In the United States, it is typical for government authorities to maintain control of policy formulation, though authorities are often informed by partnership stakeholders on what issues the policies should address and how policies should be implemented (Stewart 1996, McLaughlin & Osborne 2000). In this scenario, public/private partnerships can be thought of as 'mechanisms' for informing political powers on conservation issues, further acting as a catalyst for the implementation of new conservation policy (DETR 1998).

The end goal is the application of these policies toward the conservation and implementation of energy infrastructure corridors. By creating policies and guidelines that encourage the design of corridors providing ample width and crossing points to accommodate migratory species, the likelihood that animals will complete their journey through or across the corridor will increase. Additional benefits of energy corridors can include the provision of habitat for many species of wildlife, as well as unhindered gene flow through the corridors themselves (Forman & Godron 1986).

Figure 5.00
Stakeholder incentive concept
development diagram (Baker 2020)

STAKEHOLDER INCENTIVES

It is likely that stakeholders will desire incentives for their participation in any conservation partnership. Large corporations, especially those within the energy industry, have historically participated in conservation efforts in exchange for the portrayal of a positive, environmentally responsible image across all forms of media (Murdock et al. 2005). In addition, federal conservation credits can be awarded to energy corporations for their participation and cooperation in conservation partnerships. These credits often come in the form of tax incentives and deductions for corporations, though these types of incentives have been abused in past circumstances (Land Trust Alliance 2015).

A better solution for corporate incentive may lie with the U.S. Fish & Wildlife Service's Recovery Credit System (RCS). This system currently applies to Federal agencies, though it could feasibly be adapted in a way that benefits energy corporations without the negative repercussions of often-abused tax incentives. In brief, the RCS is a tool to promote the conservation of listed and endangered wildlife species. If an agency or corporation is able to prove that their development efforts have taken measurable steps to conserve and enhance the habitat of wildlife, they will be awarded Recovery Credits. These credits can then be utilized in other development areas where, despite best efforts, the conservation and recovery of listed or endangered species cannot be achieved (U.S. Fish & Wildlife Service 2008).

Private landowners will benefit through the management of rangelands for the benefit of wildlife on their property, education in sustainable agriculture practices, and a network of partners sharing the common goal of conserving wildlife habitat within energy corridors. Additionally, the monetary costs of implementing conservation practices incurred by private landowners is often offset through NRCS funding (NRCS 2004, Sullins 2019). Additional funding may be attained through other state-specific programs and agencies, such as the Migratory Bird Habitat Program, Bureau of Land Management (Montana Fish, Wildlife and Parks 2014), Working Lands for Wildlife (WLF 2018) and the United States EPA (EPA 2019).

Figure 5.01
(Durham 2017)

Figure 5.02
Many incentive and assistance programs offer private landowners additional knowledge on conservation practices, land management programs, and innovative grazing strategies (USDA-NRCS 2017)

PROJECTIVE SITE DESIGNS & DISCUSSION

6.0

CURRENT ENERGY CORRIDOR DESIGN GUIDELINES

Current literature on corridor design guidelines and regulations exists within Section 368 of the Energy Policy Act of 2005, though it should be noted that this literature is limited in scope. The primary consideration of Section 368 is “environmentally responsible corridor-siting decisions.” Corridor studies completed from January 2009 to October 2014 served to “establish baseline data and identify considerations and areas which should be explored in more detail during future regional reviews to be conducted by the BLM [Bureau of Land Management] and USFS [United States Forest Service]” (BLM n.d.).

The reality of both Section 368 and the corridor studies themselves is that the guidelines and regulations presented within them provide a good foundation for the conservation design of energy corridors, though there is substantial room for improvement. A summarized list of design guidelines proposed by Section 368 of the Energy Policy Act (BLM n.d.) can be found on page 82.

CURRENT BLM GUIDELINES & REGULATIONS

1) Explore opportunities to co-locate infrastructure types into the same corridor

2) Site right-of-way projects (access roads, etc.) parallel to the centerline of energy corridors where possible

3) Where feasible, corridors should be modified to allow for more uniform width to avoid 'pinch points', or narrow areas within the corridor that restrict wildlife movement.

4) Proponents of newly proposed energy corridors should engage with the industry and technical experts to explore challenges and opportunities related to implementing the project design

5) Utilize GIS for the mapping of proposed energy corridor designs and routes

6) Agencies should seek to update and expand education, training, and guidance on Section 368 corridors

While there is some focus placed upon wildlife and habitat conservation in the Section 368 design guidelines, the primary purpose of these design guidelines is to facilitate agreements between the energy corporations that wish to develop the energy corridor and the government agencies that are ultimately responsible for approving these developments.

In other words, these guidelines are essentially ‘minimum requirements’ or ‘suggested best practices’ for the environmentally responsible implementation and conservation of energy corridors that energy corporations must achieve before approval is granted to begin development.

Additionally, each of the six ‘Regions of Review’, or the geographic locations subject to Section 368 requirements, are located in the Western United States, outside the study area of this report (BLM n.d.).

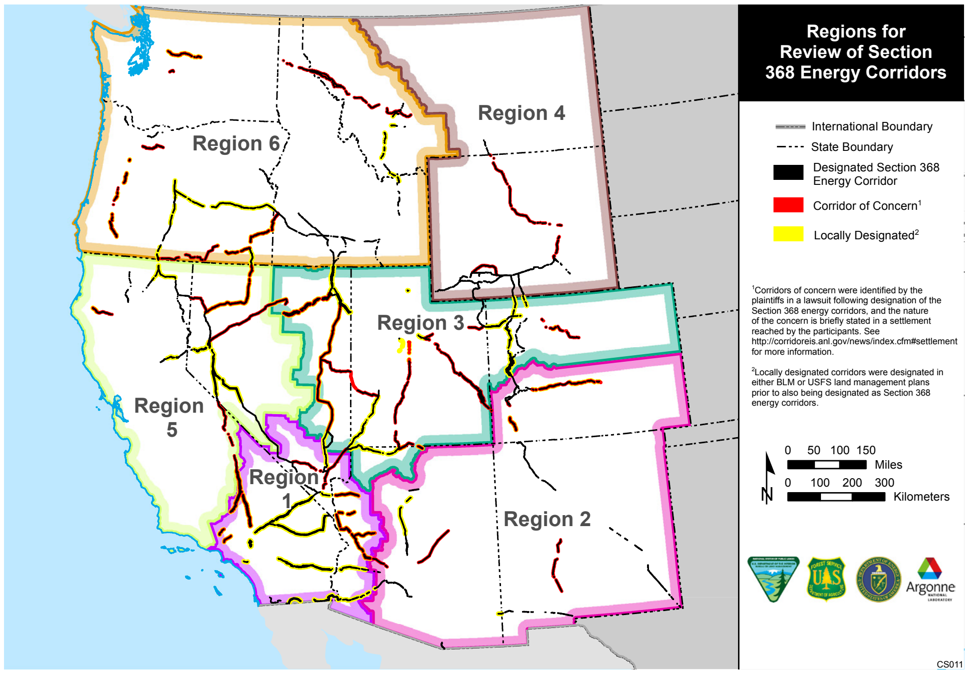


FIGURE 6.00
THE SIX ‘REGIONS OF REVIEW’ SUBJECT TO THE REGULATIONS OF BLM’S SECTION 368. [BLM DOES NOT GUARANTEE THE ACCURACY OF THE INFORMATION PRESENTED WITHIN] (BLM 2011)

INITIAL DESIGN GUIDELINE CATEGORIES

In order to best-prioritize design guideline development, a series of general design guidelines was developed within this report. These guidelines were intended to serve as general best practices for the design and conservation of key areas in energy corridors, where conservation and preservation are most needed. Initially, this proposed framework for energy corridor design guidelines and regulations was divided into four categories. These categories considered the overall functionality and production of energy corridors, while also striving to minimize and mitigate the impacts of energy corridors on the wildlife and habitat that surround them.

Initial categories for guideline and regulation development can be found in Table 6.01. Serving as the basis for guideline development within this report, these categories were derived through examining and identifying gaps in the research and guidelines proposed within the corridor studies of the Section 368 document. The suggested guideline categories focus on the ecological aspects (wildlife and habitat quality) of energy corridors that were previously neglected or entirely omitted from Section 368.

PRELIMINARY ENERGY CORRIDOR & INSTALLATION DESIGN GUIDELINE CATEGORIES

PERMEABILITY	SITING	CORRIDOR MAINTENANCE	HABITAT CREATION
CROSSING POINTS (BREAKS IN INFRASTRUCTURE)	PROXIMITY TO STREAMS & RIPARIAN ZONES	MOWING & CHEMICAL USAGE	CORRIDOR WIDTH
	TOPOGRAPHIC CONSIDERATIONS	IN-CORRIDOR GRAZING STRATEGIES	VEGETATIVE COMPOSITION
	VEGETATIVE COMPOSITION OF PROPOSED SITE		

TABLE 6.01
PRELIMINARY ENERGY CORRIDOR AND INSTALLATION DESIGN GUIDELINE CATEGORIES (BAKER 2019)

PROPOSED DESIGN GUIDELINES & POLICIES

To further expand on the general guideline and policy categories in Table 6.01, the case studies discussed in Chapter Four were examined for their use of exemplary conservation and design tactics. Many of the P3s within these case studies utilized innovative approaches to wildlife conservation, where each approach was intended to benefit a specific wildlife species. These innovative approaches drove the formation of design guidelines and policies within this report, as the most beneficial innovations from each conservation P3 were identified and applied toward energy corridor conservation, preservation, and design. This exercise essentially created a 'database' of design and conservation best practices, which then served to formulate and influence the design guidelines and conservation policies of this report.

It is important to note that though this report is concerned with the habitat preservation and conservation of five different wildlife species, the proposed design guidelines and regulatory policies may not be capable of effectively addressing or benefiting all species populations at the same time. For example, certain guidelines may be intended to prevent direct contact between energy infrastructure equipment and terrestrial ungulates. This situation clearly benefits the mule deer and pronghorn antelope populations discussed within this report but offers little or no benefit to avian species. These guidelines and policies are intended to serve as 'best practices' for corridor design and conservation; therefore, they are formulated in such a way that they are capable of being adapted to different geographical regions, different infrastructure types, and, most importantly, different wildlife species types.

The following tables identify each of the proposed design guidelines or conservation policies developed within this report. The first table, Table 6.02, lists conservation policies that are intended to address habitat degradation and energy corridor and installation management strategies for *existing* corridors and installations. The second table, Table 6.03, lists design guidelines and best practices for *proposed* energy corridors and installations and is concerned with topics including wildlife habitat quality and quantity, and the development of ecologically sensitive energy corridor maintenance plans and strategies. Additional considerations addressed within this table include increased cross-corridor permeability, both physical permeability (wildlife movement and migration) and gene flow. Finally, the third table, Table 6.04, identifies management and planning guidelines for both existing and proposed energy corridor conservation planning. These strategies are intended to act as 'management strategies', where rather than address physical conservation and design guidelines like the previous tables, they are meant to help facilitate the management and creation of conservation groups and committees.

EXISTING ENERGY CORRIDOR & INSTALLATION DESIGN GUIDELINES

DISPERSAL & GENE FLOW	HABITAT CREATION
1A. INSTALL 'WILDLIFE MARKERS' ON ALL BARRIERS TO WILDLIFE MIGRATION. THIS CAN INCLUDE FENCES, PIPELINES, OR ANY OTHER NON-PERMEABLE BARRIER. RESEARCH INDICATES THAT FOR SOME AVIAN SPECIES, AVERAGE COLLISION RATES CAN BE AS HIGH AS 1.2 STRIKES PER MILE OF FENCE OR OTHER BARRIER EACH BREEDING SEASON (STEVENS 2011).	2A. DEVELOP SEASONAL SEEDING PROGRAMS FOR THE ESTABLISHMENT OF NATIVE, LOW MAINTENANCE PLANT SPECIES. THESE PLANT SPECIES SHOULD INCLUDE VARIETIES THAT PROVIDE FOOD AND FORAGE FOR AVIAN AND TERRESTRIAL WILDLIFE. RESEARCH SHOWS THAT MULE DEER SPEND UP TO 95% OF THEIR MIGRATION PERIOD IN 'STOPOVERS', OR HABITATS RICH IN FORAGE AND SHELTER (SAWYER ET AL. 2012).
1B. INSTALL GAME-PROOF FENCING IN AREAS WHERE DANGEROUS INFRASTRUCTURE HAS A HIGH PROBABILITY OF INJURING WILDLIFE. THESE AREAS CAN INCLUDE EXPOSED PIPELINES, HIGH-VOLTAGE ELECTRICAL CONVERTER AND TRANSMISSION SUBSTATIONS, NATURAL GAS COMPRESSOR STATIONS, AND OTHER SUPPORTING ENERGY INFRASTRUCTURE (SAWYER, ROGERS, & HART 2016).	2B. CONSIDER IMPLEMENTING VEGETATIVE PLANTING PALETTES THAT VARY IN SUCCESSIONAL STAGES. ESTABLISH SEEDING PROGRAMS AND SCHEDULES THAT ALLOW FOR AGGRESSIVE RIPARIAN VEGETATION GROWTH IMMEDIATELY POST-DISTURBANCE, SHRUB AND UNDERSTORY GROWTH AS INTERMEDIATE SUCCESSIONAL STAGES, AND STRONG END STAGE TREE CANOPY GROWTH AND DEVELOPMENT (ADAPTED FROM FORMAN & GODRON 1986, NRCS 2004, & DRAMSTAD ET AL. 1996). THIS ENSURES CORRIDOR ECOSYSTEMS HAVE THE BEST CHANCE OF MAINTAINING A 'STABLE STATE' (WITH 2019).
	2C. WHERE WIDENED SEGMENTS OF ENERGY CORRIDORS EXIST, CONSIDER IMPLEMENTING AN INFILL COMMUNITY OF NATIVE PLANTINGS WITH VARYING SUCCESSIONAL STAGES (SEE ABOVE HABITAT CREATION GUIDELINES). WIDENED CORRIDOR SEGMENTS MAY EXIST IN AREAS WHERE CONSTRUCTION ACTIVITY REQUIRED STORAGE SPACE FOR MATERIALS, ADJACENT TO COMPRESSOR STATIONS OR TRANSMISSION SUBSTATIONS, OR AREAS IN WHICH TEMPORARY ACCESS ROADS WERE CONSTRUCTED TO SUPPORT CONSTRUCTION ACTIVITY AND SUBSEQUENTLY REMOVED (ADAPTED FROM YUAN, SUSEMIHL & BROWN 2019).
	2D. STRIVE TO VARY CORRIDOR WIDTH ALONG SEGMENTS OF ENERGY INFRASTRUCTURE. SUITABLE LOCATIONS FOR WIDENED CORRIDOR SEGMENTS MAY EXIST IN NATURAL CLEARINGS WHERE LIMITED WOODLAND GROWTH OCCURS, WHILE AREAS OF DENSE WOODLAND VEGETATION MAY BE SUITABLE FOR NARROWER SECTIONS OF CORRIDOR. WIDENED AREAS CAN SERVE AS 'NODES' OR 'STOPOVER POINTS' WITH INCREASED WILDLIFE HABITAT, WHILE NARROW SEGMENTS SERVE AS LINKAGES OR CONNECTORS BETWEEN THESE NODES (ADAPTED FROM FORMAN & GODRON 1986, SAWYER, ROGERS & HART 2016).

Table 6.02
EXISTING ENERGY
CORRIDOR & INSTALLATION
CONSERVATION POLICIES
(BAKER 2020)

HABITAT PRESERVATION	CORRIDOR MAINTENANCE STRATEGIES
3A. REMOVE INVASIVE HERBACEOUS PLANT SPECIES USING NON-HERBICIDAL METHODS. THIS CAN INCLUDE PHYSICAL REMOVAL OF THE PLANT SPECIES BY DIGGING, CONTROLLED FIRE REGIMES, ETC (ADAPTED FROM SGI 2019, U.S FISH & WILDLIFE SERVICE 2013). IN CERTAIN APPLICATIONS, GRAZING UNGULATES SUCH AS GOATS OR SHEEP COULD BE EMPLOYED AS A SUSTAINABLE STRATEGY IN THE PREVENTION OF INVASIVE PLANT GROWTH CONTROL. GOATS ARE ESPECIALLY SUITED, AS OVER 60% OF THEIR DIET IS SOURCED FROM BRUSH, WOODY PERENNIALS, AND BROADLEAF PLANT SOURCES (LUGINBUHL ET AL. 2015)	4A. REFRAIN FROM UTILIZING HARSH SYNTHETIC PESTICIDES FOR WEED PREVENTION OR CONTROL. WHERE NOT PRACTICAL, UTILIZE THE MINIMUM REQUIRED AMOUNTS OF PESTICIDES TO ACHIEVE ACCEPTABLE LEVELS OF PREVENTION OR CONTROL. ALTERNATIVE METHODS OF WEED PREVENTION AND CONTROL ARE STRONGLY RECOMMENDED (SEE HABITAT PRESERVATION AND CORRIDOR MAINTENANCE STRATEGIES SECTIONS OF THIS TABLE).
3B. CREATE AND IMPLEMENT WOODLAND MANAGEMENT SYSTEMS THAT TARGET THE REMOVAL OF INVASIVE WOODY SPECIES, SPECIFICALLY INVASIVE CONIFERS SUCH AS EASTERN RED CEDAR IN EASTERN PORTIONS OF TEXAS, OKLAHOMA AND KANSAS (SGI 2019), AND THE ROCKY MOUNTAIN JUNIPER IN WESTERN REGIONS.	4B. WHERE APPLICABLE, PROMOTE THE USE OF IN-CORRIDOR GRAZING STRATEGIES. ENCOURAGE GRAZING BY NATIVE UNGULATE SPECIES OR COLLABORATE WITH LAND AND LIVESTOCK OWNERS TO DEVELOP ROTATIONAL GRAZING STRATEGIES FOR ENERGY CORRIDORS THAT PASS THROUGH PRIVATELY-OWNED GRAZING LANDS (ADAPTED FROM SGI 2019 & KUIPERS 2004).
3C. CREATE VEGETATION BUFFERS ADJACENT TO NOISY ENERGY INFRASTRUCTURE EQUIPMENT SUCH AS NATURAL GAS COMPRESSOR STATIONS AND HIGH-VOLTAGE ELECTRICAL CONVERTER AND TRANSMISSION SUB-STATIONS. THESE BUFFERS CAN REDUCE EXCESSIVE NOISE INTRUSION INTO ADJACENT WILDLIFE HABITATS, LIMITING EXTERNAL STRESSORS PLACED UPON WILDLIFE SPECIES (WARRINGTON ET AL. 2017, KHALIL 2019).	4C. WHERE IN-CORRIDOR GRAZING STRATEGIES ARE NOT FEASIBLE, LIMIT CLEAR CUTTING AND MOWING OPERATIONS TO THE MINIMUM EXTENT POSSIBLE TO REDUCE EROSION POTENTIAL AND HABITAT DISTURBANCE DUE TO EXCESSIVE NOISE LEVELS.
3D. WHEREVER POSSIBLE, STRIVE TO DESIGN POINTS WHERE ENERGY INFRASTRUCTURE CROSSES RIVER OR STREAM CHANNELS AT 90 DEGREES TO THE STREAM CHANNEL CENTERLINE. THIS SERVES TO MINIMIZE STREAMBANK COMPACTION, REDUCE STREAMBANK EROSION, AND REDUCE THE REMOVAL OF RIPARIAN VEGETATION (ADAPTED FROM ROSGEN 2006 & KEANE 2019B).	4D. WHERE POSSIBLE, PARTICULARLY IN AREAS DEVOID OF SENSITIVE INFRASTRUCTURE, CONSIDER UTILIZING CONTROLLED BURNS AS A MEANS FOR INVASIVE SPECIES CONTROL, ESPECIALLY WITHIN GRASSLAND AND PRAIRIE AREAS.

PROPOSED ENERGY CORRIDOR & INSTALLATION DESIGN GUIDELINES

DISPERSAL & GENE FLOW

1A.
ENCOURAGE ENERGY CORRIDOR DESIGNERS TO IMPLEMENT WILDLIFE CROSSING POINTS (PENETRATIONS IN ENERGY INFRASTRUCTURE) PERPENDICULAR TO ABOVE-GRADE ENERGY INFRASTRUCTURE AT SPACING INTERVALS VARYING FROM ONE WILDLIFE CROSSING POINT PER 0.9 MI [1.5 KM] TO ONE CROSSING POINT PER 3.8 MILES [6.0 KM] (ADAPTED FROM FEDERAL HIGHWAY ADMINISTRATION, N.D.).

1B.
INSTALL GAME-PROOF FENCING IN AREAS WHERE DANGEROUS INFRASTRUCTURE HAS A HIGH PROBABILITY OF INJURING WILDLIFE. THESE AREAS CAN INCLUDE EXPOSED PIPELINES, ELECTRICAL CONVERTER AND TRANSMISSION STATIONS, NATURAL GAS COMPRESSOR STATIONS, AND OTHER SUPPORTING ENERGY INFRASTRUCTURE (SAWYER, ROGERS, & HART 2016).

1C.
PROVIDE A MIXTURE OF OVERPASS AND UNDERPASS TYPE WILDLIFE CROSSINGS AT INTERVALS OF NO MORE THAN 5-8 MILES (8-12KM) ALONG IMPERMEABLE ENERGY INFRASTRUCTURE BOUNDARIES. PRONGHORN TYPICALLY PREFER OVERPASS CROSSINGS TO UNDERPASS TYPE CROSSINGS (SAWYER, ROGERS & HART 2016).

2D.
STRIVE TO VARY CORRIDOR WIDTH ALONG SEGMENTS OF ENERGY INFRASTRUCTURE. SUITABLE LOCATIONS FOR WIDENED CORRIDOR SEGMENTS MAY EXIST IN NATURAL CLEARINGS WHERE LIMITED WOODLAND GROWTH OCCURS, WHILE AREAS OF DENSE WOODLAND VEGETATION MAY BE SUITABLE FOR NARROWER SECTIONS OF CORRIDOR. WIDENED AREAS CAN SERVE AS 'NODES' OR 'STOPOVER POINTS' WITH INCREASED WILDLIFE HABITAT, WHILE NARROW SEGMENTS SERVE AS LINKAGES OR CONNECTORS BETWEEN THESE NODES (ADAPTED FROM FORMAN & GODRON 1986, SAWYER, ROGERS & HART 2016).

1E.
ANALYZE DOMINANT TOPOGRAPHIC FEATURES WHEN DETERMINING WILDLIFE CROSSING PLACEMENT. RIDGELINES AND PLATEAUS OFFER SUITABLE LOCATIONS FOR UNDERPASS STRUCTURES, WHILE VALLEYS AND DEPRESSIONS TEND TO PROVIDE MORE SUITABLE AND ECONOMICAL LOCATIONS FOR THE INSTALLATION OF OVERPASS-TYPE STRUCTURES (ADAPTED FROM CLEVENGER & HUISJER 2011).

HABITAT CREATION

2A.
DEVELOP NATIVE PLANT COMMUNITIES THAT GROW IN A CONTROLLED MANNER, REQUIRE LITTLE TO NO CHEMICAL OR PESTICIDE USE, AND SERVE AS HIGH-QUALITY FOOD SOURCES FOR TERRESTRIAL AND AVIAN WILDLIFE SPECIES (ADAPTED FROM SGI 2019 & LPCI-NRCS 2010).

2B.
CONSIDER IMPLEMENTING VEGETATIVE SPECIES THAT VARY IN THEIR SUCCESSIONAL STAGES. ESTABLISH SEEDING PROGRAMS AND SCHEDULES THAT ALLOW FOR AGGRESSIVE RIPARIAN VEGETATION GROWTH IMMEDIATELY POST-DISTURBANCE, SHRUB AND UNDERSTORY GROWTH AS INTERMEDIATE SUCCESSIONAL STAGES, AND STRONG END STAGE TREE CANOPY GROWTH AND DEVELOPMENT (ADAPTED FROM FORMAN & GODRON 1986, NRCS 2004, & DRAMSTAD ET AL. 1996).

2C.
WHERE ENERGY CORRIDORS ARE INTENTIONALLY WIDENED TO REDUCE EDGE EFFECTS, THE RESULTING INCREASED HABITAT SPACE SHOULD BE INFILLED WITH NATIVE PLANT COMMUNITIES CONSISTING OF SPECIES WITH VARYING SUCCESSIONAL STAGES [SEE ABOVE HABITAT CREATION GUIDELINES] (ADAPTED FROM FORMAN & GODRON 1986).

2D.
STRIVE TO VARY CORRIDOR WIDTH ALONG SEGMENTS OF ENERGY INFRASTRUCTURE. SUITABLE LOCATIONS FOR WIDENED CORRIDOR SEGMENTS MAY EXIST IN NATURAL CLEARINGS WHERE LIMITED WOODLAND GROWTH OCCURS, WHILE AREAS OF DENSE WOODLAND VEGETATION MAY BE SUITABLE FOR NARROWER SECTIONS OF CORRIDOR. WIDENED AREAS CAN SERVE AS 'NODES' OR 'STOPOVER POINTS' WITH INCREASED WILDLIFE HABITAT, WHILE NARROW SEGMENTS SERVE AS LINKAGES OR CONNECTORS BETWEEN THESE NODES (ADAPTED FROM FORMAN & GODRON 1986, SAWYER, ROGERS & HART 2016).

Table 6.03
Proposed energy
corridor & installation
conservation policies
(baker 2020)

HABITAT PRESERVATION	CORRIDOR MAINTENANCE STRATEGIES
3A. PROVIDE VARIED VERTICAL VEGETATION STRUCTURE WITHIN ENERGY INFRASTRUCTURE CORRIDORS. FOR EXAMPLE, PROVIDE MEDIUM HEIGHT SHRUBS AND GRASSES AS A TRANSITIONAL HABITAT BETWEEN LOW VEGETATION ADJACENT TO ENERGY INFRASTRUCTURE AND TALLER TREE CANOPY HABITAT OF SURROUNDING WOODLANDS. THIS STRATEGY ENSURES THE PRESERVATION OF ECOTONE OR EDGE HABITATS COMMONLY OCCUPIED BY MANY AVIAN SPECIES (DRAMSTAD ET AL. 1996 & FORMAN & GODRON 1986).	4A. WHERE APPLICABLE, PROMOTE THE USE OF IN-CORRIDOR GRAZING STRATEGIES. ENCOURAGE GRAZING BY NATIVE UNGULATE SPECIES OR COLLABORATE WITH LAND AND LIVESTOCK OWNERS TO DEVELOP GRAZING STRATEGIES FOR ENERGY CORRIDORS THAT PASS THROUGH PRIVATELY-OWNED GRAZING LANDS (ADAPTED FROM SGI 2019 & LPCI-NRCS 2010).
3B. CREATE VEGETATION BUFFERS ADJACENT TO NOISY ENERGY INFRASTRUCTURE EQUIPMENT SUCH AS NATURAL GAS COMPRESSOR STATIONS AND HIGH-VOLTAGE ELECTRICAL CONVERTER AND TRANSMISSION SUB-STATIONS. THESE BUFFERS CAN REDUCE EXCESSIVE NOISE INTRUSION INTO ADJACENT WILDLIFE HABITATS, LIMITING EXTERNAL STRESSORS PLACED UPON WILDLIFE SPECIES (WARRINGTON ET AL. 2017, KHALIL 2019).	4B. REDUCE WIDTH OF ENERGY INFRASTRUCTURE [PHYSICAL PIPELINES, TRANSMISSION LINES, AND ACCESS ROADS] WITHIN CORRIDORS TO THE MINIMUM REQUIRED WIDTH FOR DAILY OPERATIONS AND REQUIRED MAINTENANCE PRACTICES (BLM N.D.).
3C. STRIVE TO VARY THE WIDTH OF PROPOSED ENERGY CORRIDORS WHEREVER POSSIBLE. WIDER CORRIDORS ARE LESS PRONE TO DAMAGING EDGE EFFECTS DUE TO EXTERNAL FACTORS SUCH AS ARTIFICIAL LIGHTING, CHEMICAL POLLUTION, PREDATION, INVASIVE SPECIES, AND OTHER DISTURBANCES (BEIER 2018, FORMAN & GODRON 1986).	4C. WHERE POSSIBLE, PARTICULARLY IN AREAS DEVOID OF SENSITIVE INFRASTRUCTURE, CONSIDER UTILIZING CONTROLLED BURNS AS A MEANS FOR INVASIVE SPECIES CONTROL, ESPECIALLY WITHIN GRASSLAND AND PRAIRIE AREAS.
3D. WHERE INTERSECTIONS BETWEEN ENERGY CORRIDORS AND OTHER INFRASTRUCTURE OCCUR [PRIMARILY ROADWAYS AND RAILWAYS], LIMIT THE WIDTH OF THESE BOTTLENECKS TO NO MORE THAN 10% OF TOTAL CORRIDOR LENGTH (BEIER 2018).	
3E. WHEREVER POSSIBLE, STRIVE TO DESIGN POINTS WHERE ENERGY INFRASTRUCTURE CROSSES RIVER OR STREAM CHANNELS AT 90 DEGREES TO THE STREAM CHANNEL CENTERLINE AT A RIFFLE OR CROSSOVER (NOT ON A BEND). THIS SERVES TO MINIMIZE STREAMBANK COMPACTION, REDUCE STREAMBANK EROSION, AND REDUCE THE REMOVAL OF RIPARIAN VEGETATION (ADAPTED FROM ROSGEN 2006 & KEANE 2019B).	

ENERGY CORRIDOR & INSTALLATION CONSERVATION MANAGEMENT & PLANNING GUIDELINES

INFRASTRUCTURE PLACEMENT & SITING	HABITAT CREATION
1A. CONSIDER TOPOGRAPHIC CHALLENGES AND REROUTE PROPOSED ENERGY INFRASTRUCTURE IF POSSIBLE, TO REDUCE THE NEED FOR ADDITIONAL INFRASTRUCTURE SUCH AS SUPPLEMENTAL PUMP STATIONS, ETC. (BLM N.D.).	2A. CONSIDER GATHERING DESIGN PROFESSIONALS AND LANDSCAPE ECOLOGISTS TO CONDUCT RESEARCH ON INNOVATIVE APPROACHES TO INCORPORATE WILDLIFE HABITAT WITHIN ENERGY INFRASTRUCTURE CORRIDORS. SECTION 368 OF THE 2005 ENERGY POLICY ACT ATTEMPTS TO ADDRESS ENERGY CORRIDOR HABITAT CREATION, THOUGH CURRENT LITERATURE LACKS IN-DEPTH STUDY, AND CURRENT CORRIDOR PLANNING POLICIES ARE LIMITED IN SCOPE.
1B. STRIVE TO PERFORM ENVIRONMENTAL IMPACT STATEMENTS (EIS) PRIOR TO BEGINNING ENERGY CORRIDOR DESIGN, REGARDLESS OF STATE OR FEDERAL EIS REQUIREMENTS. THESE EIS WILL IDENTIFY PHYSICAL AND ECOLOGICAL CHALLENGES ASSOCIATED WITH PROPOSED ENERGY CORRIDOR LOCATIONS, POTENTIALLY SAVING ENERGY CORPORATIONS MONEY AND PREVENTING UNNECESSARY ECOLOGICAL DAMAGES (WEST-WIDE ENERGY CORRIDOR INFORMATION CENTER N.D.).	2B. CONSIDER OFFERING PRIVATE LANDOWNERS INCENTIVE TO CONVERT AGRICULTURAL AND GRAZING LANDS TO GRASSLAND OR OTHER HABITAT SUITABLE FOR WILDLIFE. THE NRCS CONSERVATION RESERVE PROGRAM (CRP) AND WORKING LANDS FOR WILDLIFE (WLFW) PROGRAM ARE NOTABLE EXAMPLES OF SUCCESSFUL LAND-USE CONVERSIONS WITH THE COMMON GOAL OF ENHANCING WILDLIFE HABITAT ON WORKING LANDSCAPES (NRCS 2018). BOTH PROGRAMS, ALONG WITH MANY CONSERVATION-BASED NGOS, UTILIZE THE FEDERAL FARM BILL AS FUNDING FOR THESE INCENTIVES (NRCS-LPCI 2010, SGI 2019, WLF 2018).
1C. WHERE POSSIBLE, PLACE SUPPORTING ACCESS ROADS PARALLEL AND ADJACENT TO PROPOSED ENERGY INFRASTRUCTURE. THIS SERVES TO REDUCE LANDSCAPE FRAGMENTATION AND REDUCES THE AMOUNT OF REQUIRED WILDLIFE CROSSINGS BY SPANNING BOTH INFRASTRUCTURE AND ACCESS ROADS WITH ONE CROSSING STRUCTURE (BLM N.D.).	
1D. UTILIZE TELEMETRY STUDIES WHEN EXAMINING WILDLIFE MIGRATION AND MOVEMENT ROUTES. THESE STUDIES SERVE TO IDENTIFY THE MOST SUITABLE LOCATIONS FOR WILDLIFE CROSSINGS, WHETHER OVERPASS, UNDERPASS, OR PENETRATION-TYPE CROSSINGS (ADAPTED FROM SAWYER, ROGERS, & HART 2016).	

Table 6.04
ENERGY CORRIDOR &
INSTALLATION CONSERVATION
MANAGEMENT & PLANNING
GUIDELINES (BAKER 2020)

HABITAT PRESERVATION	EDUCATION & TRAINING
3A. ENCOURAGE THE CORPORATIONS OR ENTITIES WHO OWN PROPOSED ENERGY INFRASTRUCTURE TO DEVELOP A CONSERVATION PLANNING COMMITTEE. THIS COMMITTEE SHOULD INCLUDE DESIGN PROFESSIONALS SUCH AS LANDSCAPE ARCHITECTS, PLANNERS, AND ENGINEERS. THE GOAL OF THIS COMMITTEE SHOULD BE TO CREATE NEW ENERGY CORRIDOR PROPOSALS THAT UTILIZE SENSITIVE ECOLOGICAL HABITATS RESPONSIBLY AND SENSITIVELY (ADAPTED FROM SGI 2019 & LPCI-NRCS 2010).	4A. ALL INDIVIDUALS ENGAGED IN THE PLANNING, DESIGN, MAINTENANCE, OR OPERATIONS OF ENERGY INFRASTRUCTURE CORRIDORS SHOULD COMPLETE PROPER EDUCATIONAL AND TRAINING PROGRAMS PRIOR TO BEGINNING WORK. IT IS ENCOURAGED THAT THESE INDIVIDUALS COMPLETE CONTINUING EDUCATION AND TRAINING PROGRAMS ON AN ANNUAL BASIS (U.S. DEPARTMENT OF ENERGY, N.D.).
3B. CONDUCT ANNUAL REVIEWS ON EXISTING ENERGY CORRIDORS BY UTILIZING THE BUREAU OF LAND MANAGEMENT AND U.S. DEPARTMENT OF ENERGY'S REGIONAL REVIEW PROCESS. WHILE REGIONAL REVIEWS ARE NOT YET COMMON PRACTICE IN MIDWESTERN STATES, THEIR USE CAN IDENTIFY ENVIRONMENTAL CONCERNS WITHIN EXISTING ENERGY CORRIDORS (WEST-WIDE ENERGY CORRIDOR INFORMATION CENTER N.D., BLM N.D.).	

SITE SELECTION CRITERIA

In order to understand the effectiveness of the design guidelines and policies that were developed during the course of this report, it was necessary to select two sites for application. It was determined that these sites should exhibit the typical characteristics of energy infrastructure or installation development. These characteristics were to include the removal of riparian vegetation, the presence of physical barriers such as pipelines or access roads, and an overall decrease in habitat quality and quantity. Additional characteristics related to wind farm installations were then identified. The most notable impact of wind farms on wildlife habitat, specifically avian habitat, is an 8km buffer zone which prairie chickens avoid as habitat (Winder et al. 2015). Physical barriers in the form of fencing are also common within wind farm installations, and present serious hazards to low-flying avian species like Lesser and Greater Prairie chickens (McNew et al. 2014).

Because the completion of an Environmental Impact Statement (EIS) is strongly encouraged (but not required) for new energy corridor and installation development, it proved to be challenging to find suitable EIS reports. It was planned for these EIS to serve as an initial site analysis, identifying proposed sites for energy corridor and installation development,

Figure 6.01
The removal of vegetation and construction of pipelines and supporting access roads can severely degrade wildlife habitat (Baker 2020, adapted from Van Bever 2019)

Figure 6.02
Many avian species require an 8km buffer zone around wind turbines when choosing habitat and breeding grounds (Baker 2020, adapted from Burival 2018)

projected ecological impacts, and proposed corridor routes or installation sites. Currently, an EIS report for the Keystone XL Pipeline is available to the public. Because this pipeline is a direct extension of the Cushing MarketLink Pipeline, this EIS was utilized as an initial site analysis for hotspot selection, or area for further analysis.

In an effort to best represent the different types of energy infrastructure discussed within this report (oil and gas, electrical generation, and associated access roads), it was determined that the selection of a wind energy generation site would also be necessary. Wind farms are notable for environmental and habitat impacts stemming from both transmission lines and wind turbines themselves. Despite these two-fold environmental impacts, EIS for wind generation proved even more difficult to find. The BLM does require the completion of a 'Programmatic EIS', though these Programmatic EIS typically only examine the 'broad environmental impacts' of agency actions, including wind energy generation (DOI-BLM 2005). For this reason, an Environmental Impact Statement for the Gray County Wind Energy Center was not available.

Google Earth imagery was then employed to study both proposed sites for several criteria, acting as a supplemental site analysis to the Keystone EIS and location information obtained through the Gray County, Kansas official website. These key criteria are listed below:

1) Presence of riparian zones or stream channels

2) Presence of existing energy infrastructure (compressor stations, transmission sub-stations, existing corridors, or wind energy installations

3) Presence of protected, priority, or endangered plant and wildlife species

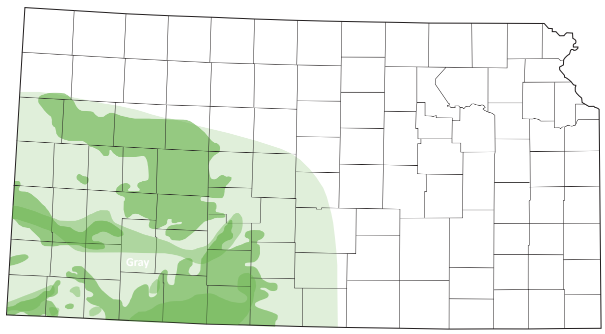
These criteria established key hotspots, or areas of interest, for further examination. The two hot spots that possessed the highest levels of disturbance were then selected as test sites for the implementation of design guidelines and regulatory policies. It was intended that these hot spots best represent the negative environmental impacts of energy infrastructure discussed previously within this report.

SELECTED SITES

Upon establishing site selection methods and criteria, the search for a suitable portion of energy infrastructure corridor and energy infrastructure installation began. To effectively address design and conservation solutions for the varying types of energy infrastructure corridors and installations within the study area, two sites were chosen for further study. It was intended that the first site would focus on oil and gas pipeline development and the associated wildlife species impacted by such development. The second site would focus on wind energy generation installations and was to be located in a geographical region featuring different vegetative and land-use conditions. By choosing energy corridors or installations at different geographical locations within the study area, an accurate representation of the adaptability of design guidelines and policies could be achieved. This design guideline and policy adaptability allows for application at locations throughout the United States, and even application toward industries outside energy production that may experience similar habitat fragmentation and degradation implications.

TARGET & SECONDARY SPECIES SELECTION

To identify which species would serve as a target species within the study area, habitat range graphics for each of the five candidate species within this report (Greater Prairie chicken, Lesser Prairie chicken, Northern Bobwhite, Mule Deer, and Pronghorn Antelope) were overlaid atop one another. Where the habitat range of a given species overlapped the two chosen hot spots, that species was automatically designated to move forward as a target species in the projective site design.



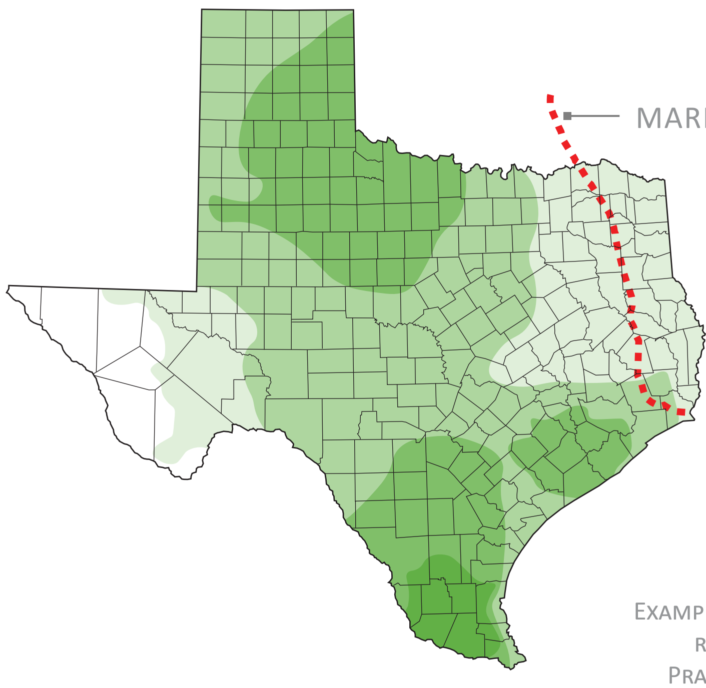


Figure 6.03
Example of overlaid habitat range graphics. Lesser Prairie Chicken habitat is shown on the Kansas map, while Northern Bobwhite is depicted on the Texas map. (Baker 2020)

SITE NO. 1- SULPHUR RIVER CROSSING | DELTA COUNTY, TX

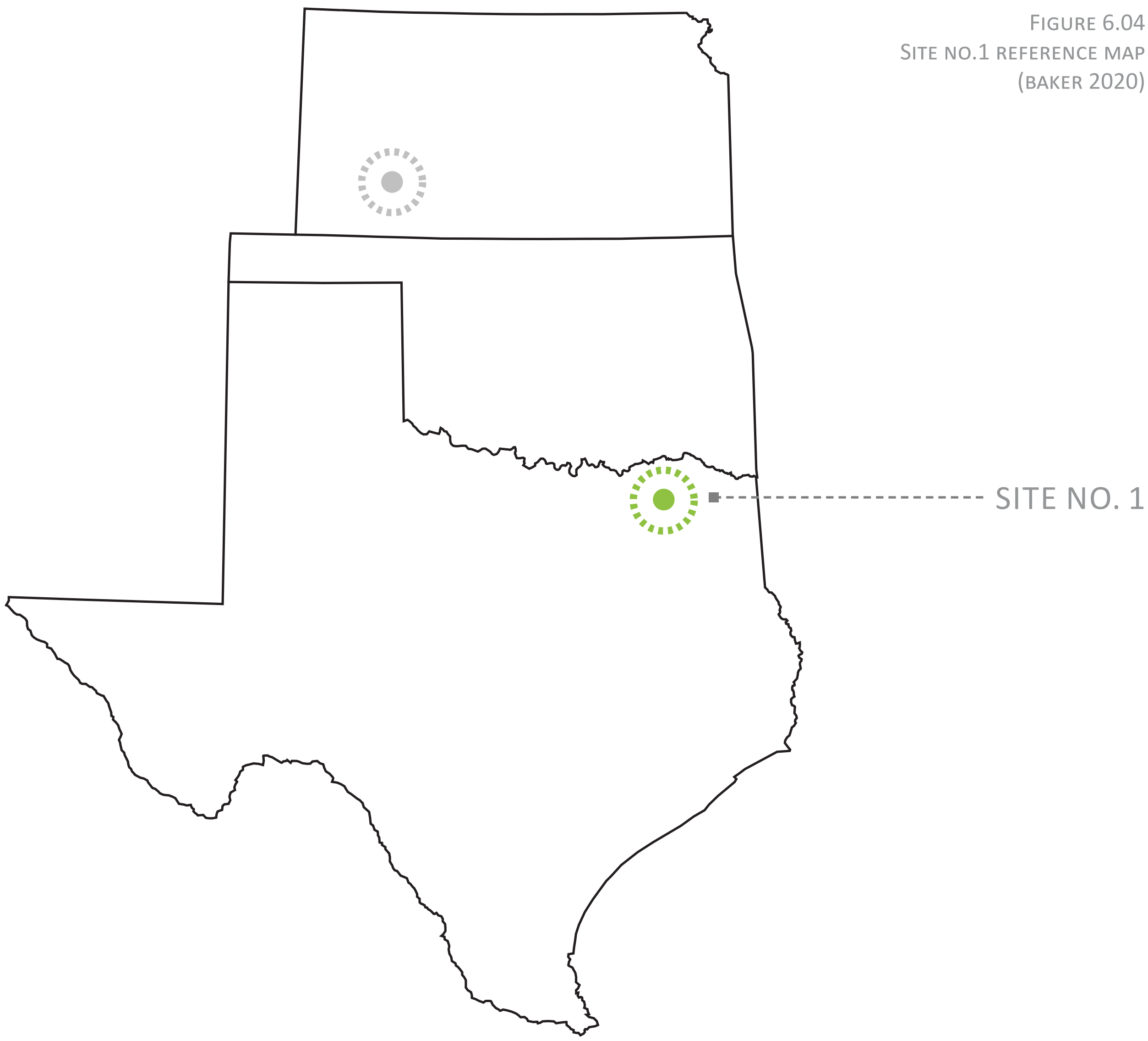


Figure 6.04
Site no.1 reference map
(baker 2020)

Analysis of aerial imagery and GIS data revealed several potential hotspots along the MarketLink pipeline. The site that most clearly displayed signs of habitat degradation was located in Delta County, Texas, and consisted of a variety of land uses, ranging from grazing and pasturelands to dense woodlands and agricultural lands. This site was chosen for a variety of reasons; however, the most notable are the widened portions of corridor that previously served as materials storage areas during pipeline construction. These areas showed considerable potential for the creation of habitat patches within the corridor itself. Additional concerns included the pipeline junctions with both the Sulphur River and Morgan Creek. These junctions, while below grade, do not cross the stream channels at perpendicular angles, and likely contributed significant amounts of bank erosion to both Sulphur River and Morgan Creek during the construction process.

Site number one contains of a segment of the MarketLink Pipeline in Delta County, Texas. This pipeline carries nearly 700,000 barrels of crude oil per day, much of which originates from the oil sands of western Canada (TransCanada Pipelines Limited 2020, Carr 2018). Originally the southernmost portion of the controversial Keystone XL pipeline, this segment failed to fulfill environmental impact study requirements and congressional deadlines required by the Presidential Permit application process in January of 2012 (Parfomak et al. 2013). As a result, this southern pipeline portion was separated from the original Keystone XL Pipeline proposal. This new, much smaller pipeline project (called the Gulf Coast Project) was exempt from Presidential Permit requirements and is now fully operational (Parfomak et al. 2013).

Despite the majority of the MarketLink Pipeline being below grade, the effects of landscape fragmentation and habitat loss are present along the entirety of the pipeline corridor. Intense excavation, vegetation removal, and soil compaction occurred along an approximately 150’-wide swath of land stretching roughly 435 miles from Cushing, Oklahoma to Port Arthur, Texas. This swath of land was eventually reduced to a permanent 100’ right-of-way for maintenance and daily operations, though it still exhibits significant signs of habitat destruction and loss (Parfomak et al. 2013).

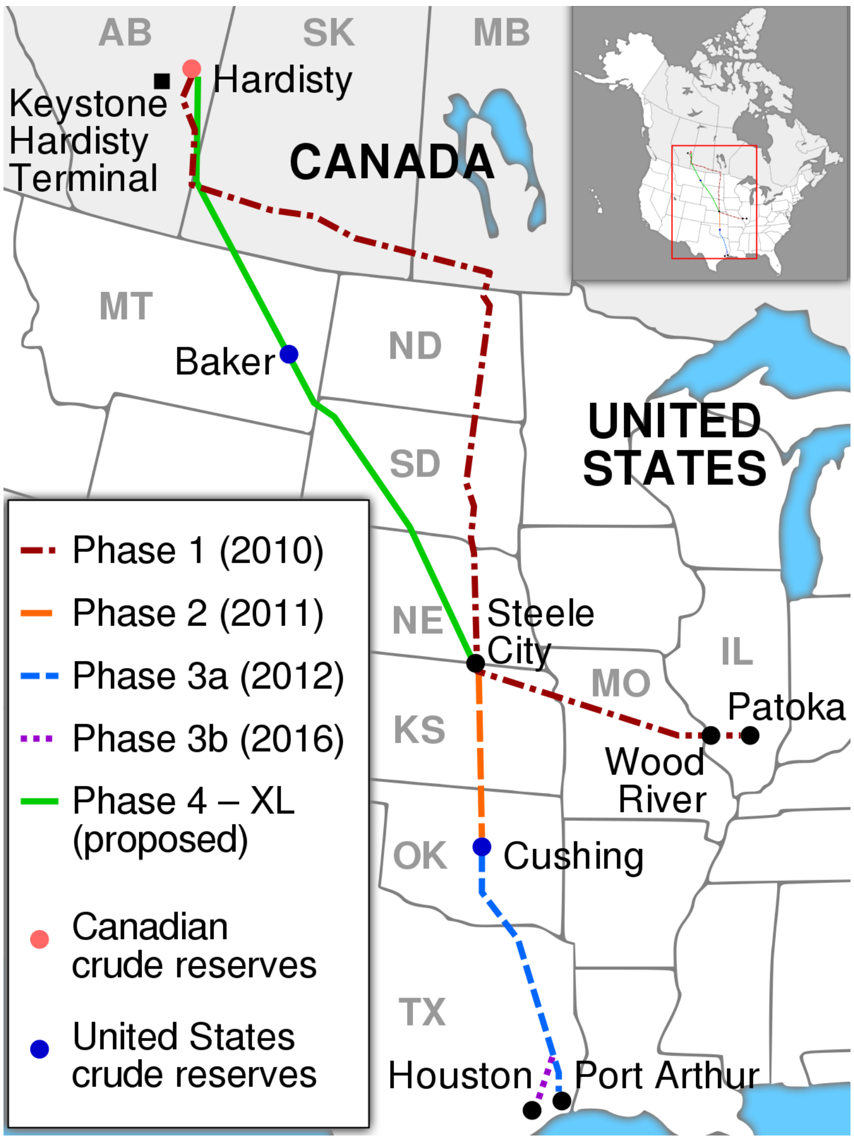


FIGURE 6.05
OPERATIONAL & PROPOSED ROUTES OF THE KEYSTONE PIPELINE SYSTEM (MECLEE 2007). THIS SECTION OF THE REPORT IS CONCERNED WITH PIPELINE PHASE 3A.

In total, 1.6 linear miles of below-grade pipeline stretches through the 0.60 square mile Sulphur River Crossing study area. The average corridor width is approximately 215’, though portions of the corridor reach nearly 260’ in width. Current aerial photographs suggest that a stretch of gravel access road approximately 3,000 feet long exists in the northern portion of the study area. Historic imagery (obtained through Bing Maps ‘historic imagery’ feature from 2016) indicates that during pipeline construction, the segment of pipeline within the study area was utilized as a materials storage area. This storage likely contributed to further soil compaction and erosion and may explain the relatively large width of this segment of corridor relative to other portions of the MarketLink pipeline. Refer to Figure 6.07 on page 107 of this chapter for detailed site analysis information.

In addition, numerous compressor stations are located at various points within the MarketLink corridor, where pipelines rise above grade and flow into large metal filtration tanks. The filtered oil and natural gas then travels to large compressor units, which pressurizes the oil and gas to sufficient levels to overcome grade change between subsequent compressor stations. Each of these compressor stations requires between five and fifteen acres of gravel-paved, level ground (Messersmith 2015). Obtaining aerial imagery of the MarketLink energy corridor proved to be challenging, as many of the common sources of imagery (Google Earth and ArcMap) featured distorted and pixelated imagery along the entirety of the corridor. It was determined that a combination of Bing Maps and ArcMap would be utilized to locate hot spots along the energy corridor.

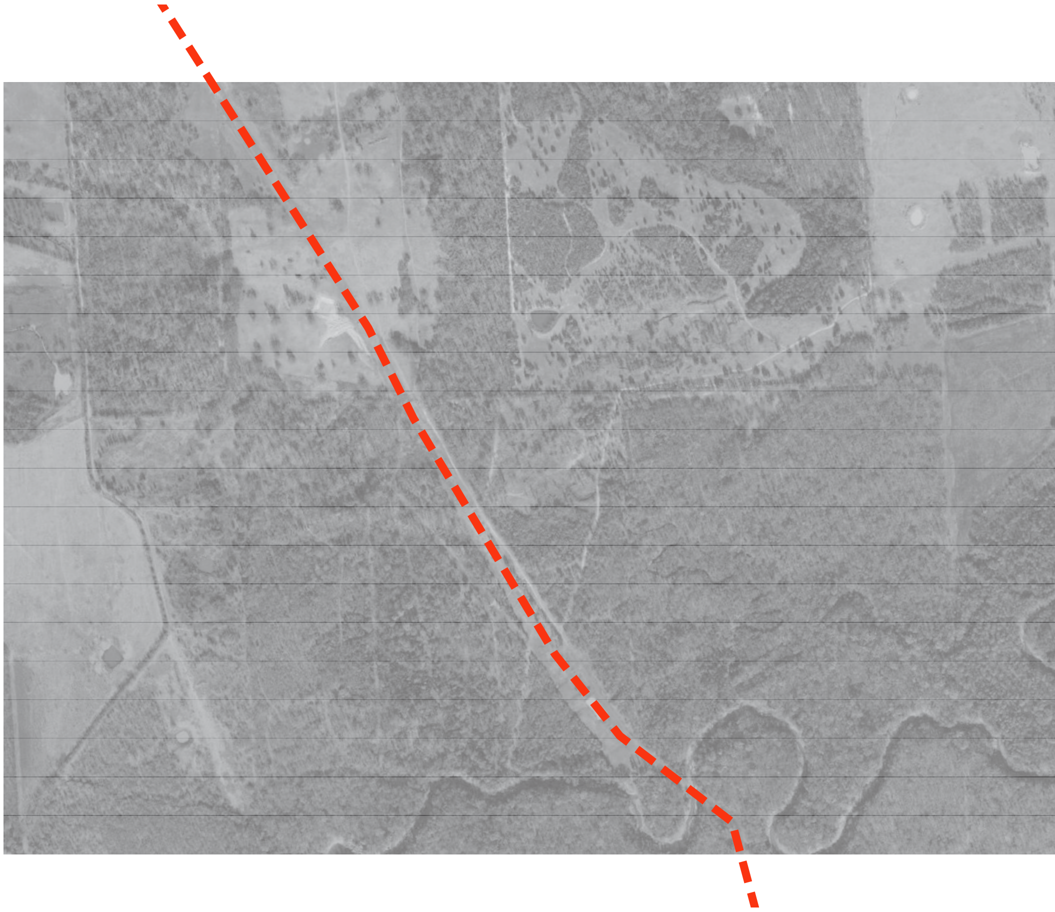


Figure 6.06
Aerial imagery of the Sulphur River crossing site. The dashed orange line represents the location of the MarketLink pipeline (baker 2020)

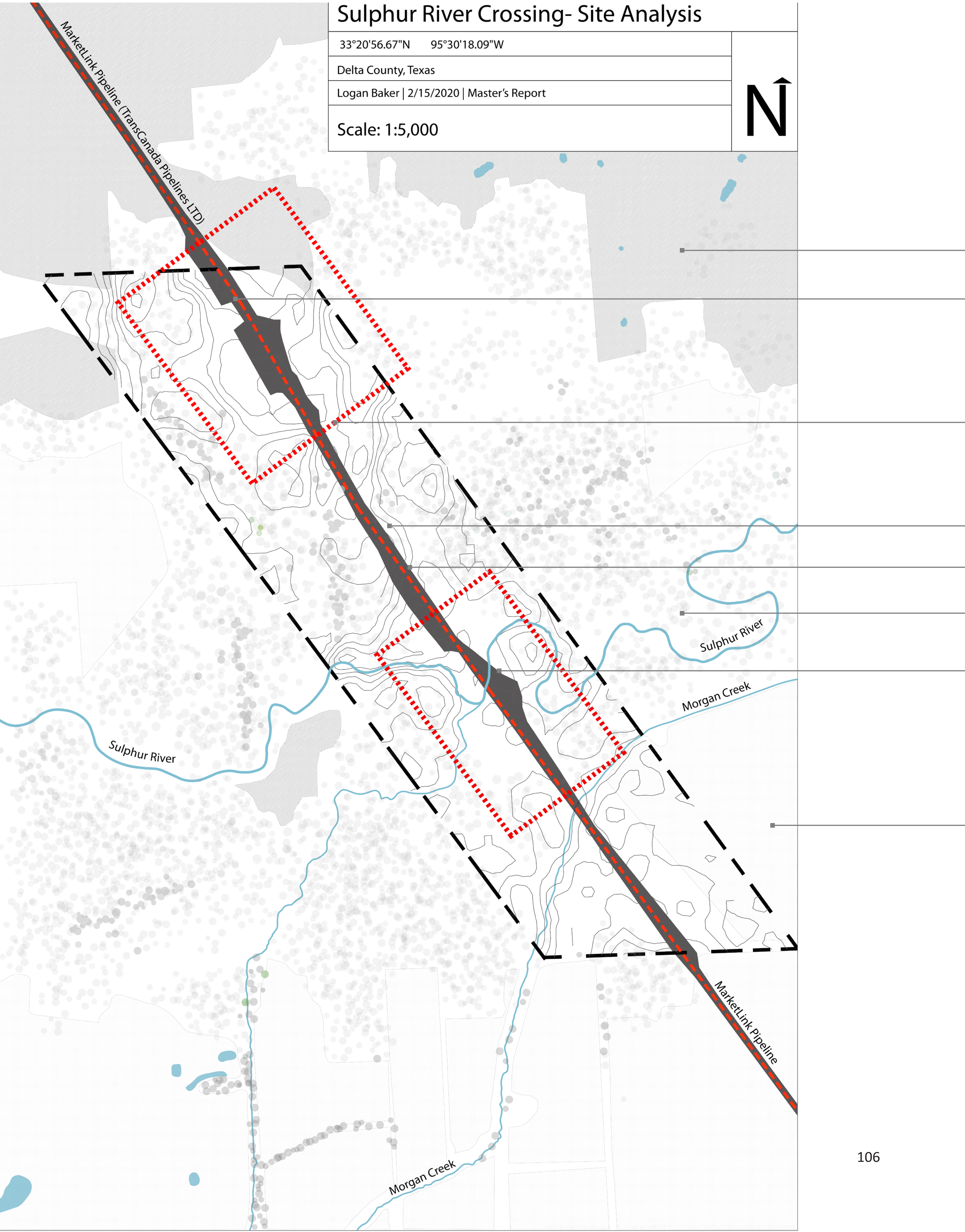
Sulphur River Crossing- Site Analysis

33°20'56.67"N 95°30'18.09"W

Delta County, Texas

Logan Baker | 2/15/2020 | Master's Report

Scale: 1:5,000



EXISTING GRAZING LAND

WIDENED AREAS WITHIN THE ENERGY CORRIDOR WERE PREVIOUSLY USED AS MATERIALS STORAGE AREAS DURING PIPELINE CONSTRUCTION. THESE AREAS LIKELY EXHIBIT SIGNS OF SOIL COMPACTION.

ABRUPT TRANSITIONS IN CORRIDOR WIDTH CAN PRESENT GREATER OPPORTUNITY FOR NEGATIVE EDGE EFFECTS.

215’ AVERAGE CORRIDOR WIDTH

1.6 LINEAR MILES OF PIPELINE BISECT STUDY AREA

EXISTING WOODLANDS

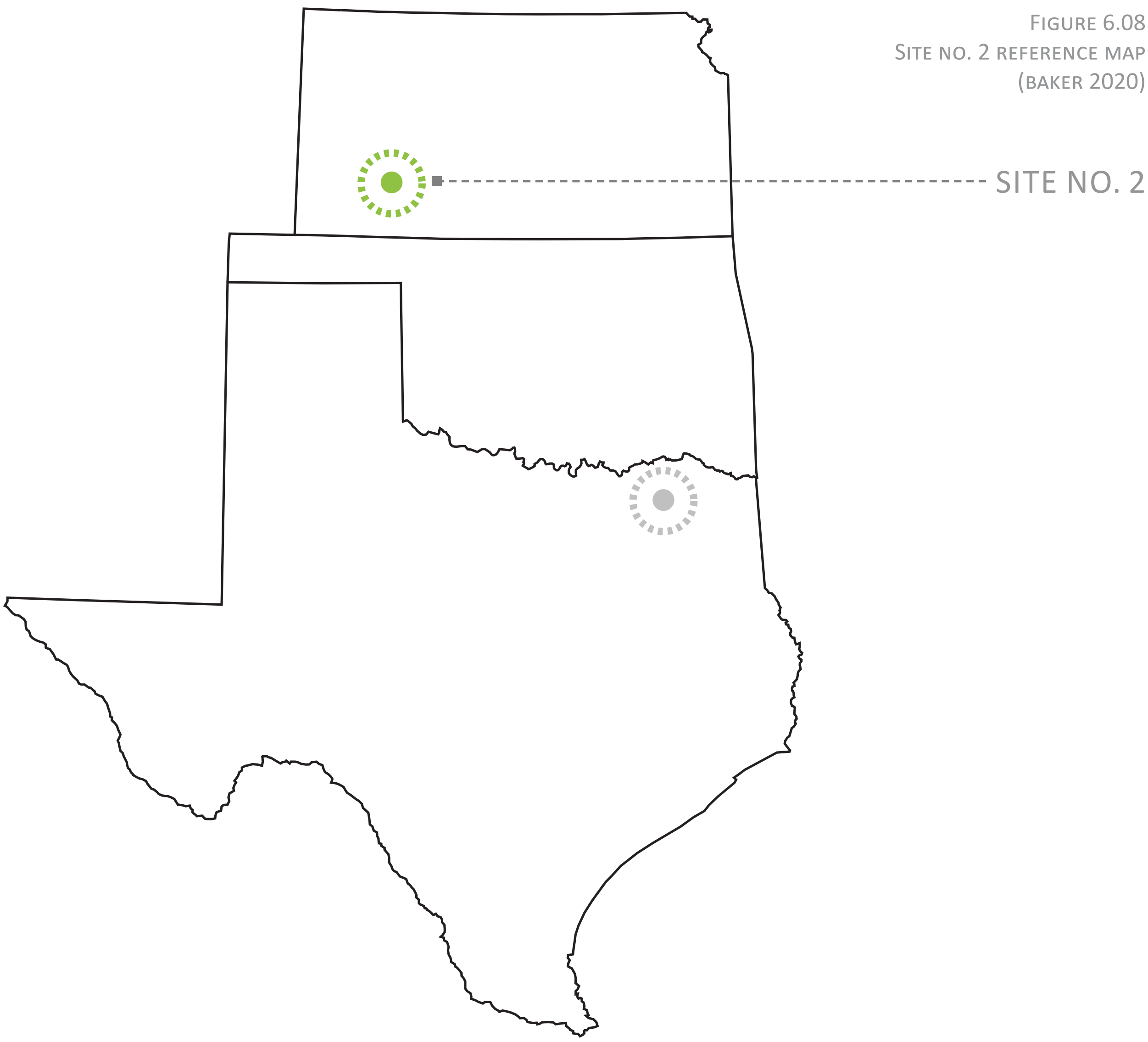
CROSSING POINTS BETWEEN THE PIPELINE AND STREAM CHANNEL ARE NOT PERPENDICULAR TO ONE ANOTHER. INCREASED STREAMBANK EROSION IS LIKELY PRESENT IN THESE LOCATIONS (ROSGEN 2006, KEANE 2019B).

EXISTING AGRICULTURAL LAND

Figure 6.07
Sulphur River Crossing site analysis (baker & McNair 2020).

SITE NO. 2- GRAY COUNTY WIND ENERGY CENTER | GRAY COUNTY, KS

Figure 6.08
Site no. 2 reference map
(baker 2020)



Known for average wind speeds of greater than 20 miles per hour, the High Plains of western Kansas is home to several large-scale wind farms. The first of these, the Gray County Wind Energy Center, was established in 2001 on the outskirts of Montezuma, Kansas (Aber & Aber 2012). In its current configuration, the Gray County wind farm employs 213 total wind turbines within 21 different turbine arrays. These arrays vary in overall length, from 0.49 miles at the shortest to 2.6 miles at the longest. The density of individual turbines within turbine arrays increases in the western portion of the 41 square mile study area, with an average of 12.1 turbines per array compared to 5.4 turbines per array in eastern portions of the study area (see Figure 6.09 on page 111 of this chapter).

While it is generally accepted that wind-energy generation is compatible with traditional rural and agricultural land use (Aber & Aber 2012), it is apparent that wind turbines can impact many avian species and their associated habitats (Khalil 2019, Sullins 2019, Beston et al. 2016). According to Winder et al. (2015), Lesser Prairie chickens avoid utilizing land within an 8km radius of wind turbines for nesting, booming, and foraging. In a study conducted by McNew et al. (2014), it was found that collisions involving Prairie chicken and wind turbines themselves are low; however, collisions with fencing surrounding the turbines and the transmission lines distributing produced energy are more common. To date, there have been many studies that examine avian fatality rates resulting from direct collisions with wind turbines, though few studies concerned with wind-energy noise intrusion on avian habitats exist.

THE PRESENCE OF CENTER-PIVOTS MAKES THE CREATION OF LESSER PRAIRIE CHICKEN HABITAT UNSUITABLE IN THESE AREAS.

LESSER PRAIRIE CHICKENS AVOID UTILIZING LAND WITHIN AN 8KM RADIUS OF WIND TURBINES FOR NESTING, BOOMING, AND FORAGING (WINDER ET AL. 2015).

REGIONAL AIRPORT

WIND TURBINES

GRAY COUNTY WIND ENERGY CENTER BOUNDARY

MONTEZUMA, KS

HIGHWAY 56

THE PRESENCE OF CENTER-PIVOTS MAKES THE CREATION OF LESSER PRAIRIE CHICKEN HABITAT UNSUITABLE IN THESE AREAS.

HIGHWAY 23

THE LACK OF CENTER PIVOTS AND ARTERIAL HIGHWAYS MAKES THIS LOCATION SUITABLE FOR THE CREATION OF LESSER PRAIRIE CHICKEN HABITAT. THIS AREA IS OUTSIDE THE 8KM ‘NO HABITAT RADIUS’ PREFERRED BY PRAIRIE CHICKENS, AND CONSISTS PRIMARILY OF OPEN AGRICULTURAL FIELDS.

OPEN, HIGHLY-VISIBLE CROPLANDS PROVIDE DESIRABLE HABITAT FOR ‘LEKS’, OR LESSER PRAIRIE CHICKEN BREEDING AREAS (ADAPTED FROM WINDER ET AL. 2015).

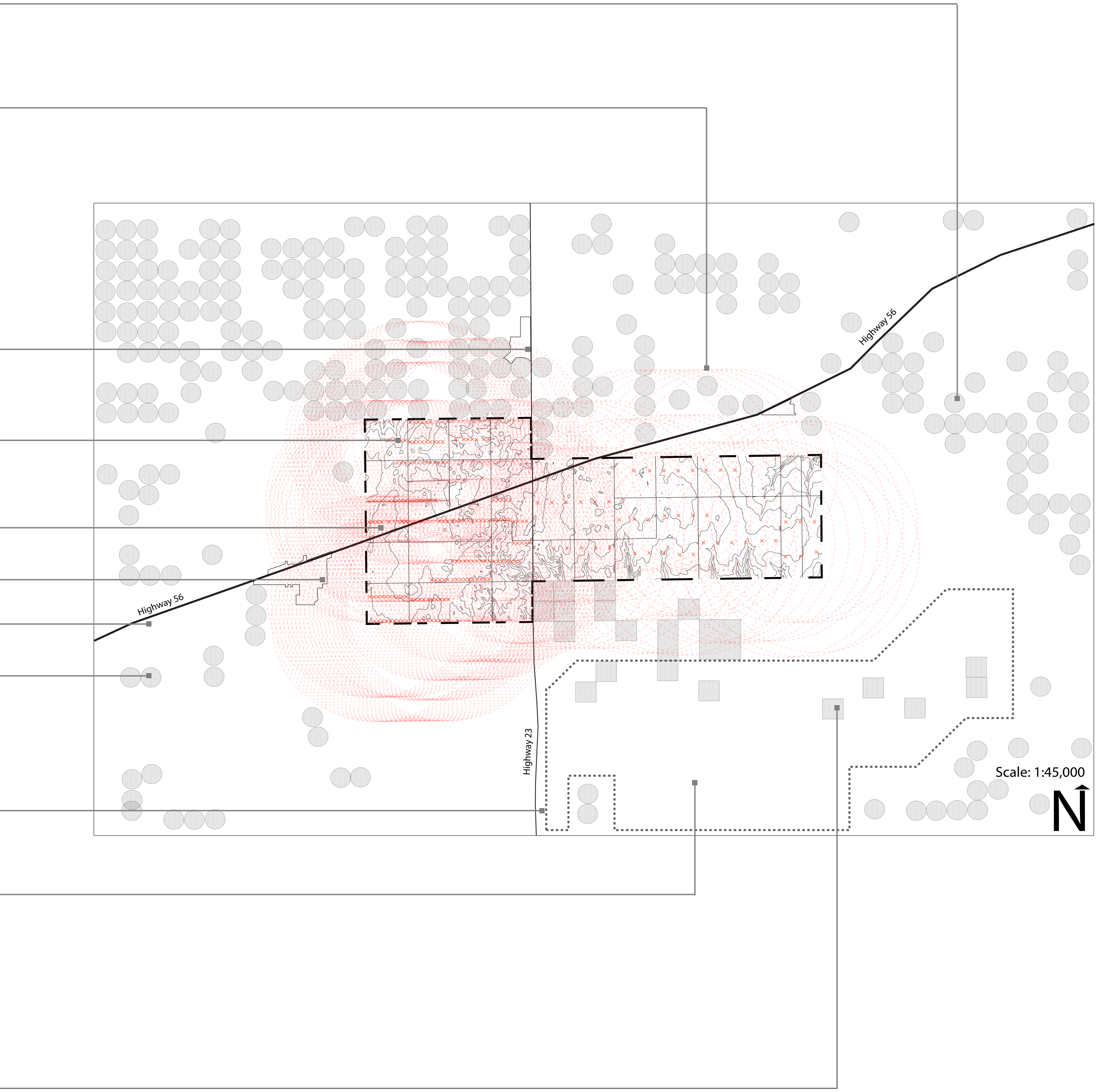


FIGURE 6.09
GRAY COUNTY WIND ENERGY CENTER SITE ANALYSIS (BAKER & MCNAIR 2020).

APPLICATION OF DESIGN GUIDELINES & POLICIES

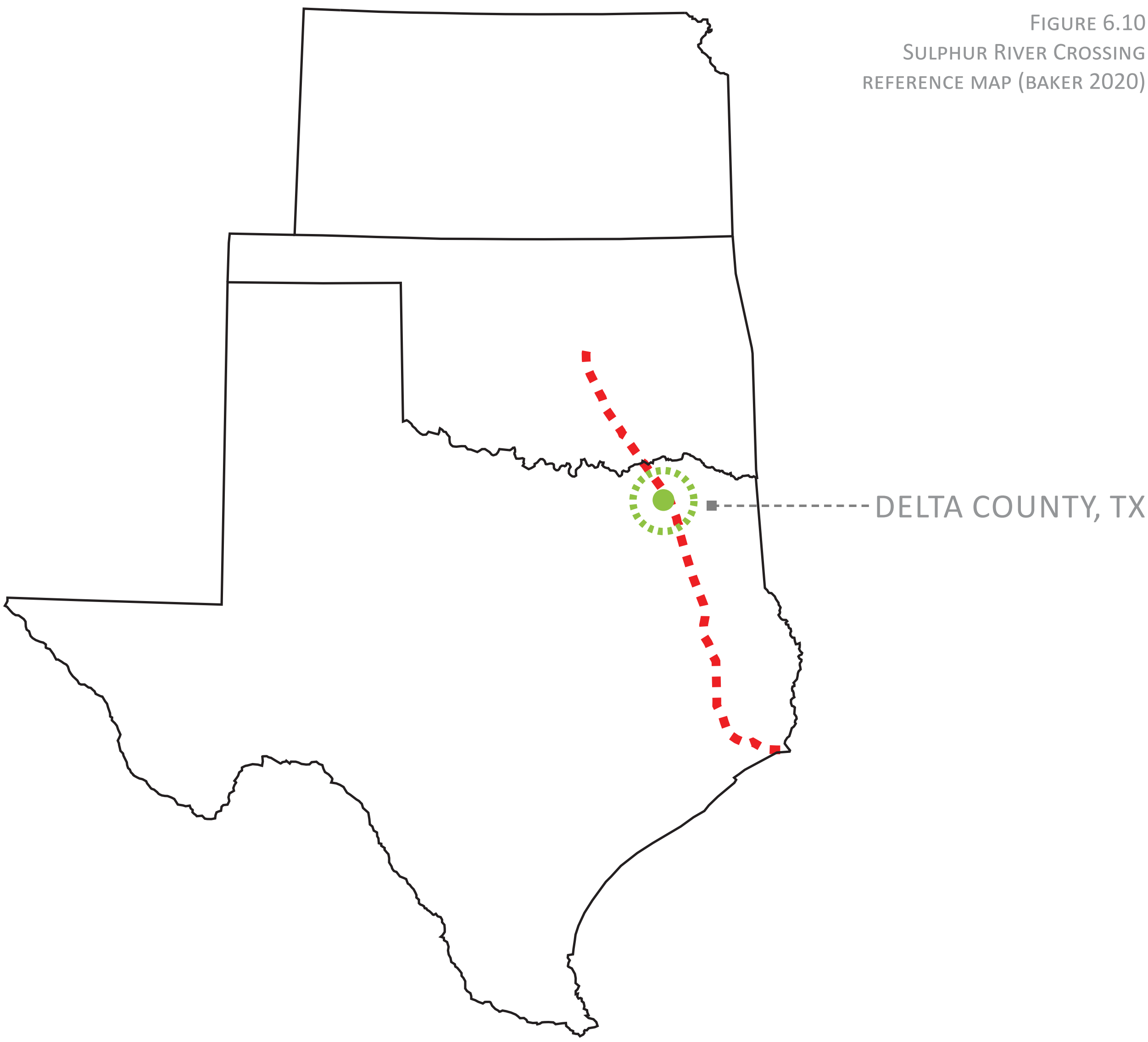
Following site selection, the overall effectiveness and applicability of the design guidelines and policies within this report was tested by developing two site-specific master plans. These master plans challenged the adaptability of the proposed design guidelines and policies, where vastly different geographic regions, target species, and land-uses had to be considered. Because both sites contained existing forms of energy infrastructure, guidelines and policies from the 'Existing Energy Corridor & Installation Conservation Policies' (Table 6.02) were utilized. The guidelines and policies pulled from this table were primarily concerned with physical energy corridor and installation alterations or maintenance practices, such as the introduction of native plant communities, game-proof fencing, or the avoidance of clear-cut mowing practices. In addition, conservation strategies from the 'Energy Corridor and Installation Conservation Management and Planning Guidelines' (Table 6.04) were employed. These management and planning strategies examined high-level energy corridor and installation management practices, where focus was placed on the formation of conservation committees, education and training programs, and general 'people-management' aspects of energy corridor and installation conservation.

It is important to reiterate that the design guidelines and policies introduced within this report are intended to serve as a supplemental ‘checklist’ for the responsible design and conservation of existing and proposed energy corridors and installations. These guidelines and policies are not intended to serve as a ‘one size fits all’ approach. Every energy infrastructure project, existing or proposed, will have its own set of unique ecological and environmental design challenges. Therefore, the guidelines and policies discussed here represent only one aspect of energy corridor and installation Best Management and Design Practices (BMPDs). It is suggested that the guidelines and policies discussed within this report be applied in conjunction with BLM’s Section 368 ‘Environmentally Responsible Corridor-Siting Decisions’ and Corridor Studies (BLM, n.d.).

PROJECTIVE SITE DESIGN STRATEGIES

SITE NO. 1- SULPHUR RIVER CROSSING | DELTA COUNTY, TX

FIGURE 6.10
SULPHUR RIVER CROSSING
REFERENCE MAP (BAKER 2020)



The primary goal of the Sulphur River Crossing projective site design was the creation of habitat for Northern Bobwhite. Prior to pipeline construction, the range of land uses in and adjacent to the Sulphur River Crossing site provided excellent Bobwhite habitat. Agricultural fields, grazing lands, and mixed hardwood forests supported high population densities (Brennan & Wilford 2014). As a result of excavation required for pipeline installation, significant amounts of woodland and grassland vegetation were removed from the study area.

While the removal of approximately one-third of the total dense woodland land cover can be beneficial to Northern Bobwhite populations (Sullins 2019), this vegetation removal contributed to significant amounts of soil erosion, compaction, and an overall reduction in biodiversity. Coupled with high levels of noise from construction activity, these pipeline-related construction activities severely damaged the breeding, nesting, and foraging habitat of the Northern Bobwhite.

This habitat damage, in conjunction with the dwindling number of Northern Bobwhite residing in areas adjacent to the MarketLink Pipeline corridor (see Figure 6.11 on the following page), led to the Northern Bobwhite population within the study area being chosen as the primary target species for a

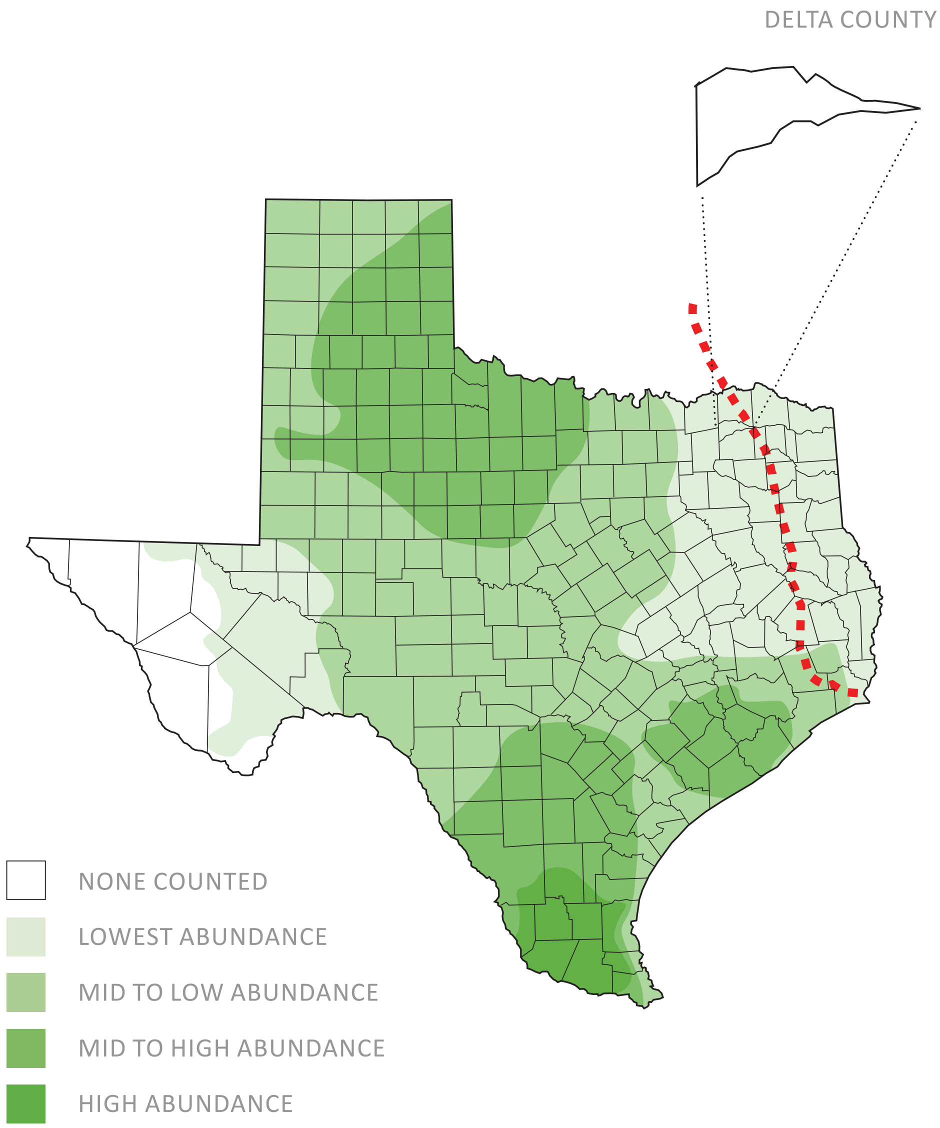


FIGURE 6.11
CURRENT TEXAS POPULATION DENSITY OF THE NORTHERN BOBWHITE. NOTE THE DECREASE IN DENSITY IN AREAS ADJACENT TO THE PIPELINE (BAKER 2020, ADAPTED FROM BBS 2012). AREAS ALONG THE MARKETLINK PIPELINE ONCE SERVED TO SUPPORT LARGER POPULATION DENSITIES OF NORTHERN BOBWHITE (TEXAS PARKS & WILDLIFE 2001).

projective site design. Related secondary species within the study area include white-tailed deer, various songbirds, and woodpeckers. These species may indirectly benefit from increased vegetation and habitat while utilizing the pipeline corridor as a passageway for movement between landscape patches, though they are not the primary beneficiaries.

The Sulphur River Crossing master plan capitalized on previously existing widened segments of pipeline corridor by creating large habitat patches infilled with native plant communities. See the 'Existing Energy Corridor & Installation Conservation Policies' (Table 6.02, section 2d) for more information. These plant communities, composed of vegetative species that vary in their successional stages, provide a range of habitat types within the corridor. Low growing native bunch grasses within the center of the corridor provide wildlife with foraging opportunities, while still allowing pipeline maintenance crews uninhibited access. Larger shrub, forb, and grass species flank the sides of the pipeline corridor, providing nesting and shelter for Bobwhite, while mixed-hardwood forest extends beyond the corridor itself and creates a dense tree canopy for songbirds, woodpeckers, and other avian species. See the 'Existing Energy Corridor & Installation Conservation Policies' (Table 6.02, sections 2a, 2b, and 2c) for more information.

EXISTING GRAZING LAND

PREVIOUSLY EXISTING WIDENED SEGMENTS OF PIPELINE CORRIDOR REPURPOSED INTO LARGE HABITAT PATCHES INFILLED WITH NATIVE PLANT COMMUNITIES.

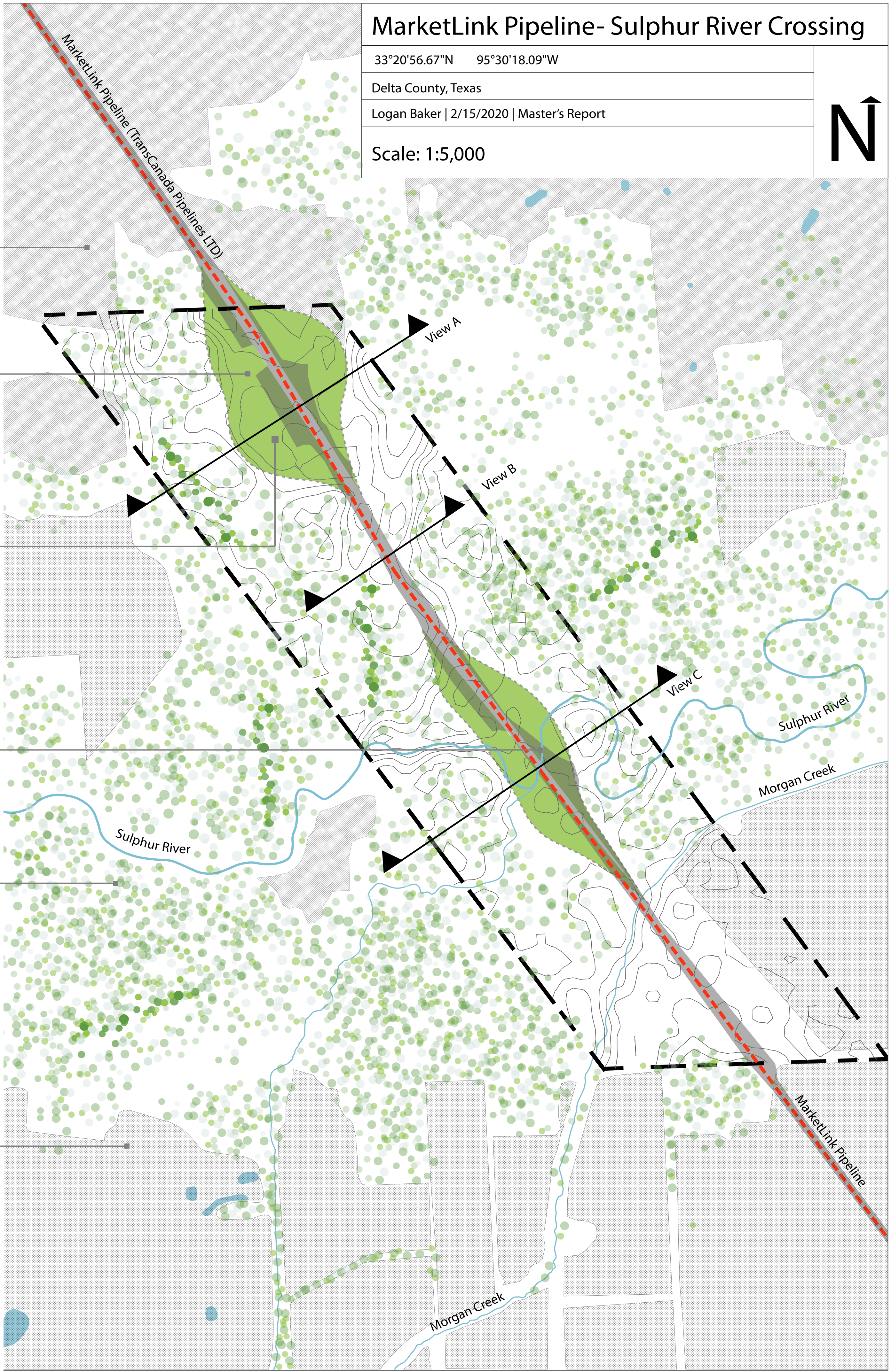
NATIVE INFILL PLANT COMMUNITIES VARY IN SUCCESSIONAL STAGES, PROVIDING HABITAT, SHELTER, AND FORAGE FOR NORTHERN BOBWHITE AND OTHER SECONDARY SPECIES.

NATIVELY-VEGETATED STREAM CHANNEL CROSSING PREVENTS ACCELERATED STREAMBANK EROSION (ROSGEN 2006, KEANE 2019B).

EXISTING WOODLANDS

EXISTING AGRICULTURAL LAND

Figure 6.12
Sulphur River Crossing Master Plan
(Baker & McNair 2020)


MarketLink Pipeline- Sulphur River Crossing
33°20'56.67"N 95°30'18.09"W
Delta County, Texas
Logan Baker | 2/15/2020 | Master's Report
Scale: 1:5,000
N
MarketLink Pipeline (TransCanada Pipelines LTD)
View A
View B
View C
Sulphur River
Sulphur River
Morgan Creek
Morgan Creek
MarketLink Pipeline

VIEW A:
MARKETLINK PIPELINE CORRIDOR STORAGE AREA CONSTRUCTION CONDITIONS

Figure 6.13
Widened portions of the Sulphur River Crossing segment of MarketLink Pipeline were used as construction storage areas, leading to increased soil compaction and erosion (baker 2020)

PROPOSED HABITAT PATCH DESIGN STRATEGY

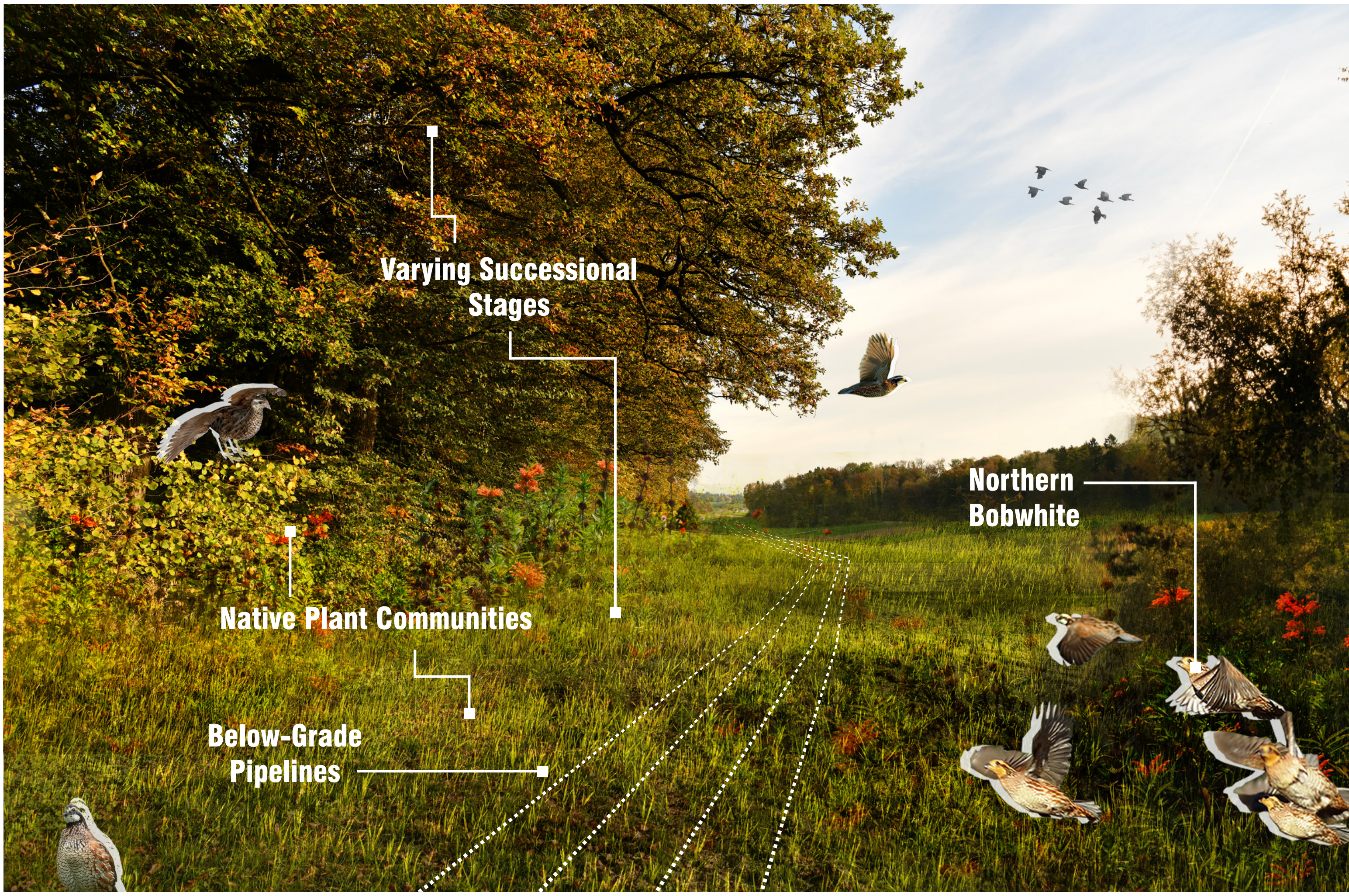


Figure 6.14
Proposed Design for habitat patch areas along the MarketLink pipeline corridor at sulphur river crossing (baker 2020)

VIEW B:
MARKETLINK PIPELINE CORRIDOR CONSTRUCTION CONDITIONS

FIGURE 6.15
PAST AND CURRENT MARKETLINK PIPELINE CONSTRUCTION CONDITIONS AT SULPHUR RIVER CROSSING (BAKER 2020)

PROPOSED CORRIDOR DESIGN STRATEGY

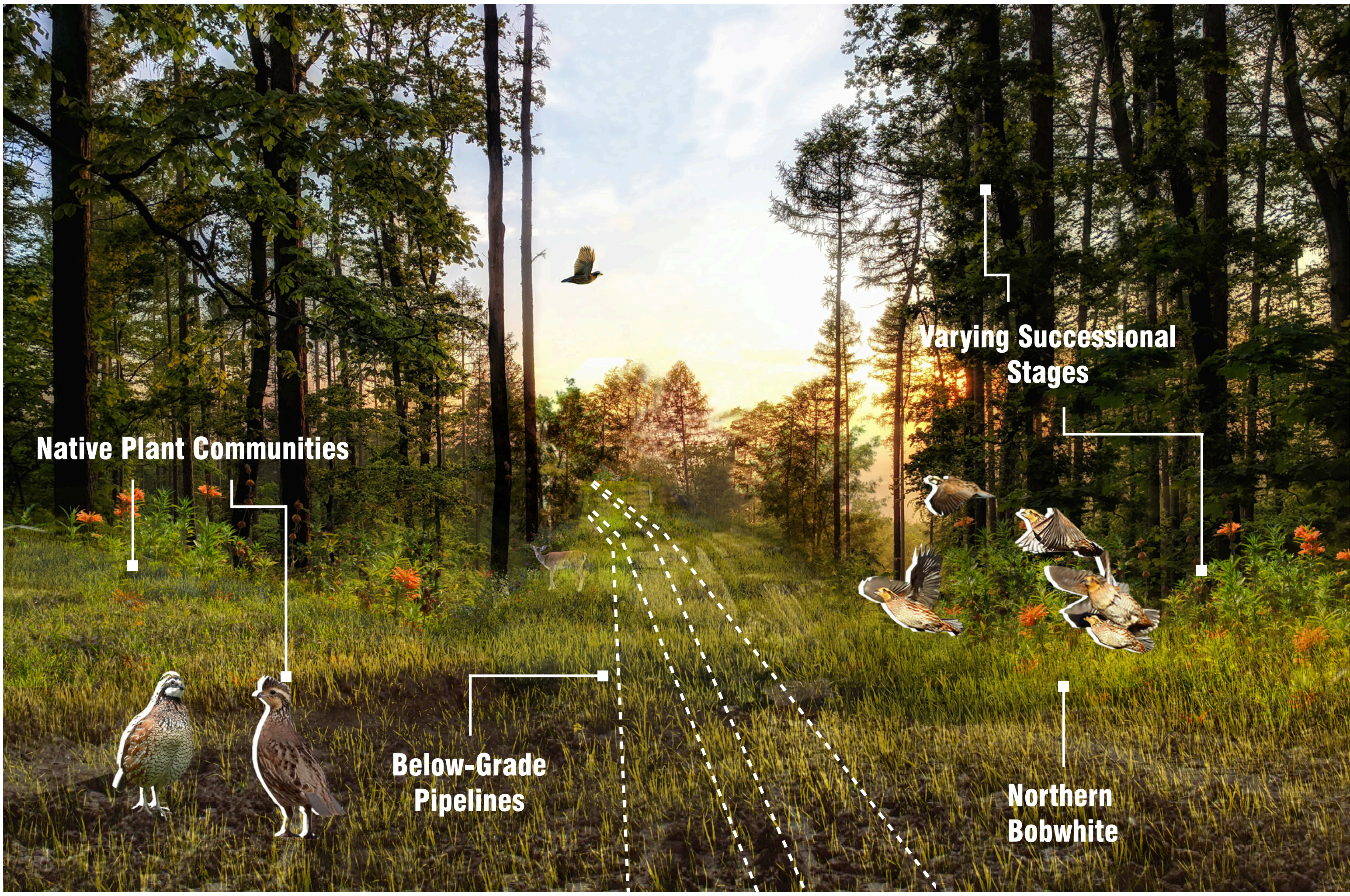


Figure 6.16
Proposed Design for the MarketLink pipeline corridor at Sulphur River crossing (Baker 2020)

A secondary goal to habitat creation, decreasing streambank erosion along the Sulphur River and Morgan Creek was deemed vital to preserving the remaining existing and newly-created habitat. Rosgen's (2006) Reconnaissance Level Assessment (RLA) was utilized as an initial 'screening' approach to identify increased sediment sources as a result of streambank erosion and channel instability. This approach identified the intersection of the Sulphur River and MarketLink pipeline as a 'hot spot', or area of concern, that then advanced to the next assessment level. This second assessment, referred to as the Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC), informed design, monitoring, and mitigation strategies aimed at preventing further streambank erosion. This site design proposes re-vegetating the streambanks along the Sulphur River stream channel to reduce accelerated streambank erosion and sedimentation. See 'Existing Energy Corridor & Installation Design Guidelines (Table 6.02) for additional information.

General upkeep and maintenance will be required to achieve the full range of ecological benefits associated with the projective site design described in this section. Where the MarketLink Pipeline corridor crosses privately-owned agricultural or grazing lands, the use of in-corridor grazing strategies suggested in Corridor Maintenance Strategies section 4b is highly encouraged. Additionally, all corridor segments within the MarketLink corridor should abide by the vegetation maintenance strategies suggested in Corridor Maintenance Strategies (Table 6.02, sections 4a and 4c.)

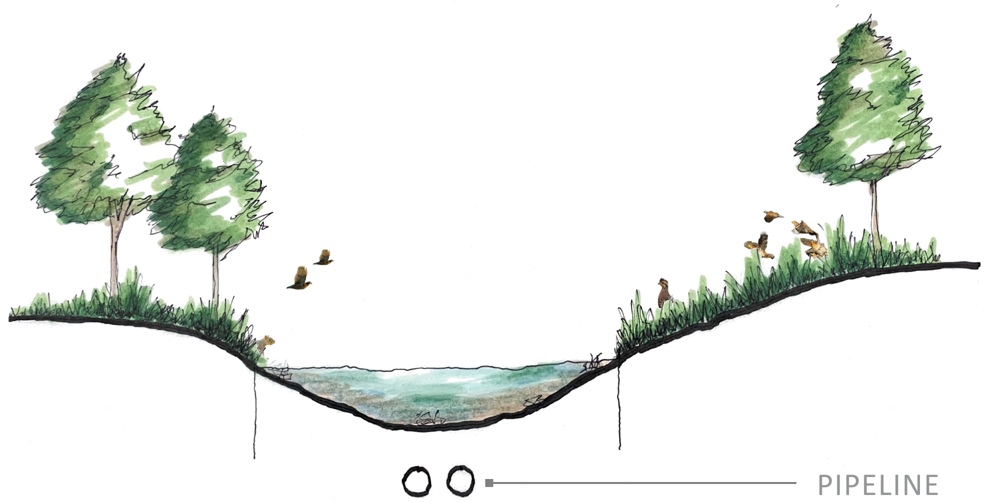


Figure 6.17
Conceptual section sketch analyzing stream channel restoration strategies
(Baker 2020)

VIEW C:
PIPELINE CONSTRUCTION AT SULPHUR RIVER

Figure 6.18
This segment of pipeline was not installed perpendicular to the Sulphur River stream channel, causing the stream channel to deepen and widen due to accelerated streambank erosion (baker 2020)

PROPOSED SULPHUR RIVER STREAMBANK RESTORATION

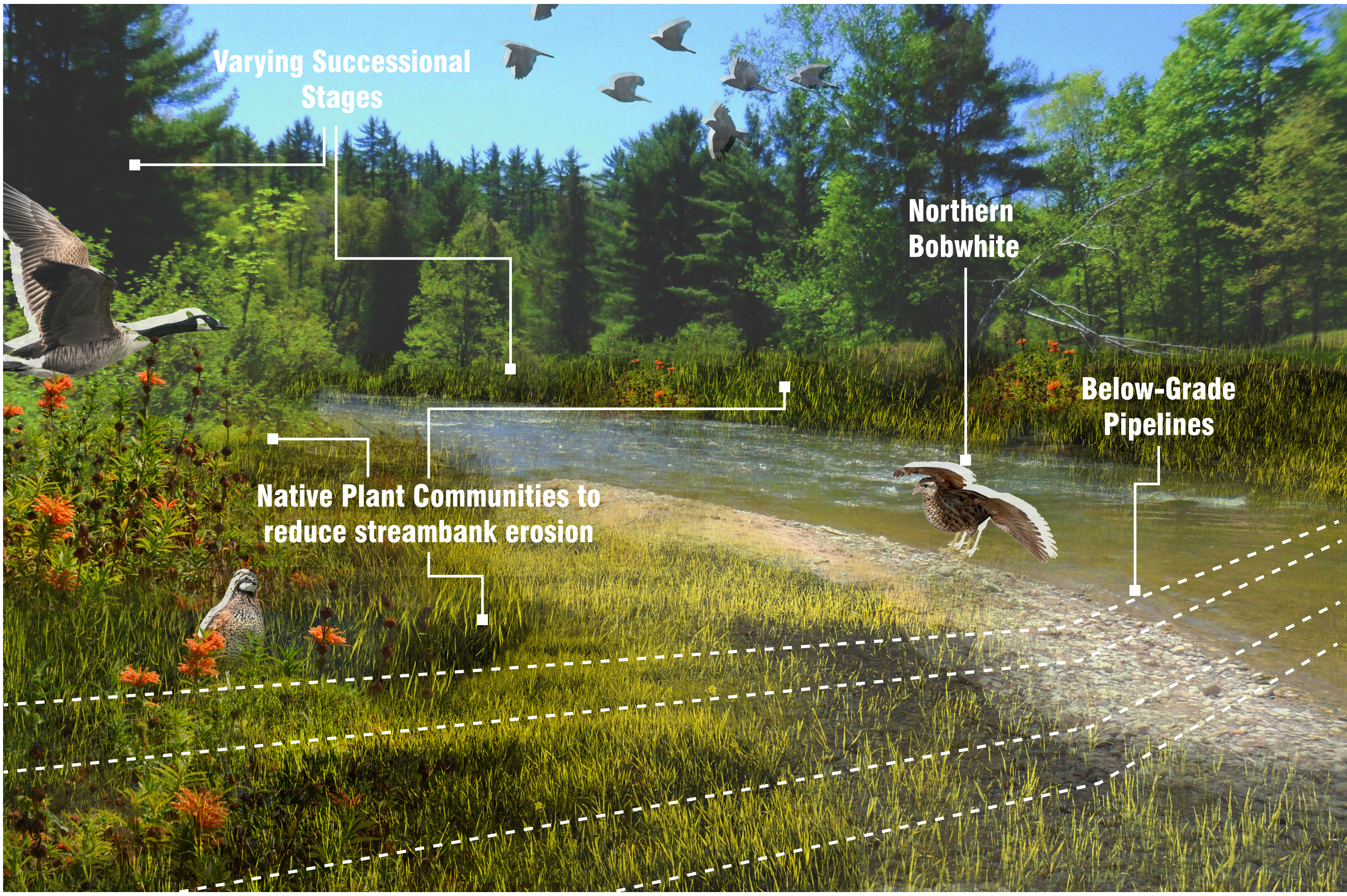


Figure 6.19
Native plant communities installed along the Sulphur River streambanks hold soil in place, reducing accelerated streambank erosion while providing nesting and breeding habitat for Northern Bobwhite and other avian species (Baker 2020)

SITE NO. 2- GRAY COUNTY WIND ENERGY CENTER | GRAY COUNTY, KS

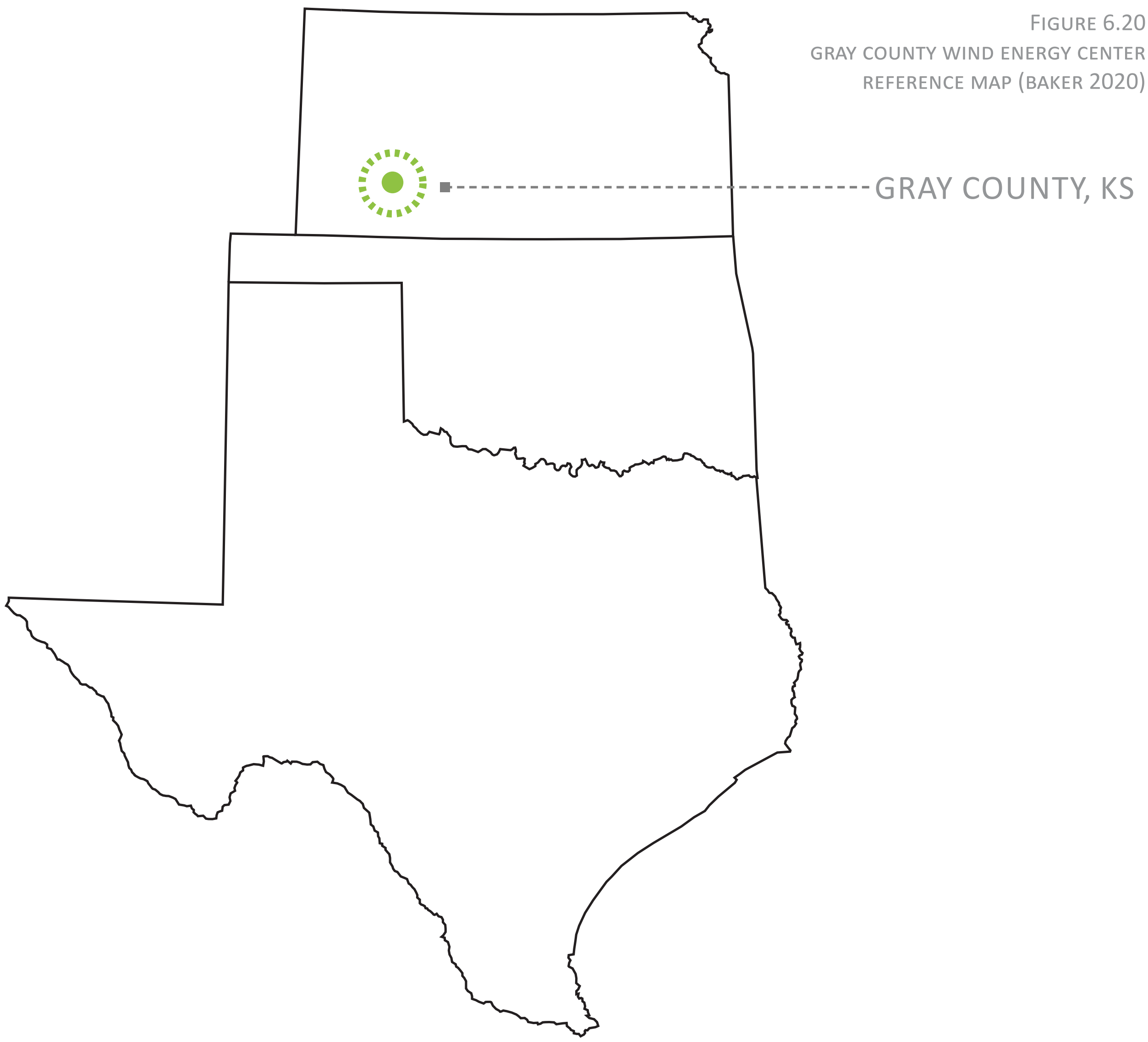
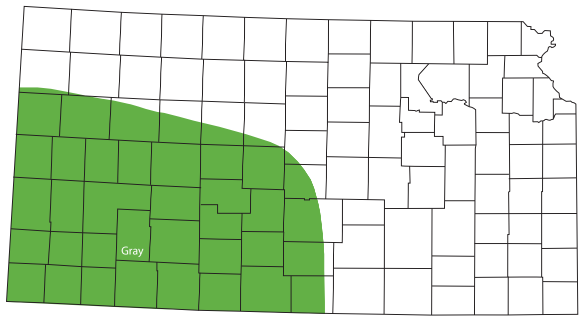


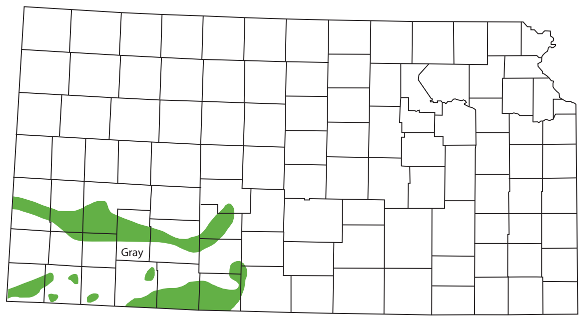
FIGURE 6.20
GRAY COUNTY WIND ENERGY CENTER
REFERENCE MAP (BAKER 2020)

Given the Gray County wind farm's central location in the heart of Western Kansas's Lesser Prairie chicken habitat range, Lesser Prairie chicken (LPC) was determined to be the primary target species of concern in this projective site design. Secondary species that have the potential to see indirect benefits of habitat creation adjacent to the Gray County wind farm include Mule Deer and Northern Bobwhite.

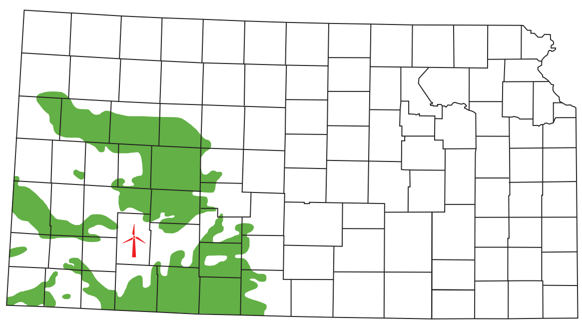
The primary goal of this projective site design was the creation of grassland habitat for Lesser Prairie chicken. To accomplish this, a regional-scale master plan was developed.



Historic western Kansas habitat range of the lesser prairie chicken



1955 western Kansas lesser prairie chicken habitat range. While prairie chicken habitat within Gray County declined, roughly 1/3 of the county still offered prairie chicken habitat



Current (2008) western Kansas lesser prairie chicken habitat range. Note the lack of habitat surrounding the Gray County wind energy center

Figure 6.21
Progression of lesser prairie chicken habitat fragmentation (Baker 2020, adapted from Channell 2008)

Since an 8km buffer around wind turbine development is required for LPC habitat, it was deemed necessary to expand the study area to include an area of approximately 380 square miles around the entirety of the Gray County wind farm. Land use in areas surrounding the Gray County wind farm is predominantly agricultural, with a high distribution of center-pivot irrigation systems to the North, West, and East. The small towns of Montezuma and Ensign lie to the West and East, respectively, while a small regional airport sits north of the wind farm.

Given the presence of center-pivots, rural development, and an airport, the land to the North, East, and West was determined to be unsuitable for Lesser Prairie chicken habitat development. Lands to the South function predominantly as agricultural lands, and the lack of center-pivots and arterial highways proved more suitable for LPC habitat creation. These lands consist of open, highly visible cropland and grasslands, occasionally segmented by narrow gravel roadways that typically experience low to moderate traffic during harvest and planting seasons (refer to the Gray County Wind Farm site analysis map, Figure 6.09 on page 111, for additional information). Lands of this type provide desirable habitat for leks, or LPC breeding and booming areas (adapted from Winder et al. 2015). Similar to the Sulphur River Crossing projective site design, native plant communities were employed to facilitate the creation of habitat. Rather than utilizing mixed-hardwood and shrub communities, these newly created habitat areas rely upon native, low-growing bunch grass and forb species preferred by LPC. In a recent dissertation completed by Daniel Sullins, Ph. D., it was stated that "promising [LPC] conservation options include the conversion of cropland to grassland through the Conservation Reserve Program (CRP) and tree removal in mixed-grass prairie landscapes." (Sullins 2017). See the 'Existing Energy Corridor & Installation Conservation Policies' (Table 6.02, sections 2a and 2c) for more information.

In total, 55% of the total land available for conversion from agricultural land to LPC habitat was marked for grassland habitat development within the proposed Master Plan. While LPC are typically much more likely to utilize areas with greater than 60% of total available land as grassland, they have been shown to utilize areas with as little as 30-40% total grassland and 60-70% pastureland coverage if other CRP lands are accessible nearby (Sullins 2017). Ideally, a greater percentage of agricultural land would be available for habitat conversion; however, this would likely result in negative economic impacts to the primarily agricultural economy of Gray county. Refer to 'Energy Corridor & Installation Conservation Management & Planning Guidelines (Table 6.04, section 2b) for more information.

8KM BUFFER ZONE SURROUNDING WIND TURBINES

REGIONAL AIRPORT

WIND TURBINES

GRAY COUNTY WIND ENERGY CENTER BOUNDARY

MONTEZUMA, KS

HIGHWAY 56

HIGHWAY 23

AREAS OF PROPOSED GRASSLAND HABITAT CREATION. CONSISTING PRIMARILY OF PREVIOUSLY DISTURBED AGRICULTURAL FIELDS AND EXISTING GRASSLAND, THESE AREAS SERVE AS SUITABLE LOCATION FOR LESSER PRAIRIE CHICKEN ‘LEKS’, OR BREEDING AREAS (ADAPTED FROM WINDER ET AL. 2015).

PROPOSED HABITAT LINKAGES CONNECTING AREAS OF NEWLY CREATED HABITAT. THESE LINKAGES MAY ALSO SERVE AS TRANSITIONAL HABITATS FOR MULE DEER OR NORTHERN BOBWHITE.

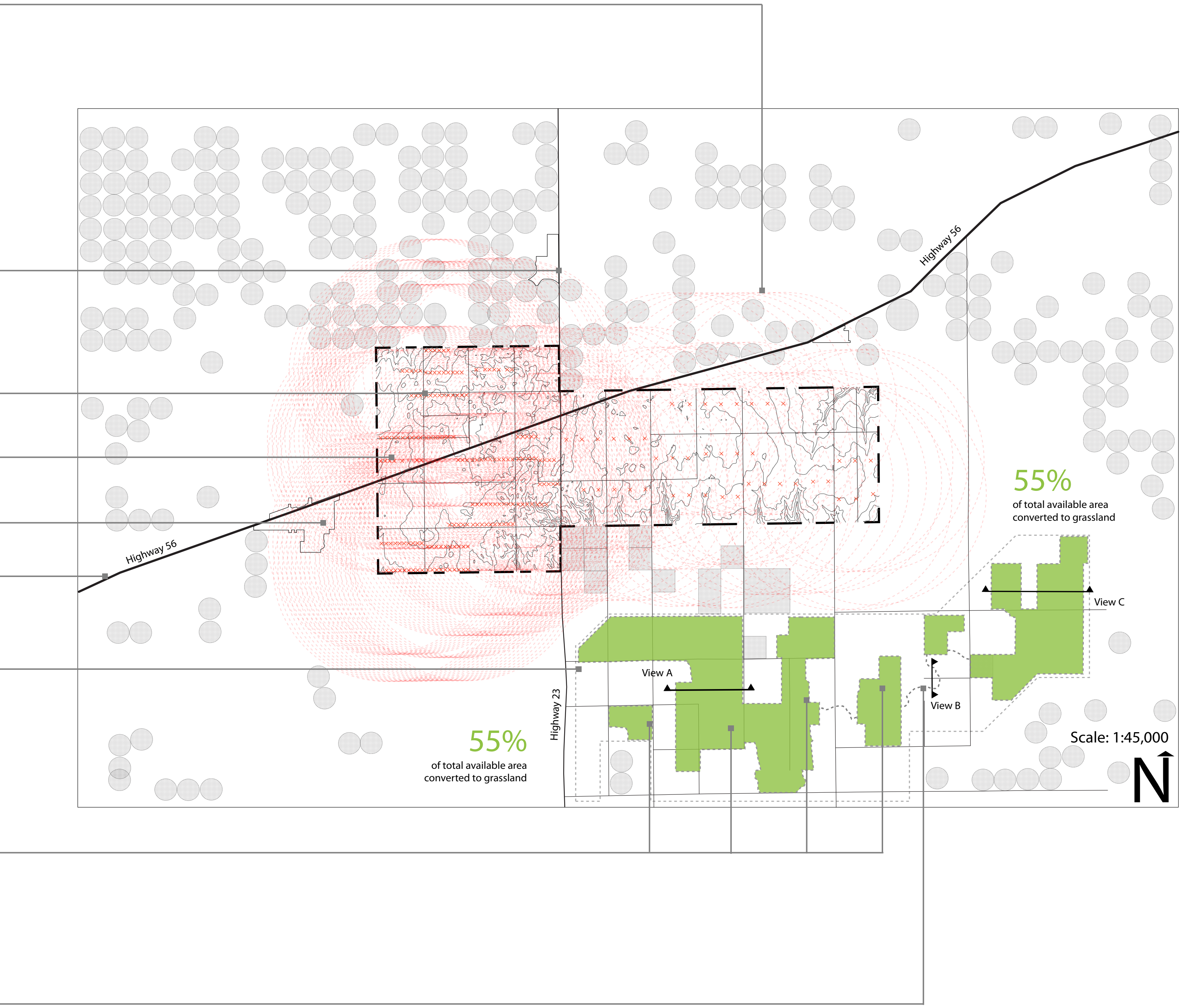


FIGURE 6.22
GRAY COUNTY WIND ENERGY CENTER
MASTER PLAN (BAKER & MCNAIR 2020).

VIEW A:
EXISTING AGRICULTURAL LAND-USE CONDITIONS

FIGURE 6.23
CURRENT LAND-USE CONDITIONS IN AREAS SUITABLE FOR LESSER PRAIRIE CHICKEN HABITAT CREATION ARE PRIMARILY AGRICULTURAL, THOUGH MANAGED GRASSLANDS EXIST TO A LIMITED EXTENT (BAKER 2020)

PROPOSED LESSER PRAIRIE CHICKEN GRASSLAND HABITAT DESIGN STRATEGY

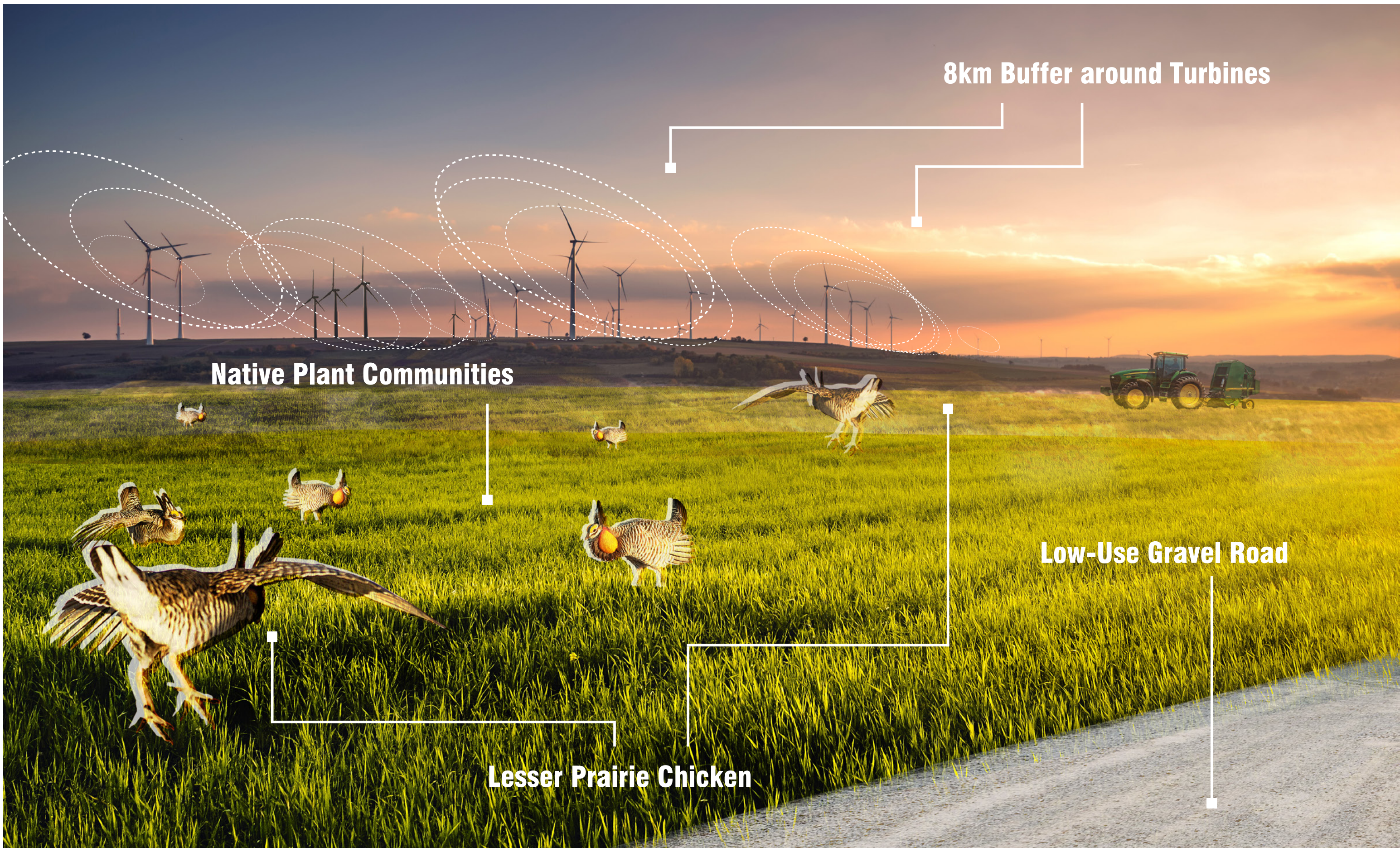


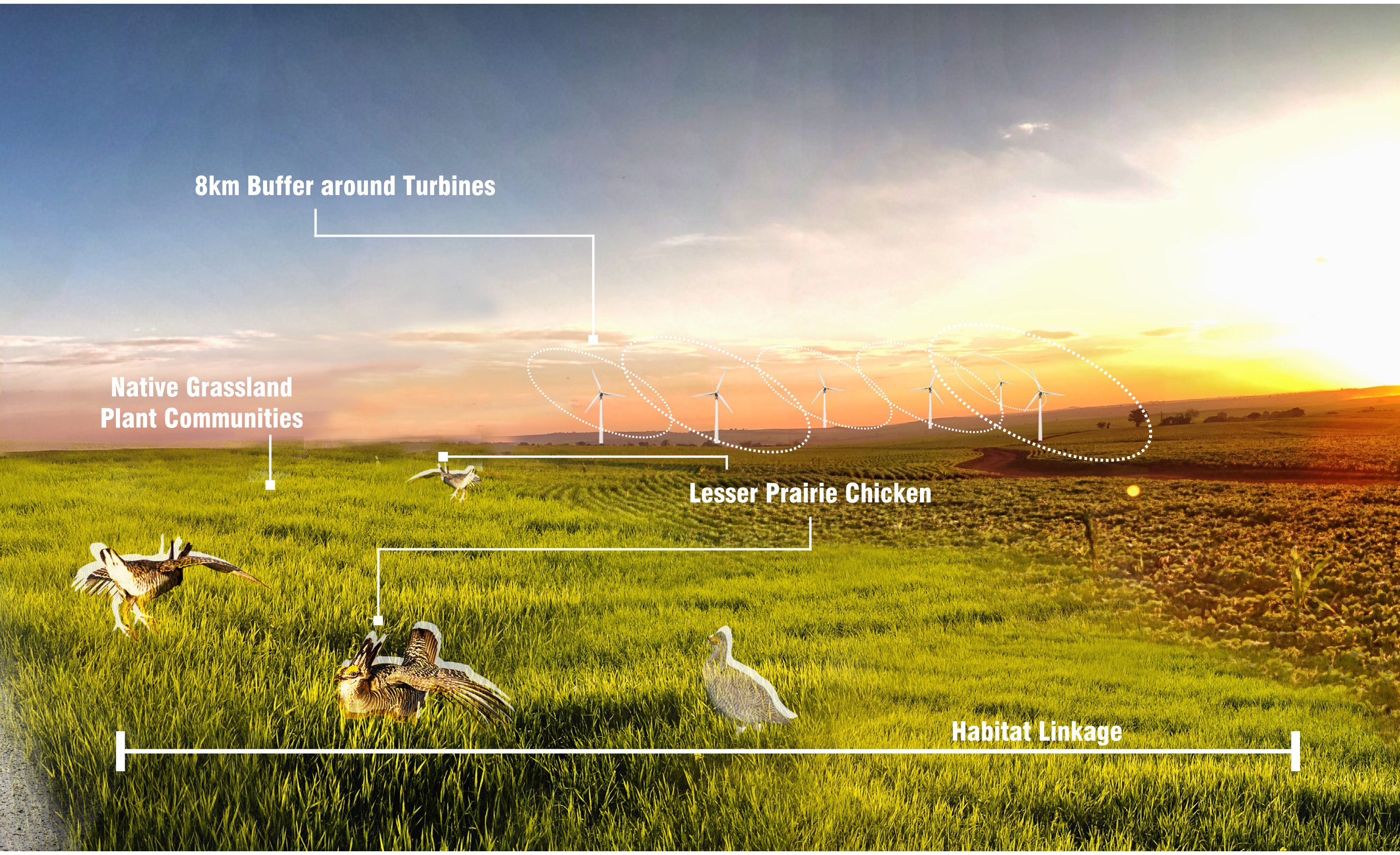
Figure 6.24
Proposed Design for Lesser Prairie Chicken
Grassland Habitat (baker 2020)

VIEW B:
EXISTING AGRICULTURAL LAND-USE CONDITIONS

Figure 6.25
Current land-use conditions near
the Gray County Wind Energy Center
(baker 2020)

VIEW B:
PROPOSED LESSER PRAIRIE CHICKEN HABITAT LINKAGES

Figure 6.26
Proposed habitat linkages connecting newly created lesser prairie chicken habitat patches (baker 2020)


8km Buffer around Turbines
Native Grassland
Plant Communities
Lesser Prairie Chicken
Habitat Linkage

VIEW C:
EXISTING AGRICULTURAL LAND-USE CONDITIONS

Figure 6.27
While agricultural land-uses are important to the agrarian communities of western Kansas, the cost implications associated with the conversion of agricultural land to lesser prairie chicken habitat can be offset with NRCS funding programs (Baker 2020, adapted from Owen 2018)

PROPOSED LESSER PRAIRIE CHICKEN GRASSLAND MAINTENANCE STRATEGY

Figure 6.28
Areas of open grassland composing prairie chicken habitat will require annual mowing or controlled burns to mitigate the spread of invasive species [see table 6.02, section 4D for additional information] (Baker 2020)

DISCUSSION

While initial attempts have been made toward addressing environmental stewardship in the design and conservation of energy infrastructure corridors and installations, few have utilized the concept of Social Capital to do so. Social Capital has proven itself an effective tool for habitat conservation in many successful NGOs, where groups including the Sage Grouse Initiative, Lesser Prairie Chicken Initiative, and the Ranchland Trust of Kansas have successfully gathered stakeholders who share the common goal of habitat conservation since the early 2000s (SGI 2019, NRCS-LPCI 2010, Ranchland Trust of Kansas n.d.). This signifies that the notion of utilizing Social Capital as a resource for gathering individuals, corporations, design professionals, and federal and state agencies toward the common goal of responsible energy infrastructure management and design is entirely feasible.

Additionally, the inclusion of NGOs and P3s for energy corridor and installation conservation and design goes far beyond the initial drafting and creation of design guidelines. It is suggested that the theoretical partnership used in the creation of these design guidelines and policies be utilized to form sub-committees for the responsible management of energy corridors and installations. These sub-committees serve two main purposes- the monitoring of energy corridors and installations after conservation design strategies have been implemented, and the adaptive management of these corridors and installations.

The adaptive monitoring and management strategies carried out by these sub-committees allows for the design guidelines and policies presented within this report to be evaluated over a period of time, analyzing their effectiveness toward overall habitat conservation. It is intended that sub-committees be established in different geographic regions of the U.S., where they can then make adjustments to the design guidelines and policies to accommodate the unique requirements of each geographic region. This allows for further refinement of the design guidelines and policies while meeting the desired wildlife habitat conservation goals and outcomes of specific regions.

Though the future of the world's energy production landscape remains uncertain, the need for an integrated, holistic, and sustainable approach to responsible energy production is indisputable. By devising design guidelines and policies through a diverse and collaborative forum of stakeholders, the ideas and knowledge generated through these efforts are represented by a wealth of differing knowledge bases. Utilizing this collaborative forum, landscape architects, engineers, and community planners are better able to shape the design, conservation, and maintenance strategies of energy corridors and installations. Their design decisions are founded upon the expertise and knowledge offered by energy corporation professionals, state and federal conservation agencies, ecologists, biologists, and range conservationists. Private landowners are represented along every step of the design and decision-making process, many of whom are able to provide decades-worth of land preservation and ecosystem stewardship advice. This approach leads to a mutually-beneficial relationship, where energy corporations reap the benefits of tax credits and positive public perception resulting from sustainable energy production, design professionals are equipped with the expertise and knowledge needed to formulate better design decisions, and private landowners receive funding and enhanced agricultural production of their lands while still providing vital wildlife habitat.

The projective site designs developed in this report represent just two strategies for addressing habitat degradation resulting from energy corridors and installations. Many ecosystems across the globe have seen the negative impacts of energy corridors and installations, and many more could see these impacts with future energy infrastructure projects. By creating design guidelines and conservation policies for responsible energy corridor installation design and conservation, ecosystems already damaged by energy infrastructure have the potential to be transformed into vital wildlife habitat, while future energy infrastructure development can become better integrated with sensitive natural systems.

Though the design guidelines and policies presented within this report are intended for energy infrastructure corridors and installations, the potential applications of these guidelines do not end within the energy production industry. Intended to act as a scalable and adaptable framework, these guidelines and policies could eventually be adapted to accommodate the worldwide transportation industry. Corridors in the form of interstate and state highways, railroads, canal channels, and light-rail systems cross sensitive wildlife habitat across the globe, and many of the same design and conservation strategies could be applied in these instances. Other potential guideline and policy applications include small-scale directional boring (common in the utilities installation industry), post-disturbance riparian corridor restoration, and even stream channel restoration.

CHALLENGES & FUTURE RESEARCH

Establishing NGOs or public/private partnerships is no easy task. The process of studying environmental impacts of energy corridors and installations while forming and maintaining a positive relationship with energy professionals proved to be challenging. The best solution toward establishing a mutually beneficial relationship between these entities is the act of networking. Networking serves to create a line of trust between energy corporations, design professionals, and private landowners. By stressing that the intentions of energy infrastructure conservation and design guidelines are aimed at helping energy corporations distribute their products in an efficient, profitable, and ecologically responsible manner, the likelihood of these corporations actively engaging the partnership is much greater. In addition, the inclusion of Geographic Information Systems (GIS) professionals for energy infrastructure mapping and geospatial analysis should be a priority. These professionals can play a vital role in assisting design professionals identify suitable locations for proposed energy infrastructure projects.

Great effort was taken to ensure that the design guidelines and policies in this report were drafted in such a way that their application was adaptable to different parts of the country. However, several of the guidelines and policies presented within, specifically those guidelines concerned with above and below-grade wildlife crossings, are currently applicable only within certain geographic regions of the western United States. While these guidelines serve as excellent design strategies within those specific regions, their applicability is reduced outside those regions. Because of this, it is encouraged that the design guidelines and policies within this report be further explored and expanded upon, particularly by those in the design and engineering fields. By combining the guidelines and policies suggested here with future design guideline and policy contributions targeted at other species of concern, the future of energy corridors and installations can become far more sustainable.

Finally, it is suggested that, supplemental to the general design guidelines and projective site designs presented within this report, additional research be conducted on wind energy noise intrusion into wildlife habitats. The studies conducted by Warrington et al. (2017), and Khalil (2019) are excellent starting points, though it would be beneficial for more research and literature to be developed on this topic. Studies such as those conducted by Winder et al. (2015) and Sullins (2017) have identified potential solutions to mitigate the habitat damages associated with noise intrusion, primarily through the introduction of habitat utilizing the Conservation Reserve Program and other conservation easement programs. Additional research and studies involving Agricultural Economics professionals toward creating a cost/benefit analysis on cropland to CRP conversion is strongly encouraged.

Lastly, and most importantly, future efforts should be made toward developing sub-committees supplementing the design guideline and policy contributions made by the theoretical public/private partnership established within this report. These committees should employ design professionals such as landscape architects, civil and bioagricultural engineers, private landowners, conservationists, ecologists, and representatives of energy corporations to actively monitor and maintain energy corridors and installations.

Because conservation-based NGOs and P3s already exist throughout the United States (i.e. Lesser Prairie Chicken Initiative, Sage Grouse Initiative, Wyoming Migration Initiative), precedents have already been set for the provision of funds for this theoretical private partnership and its associated sub-committees. Funding for these sub-committees could be acquired through a variety of sources, from the application of the Federal Farm Bill, to private contributions by energy corporations in exchange for incentives including federal conservation credits or participation in the Fish & Wildlife Service's Recovery Credit System.

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APPENDICES

APPENDIX "A"

PRELIMINARY ENERGY CORRIDOR & INSTALLATION DESIGN GUIDELINE CATEGORIES

PERMEABILITY	SITING	CORRIDOR MAINTENANCE	HABITAT CREATION
CROSSING POINTS (BREAKS IN INFRASTRUCTURE)	PROXIMITY TO STREAMS & RIPARIAN ZONES	MOWING & CHEMICAL USAGE	CORRIDOR WIDTH
	TOPOGRAPHIC CONSIDERATIONS	IN-CORRIDOR GRAZING STRATEGIES	VEGETATIVE COMPOSITION
	VEGETATIVE COMPOSITION OF PROPOSED SITE		

TABLE 6.01
PRELIMINARY ENERGY CORRIDOR AND INSTALLATION DESIGN GUIDELINE CATEGORIES (BAKER 2019)

EXISTING ENERGY CORRIDOR & INSTALLATION DESIGN GUIDELINES

DISPERSAL & GENE FLOW	HABITAT CREATION
1A. INSTALL 'WILDLIFE MARKERS' ON ALL BARRIERS TO WILDLIFE MIGRATION. THIS CAN INCLUDE FENCES, PIPELINES, OR ANY OTHER NON-PERMEABLE BARRIER. RESEARCH INDICATES THAT FOR SOME AVIAN SPECIES, AVERAGE COLLISION RATES CAN BE AS HIGH AS 1.2 STRIKES PER MILE OF FENCE OR OTHER BARRIER EACH BREEDING SEASON (STEVENS 2011).	2A. DEVELOP SEASONAL SEEDING PROGRAMS FOR THE ESTABLISHMENT OF NATIVE, LOW MAINTENANCE PLANT SPECIES. THESE PLANT SPECIES SHOULD INCLUDE VARIETIES THAT PROVIDE FOOD AND FORAGE FOR AVIAN AND TERRESTRIAL WILDLIFE. RESEARCH SHOWS THAT MULE DEER SPEND UP TO 95% OF THEIR MIGRATION PERIOD IN 'STOPOVERS', OR HABITATS RICH IN FORAGE AND SHELTER (SAWYER ET AL. 2012).
1B. INSTALL GAME-PROOF FENCING IN AREAS WHERE DANGEROUS INFRASTRUCTURE HAS A HIGH PROBABILITY OF INJURING WILDLIFE. THESE AREAS CAN INCLUDE EXPOSED PIPELINES, HIGH-VOLTAGE ELECTRICAL CONVERTER AND TRANSMISSION SUBSTATIONS, NATURAL GAS COMPRESSOR STATIONS, AND OTHER SUPPORTING ENERGY INFRASTRUCTURE (SAWYER, ROGERS, & HART 2016).	2B. CONSIDER IMPLEMENTING VEGETATIVE PLANTING PALETTES THAT VARY IN SUCCESSIONAL STAGES. ESTABLISH SEEDING PROGRAMS AND SCHEDULES THAT ALLOW FOR AGGRESSIVE RIPARIAN VEGETATION GROWTH IMMEDIATELY POST-DISTURBANCE, SHRUB AND UNDERSTORY GROWTH AS INTERMEDIATE SUCCESSIONAL STAGES, AND STRONG END STAGE TREE CANOPY GROWTH AND DEVELOPMENT (ADAPTED FROM FORMAN & GODRON 1986, NRCS 2004, & DRAMSTAD ET AL. 1996). THIS ENSURES CORRIDOR ECOSYSTEMS HAVE THE BEST CHANCE OF MAINTAINING A 'STABLE STATE' (WITH 2019).
	2C. WHERE WIDENED SEGMENTS OF ENERGY CORRIDORS EXIST, CONSIDER IMPLEMENTING AN INFILL COMMUNITY OF NATIVE PLANTINGS WITH VARYING SUCCESSIONAL STAGES (SEE ABOVE HABITAT CREATION GUIDELINES). WIDENED CORRIDOR SEGMENTS MAY EXIST IN AREAS WHERE CONSTRUCTION ACTIVITY REQUIRED STORAGE SPACE FOR MATERIALS, ADJACENT TO COMPRESSOR STATIONS OR TRANSMISSION SUBSTATIONS, OR AREAS IN WHICH TEMPORARY ACCESS ROADS WERE CONSTRUCTED TO SUPPORT CONSTRUCTION ACTIVITY AND SUBSEQUENTLY REMOVED (ADAPTED FROM YUAN, SUSEMIHL & BROWN 2019).
	2D. STRIVE TO VARY CORRIDOR WIDTH ALONG SEGMENTS OF ENERGY INFRASTRUCTURE. SUITABLE LOCATIONS FOR WIDENED CORRIDOR SEGMENTS MAY EXIST IN NATURAL CLEARINGS WHERE LIMITED WOODLAND GROWTH OCCURS, WHILE AREAS OF DENSE WOODLAND VEGETATION MAY BE SUITABLE FOR NARROWER SECTIONS OF CORRIDOR. WIDENED AREAS CAN SERVE AS 'NODES' OR 'STOPOVER POINTS' WITH INCREASED WILDLIFE HABITAT, WHILE NARROW SEGMENTS SERVE AS LINKAGES OR CONNECTORS BETWEEN THESE NODES (ADAPTED FROM FORMAN & GODRON 1986, SAWYER, ROGERS & HART 2016).

Table 6.02
Existing Energy
Corridor & Installation
Conservation Policies
(Baker 2020)

HABITAT PRESERVATION	CORRIDOR MAINTENANCE STRATEGIES
3A. REMOVE INVASIVE HERBACEOUS PLANT SPECIES USING NON-HERBICIDAL METHODS. THIS CAN INCLUDE PHYSICAL REMOVAL OF THE PLANT SPECIES BY DIGGING, CONTROLLED FIRE REGIMES, ETC (ADAPTED FROM SGI 2019, U.S FISH & WILDLIFE SERVICE 2013). IN CERTAIN APPLICATIONS, GRAZING UNGULATES SUCH AS GOATS OR SHEEP COULD BE EMPLOYED AS A SUSTAINABLE STRATEGY IN THE PREVENTION OF INVASIVE PLANT GROWTH CONTROL. GOATS ARE ESPECIALLY SUITED, AS OVER 60% OF THEIR DIET IS SOURCED FROM BRUSH, WOODY PERENNIALS, AND BROADLEAF PLANT SOURCES (LUGINBUHL ET AL. 2015)	4A. REFRAIN FROM UTILIZING HARSH SYNTHETIC PESTICIDES FOR WEED PREVENTION OR CONTROL. WHERE NOT PRACTICAL, UTILIZE THE MINIMUM REQUIRED AMOUNTS OF PESTICIDES TO ACHIEVE ACCEPTABLE LEVELS OF PREVENTION OR CONTROL. ALTERNATIVE METHODS OF WEED PREVENTION AND CONTROL ARE STRONGLY RECOMMENDED (SEE HABITAT PRESERVATION AND CORRIDOR MAINTENANCE STRATEGIES SECTIONS OF THIS TABLE).
3B. CREATE AND IMPLEMENT WOODLAND MANAGEMENT SYSTEMS THAT TARGET THE REMOVAL OF INVASIVE WOODY SPECIES, SPECIFICALLY INVASIVE CONIFERS SUCH AS EASTERN RED CEDAR IN EASTERN PORTIONS OF TEXAS, OKLAHOMA AND KANSAS (SGI 2019), AND THE ROCKY MOUNTAIN JUNIPER IN WESTERN REGIONS.	4B. WHERE APPLICABLE, PROMOTE THE USE OF IN-CORRIDOR GRAZING STRATEGIES. ENCOURAGE GRAZING BY NATIVE UNGULATE SPECIES OR COLLABORATE WITH LAND AND LIVESTOCK OWNERS TO DEVELOP ROTATIONAL GRAZING STRATEGIES FOR ENERGY CORRIDORS THAT PASS THROUGH PRIVATELY-OWNED GRAZING LANDS (ADAPTED FROM SGI 2019 & KUIPERS 2004).
3C. CREATE VEGETATION BUFFERS ADJACENT TO NOISY ENERGY INFRASTRUCTURE EQUIPMENT SUCH AS NATURAL GAS COMPRESSOR STATIONS AND HIGH-VOLTAGE ELECTRICAL CONVERTER AND TRANSMISSION SUB-STATIONS. THESE BUFFERS CAN REDUCE EXCESSIVE NOISE INTRUSION INTO ADJACENT WILDLIFE HABITATS, LIMITING EXTERNAL STRESSORS PLACED UPON WILDLIFE SPECIES (WARRINGTON ET AL. 2017, KHALIL 2019).	4C. WHERE IN-CORRIDOR GRAZING STRATEGIES ARE NOT FEASIBLE, LIMIT CLEAR CUTTING AND MOWING OPERATIONS TO THE MINIMUM EXTENT POSSIBLE TO REDUCE EROSION POTENTIAL AND HABITAT DISTURBANCE DUE TO EXCESSIVE NOISE LEVELS.
3D. WHEREVER POSSIBLE, STRIVE TO DESIGN POINTS WHERE ENERGY INFRASTRUCTURE CROSSES RIVER OR STREAM CHANNELS AT 90 DEGREES TO THE STREAM CHANNEL CENTERLINE. THIS SERVES TO MINIMIZE STREAMBANK COMPACTION, REDUCE STREAMBANK EROSION, AND REDUCE THE REMOVAL OF RIPARIAN VEGETATION (ADAPTED FROM ROSGEN 2006 & KEANE 2019B).	4D. WHERE POSSIBLE, PARTICULARLY IN AREAS DEVOID OF SENSITIVE INFRASTRUCTURE, CONSIDER UTILIZING CONTROLLED BURNS AS A MEANS FOR INVASIVE SPECIES CONTROL, ESPECIALLY WITHIN GRASSLAND AND PRAIRIE AREAS.

PROPOSED ENERGY CORRIDOR & INSTALLATION DESIGN GUIDELINES

DISPERSAL & GENE FLOW	HABITAT CREATION
1A. ENCOURAGE ENERGY CORRIDOR DESIGNERS TO IMPLEMENT WILDLIFE CROSSING POINTS (PENETRATIONS IN ENERGY INFRASTRUCTURE) PERPENDICULAR TO ABOVE-GRADE ENERGY INFRASTRUCTURE AT SPACING INTERVALS VARYING FROM ONE WILDLIFE CROSSING POINT PER 0.9 MI [1.5 KM] TO ONE CROSSING POINT PER 3.8 MILES [6.0 KM] (ADAPTED FROM FEDERAL HIGHWAY ADMINISTRATION, N.D.).	2A. DEVELOP NATIVE PLANT COMMUNITIES THAT GROW IN A CONTROLLED MANNER, REQUIRE LITTLE TO NO CHEMICAL OR PESTICIDE USE, AND SERVE AS HIGH-QUALITY FOOD SOURCES FOR TERRESTRIAL AND AVIAN WILDLIFE SPECIES (ADAPTED FROM SGI 2019 & LPCI-NRCS 2010).
1B. INSTALL GAME-PROOF FENCING IN AREAS WHERE DANGEROUS INFRASTRUCTURE HAS A HIGH PROBABILITY OF INJURING WILDLIFE. THESE AREAS CAN INCLUDE EXPOSED PIPELINES, ELECTRICAL CONVERTER AND TRANSMISSION STATIONS, NATURAL GAS COMPRESSOR STATIONS, AND OTHER SUPPORTING ENERGY INFRASTRUCTURE (SAWYER, ROGERS, & HART 2016).	2B. CONSIDER IMPLEMENTING VEGETATIVE SPECIES THAT VARY IN THEIR SUCCESSIONAL STAGES. ESTABLISH SEEDING PROGRAMS AND SCHEDULES THAT ALLOW FOR AGGRESSIVE RIPARIAN VEGETATION GROWTH IMMEDIATELY POST-DISTURBANCE, SHRUB AND UNDERSTORY GROWTH AS INTERMEDIATE SUCCESSIONAL STAGES, AND STRONG END STAGE TREE CANOPY GROWTH AND DEVELOPMENT (ADAPTED FROM FORMAN & GODRON 1986, NRCS 2004, & DRAMSTAD ET AL. 1996).
1C. PROVIDE A MIXTURE OF OVERPASS AND UNDERPASS TYPE WILDLIFE CROSSINGS AT INTERVALS OF NO MORE THAN 5-8 MILES (8-12KM) ALONG IMPERMEABLE ENERGY INFRASTRUCTURE BOUNDARIES. PRONGHORN TYPICALLY PREFER OVERPASS CROSSINGS TO UNDERPASS TYPE CROSSINGS (SAWYER, ROGERS & HART 2016).	2C. WHERE ENERGY CORRIDORS ARE INTENTIONALLY WIDENED TO REDUCE EDGE EFFECTS, THE RESULTING INCREASED HABITAT SPACE SHOULD BE INFILLED WITH NATIVE PLANT COMMUNITIES CONSISTING OF SPECIES WITH VARYING SUCCESSIONAL STAGES [SEE ABOVE HABITAT CREATION GUIDELINES] (ADAPTED FROM FORMAN & GODRON 1986).
2D. STRIVE TO VARY CORRIDOR WIDTH ALONG SEGMENTS OF ENERGY INFRASTRUCTURE. SUITABLE LOCATIONS FOR WIDENED CORRIDOR SEGMENTS MAY EXIST IN NATURAL CLEARINGS WHERE LIMITED WOODLAND GROWTH OCCURS, WHILE AREAS OF DENSE WOODLAND VEGETATION MAY BE SUITABLE FOR NARROWER SECTIONS OF CORRIDOR. WIDENED AREAS CAN SERVE AS ‘NODES’ OR ‘STOPOVER POINTS’ WITH INCREASED WILDLIFE HABITAT, WHILE NARROW SEGMENTS SERVE AS LINKAGES OR CONNECTORS BETWEEN THESE NODES (ADAPTED FROM FORMAN & GODRON 1986, SAWYER, ROGERS & HART 2016).	2D. STRIVE TO VARY CORRIDOR WIDTH ALONG SEGMENTS OF ENERGY INFRASTRUCTURE. SUITABLE LOCATIONS FOR WIDENED CORRIDOR SEGMENTS MAY EXIST IN NATURAL CLEARINGS WHERE LIMITED WOODLAND GROWTH OCCURS, WHILE AREAS OF DENSE WOODLAND VEGETATION MAY BE SUITABLE FOR NARROWER SECTIONS OF CORRIDOR. WIDENED AREAS CAN SERVE AS ‘NODES’ OR ‘STOPOVER POINTS’ WITH INCREASED WILDLIFE HABITAT, WHILE NARROW SEGMENTS SERVE AS LINKAGES OR CONNECTORS BETWEEN THESE NODES (ADAPTED FROM FORMAN & GODRON 1986, SAWYER, ROGERS & HART 2016).
1E. ANALYZE DOMINANT TOPOGRAPHIC FEATURES WHEN DETERMINING WILDLIFE CROSSING PLACEMENT. RIDGELINES AND PLATEAUS OFFER SUITABLE LOCATIONS FOR UNDERPASS STRUCTURES, WHILE VALLEYS AND DEPRESSIONS TEND TO PROVIDE MORE SUITABLE AND ECONOMICAL LOCATIONS FOR THE INSTALLATION OF OVERPASS-TYPE STRUCTURES (ADAPTED FROM CLEVENGER & HUISJER 2011).	

Table 6.03
Proposed energy
corridor & installation
conservation policies
(baker 2020)

HABITAT PRESERVATION	CORRIDOR MAINTENANCE STRATEGIES
3A. PROVIDE VARIED VERTICAL VEGETATION STRUCTURE WITHIN ENERGY INFRASTRUCTURE CORRIDORS. FOR EXAMPLE, PROVIDE MEDIUM HEIGHT SHRUBS AND GRASSES AS A TRANSITIONAL HABITAT BETWEEN LOW VEGETATION ADJACENT TO ENERGY INFRASTRUCTURE AND TALLER TREE CANOPY HABITAT OF SURROUNDING WOODLANDS. THIS STRATEGY ENSURES THE PRESERVATION OF ECOTONE OR EDGE HABITATS COMMONLY OCCUPIED BY MANY AVIAN SPECIES (DRAMSTAD ET AL. 1996 & FORMAN & GODRON 1986).	4A. WHERE APPLICABLE, PROMOTE THE USE OF IN-CORRIDOR GRAZING STRATEGIES. ENCOURAGE GRAZING BY NATIVE UNGULATE SPECIES OR COLLABORATE WITH LAND AND LIVESTOCK OWNERS TO DEVELOP GRAZING STRATEGIES FOR ENERGY CORRIDORS THAT PASS THROUGH PRIVATELY-OWNED GRAZING LANDS (ADAPTED FROM SGI 2019 & LPCI-NRCS 2010).
3B. CREATE VEGETATION BUFFERS ADJACENT TO NOISY ENERGY INFRASTRUCTURE EQUIPMENT SUCH AS NATURAL GAS COMPRESSOR STATIONS AND HIGH-VOLTAGE ELECTRICAL CONVERTER AND TRANSMISSION SUB-STATIONS. THESE BUFFERS CAN REDUCE EXCESSIVE NOISE INTRUSION INTO ADJACENT WILDLIFE HABITATS, LIMITING EXTERNAL STRESSORS PLACED UPON WILDLIFE SPECIES (WARRINGTON ET AL. 2017, KHALIL 2019).	4B. REDUCE WIDTH OF ENERGY INFRASTRUCTURE [PHYSICAL PIPELINES, TRANSMISSION LINES, AND ACCESS ROADS] WITHIN CORRIDORS TO THE MINIMUM REQUIRED WIDTH FOR DAILY OPERATIONS AND REQUIRED MAINTENANCE PRACTICES (BLM N.D.).
3C. STRIVE TO VARY THE WIDTH OF PROPOSED ENERGY CORRIDORS WHEREVER POSSIBLE. WIDER CORRIDORS ARE LESS PRONE TO DAMAGING EDGE EFFECTS DUE TO EXTERNAL FACTORS SUCH AS ARTIFICIAL LIGHTING, CHEMICAL POLLUTION, PREDATION, INVASIVE SPECIES, AND OTHER DISTURBANCES (BEIER 2018, FORMAN & GODRON 1986).	4C. WHERE POSSIBLE, PARTICULARLY IN AREAS DEVOID OF SENSITIVE INFRASTRUCTURE, CONSIDER UTILIZING CONTROLLED BURNS AS A MEANS FOR INVASIVE SPECIES CONTROL, ESPECIALLY WITHIN GRASSLAND AND PRAIRIE AREAS.
3D. WHERE INTERSECTIONS BETWEEN ENERGY CORRIDORS AND OTHER INFRASTRUCTURE OCCUR [PRIMARILY ROADWAYS AND RAILWAYS], LIMIT THE WIDTH OF THESE BOTTLENECKS TO NO MORE THAN 10% OF TOTAL CORRIDOR LENGTH (BEIER 2018).	
3E. WHEREVER POSSIBLE, STRIVE TO DESIGN POINTS WHERE ENERGY INFRASTRUCTURE CROSSES RIVER OR STREAM CHANNELS AT 90 DEGREES TO THE STREAM CHANNEL CENTERLINE AT A RIFFLE OR CROSSOVER (NOT ON A BEND). THIS SERVES TO MINIMIZE STREAMBANK COMPACTION, REDUCE STREAMBANK EROSION, AND REDUCE THE REMOVAL OF RIPARIAN VEGETATION (ADAPTED FROM ROSGEN 2006 & KEANE 2019B).	

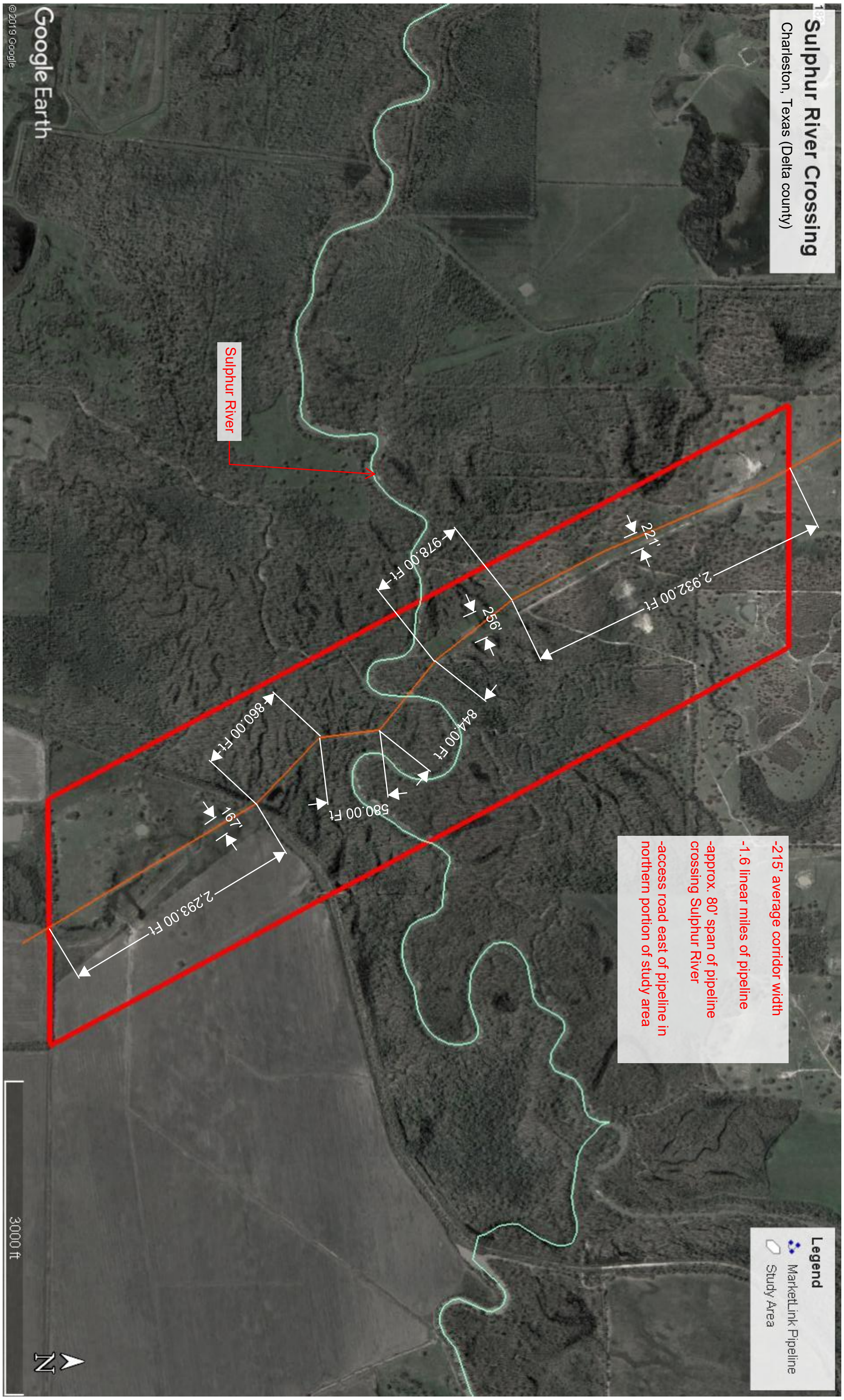
ENERGY CORRIDOR & INSTALLATION CONSERVATION MANAGEMENT & PLANNING GUIDELINES

INFRASTRUCTURE PLACEMENT & SITING	HABITAT CREATION
1A. CONSIDER TOPOGRAPHIC CHALLENGES AND REROUTE PROPOSED ENERGY INFRASTRUCTURE IF POSSIBLE, TO REDUCE THE NEED FOR ADDITIONAL INFRASTRUCTURE SUCH AS SUPPLEMENTAL PUMP STATIONS, ETC. (BLM N.D.).	2A. CONSIDER GATHERING DESIGN PROFESSIONALS AND LANDSCAPE ECOLOGISTS TO CONDUCT RESEARCH ON INNOVATIVE APPROACHES TO INCORPORATE WILDLIFE HABITAT WITHIN ENERGY INFRASTRUCTURE CORRIDORS. SECTION 368 OF THE 2005 ENERGY POLICY ACT ATTEMPTS TO ADDRESS ENERGY CORRIDOR HABITAT CREATION, THOUGH CURRENT LITERATURE LACKS IN-DEPTH STUDY, AND CURRENT CORRIDOR PLANNING POLICIES ARE LIMITED IN SCOPE.
1B. STRIVE TO PERFORM ENVIRONMENTAL IMPACT STATEMENTS (EIS) PRIOR TO BEGINNING ENERGY CORRIDOR DESIGN, REGARDLESS OF STATE OR FEDERAL EIS REQUIREMENTS. THESE EIS WILL IDENTIFY PHYSICAL AND ECOLOGICAL CHALLENGES ASSOCIATED WITH PROPOSED ENERGY CORRIDOR LOCATIONS, POTENTIALLY SAVING ENERGY CORPORATIONS MONEY AND PREVENTING UNNECESSARY ECOLOGICAL DAMAGES (WEST-WIDE ENERGY CORRIDOR INFORMATION CENTER N.D.).	2B. CONSIDER OFFERING PRIVATE LANDOWNERS INCENTIVE TO CONVERT AGRICULTURAL AND GRAZING LANDS TO GRASSLAND OR OTHER HABITAT SUITABLE FOR WILDLIFE. THE NRCS CONSERVATION RESERVE PROGRAM (CRP) AND WORKING LANDS FOR WILDLIFE (WLFW) PROGRAM ARE NOTABLE EXAMPLES OF SUCCESSFUL LAND-USE CONVERSIONS WITH THE COMMON GOAL OF ENHANCING WILDLIFE HABITAT ON WORKING LANDSCAPES (NRCS 2018). BOTH PROGRAMS, ALONG WITH MANY CONSERVATION-BASED NGOS, UTILIZE THE FEDERAL FARM BILL AS FUNDING FOR THESE INCENTIVES (NRCS-LPCI 2010, SGI 2019, WLF 2018).
1C. WHERE POSSIBLE, PLACE SUPPORTING ACCESS ROADS PARALLEL AND ADJACENT TO PROPOSED ENERGY INFRASTRUCTURE. THIS SERVES TO REDUCE LANDSCAPE FRAGMENTATION AND REDUCES THE AMOUNT OF REQUIRED WILDLIFE CROSSINGS BY SPANNING BOTH INFRASTRUCTURE AND ACCESS ROADS WITH ONE CROSSING STRUCTURE (BLM N.D.).	
1D. UTILIZE TELEMETRY STUDIES WHEN EXAMINING WILDLIFE MIGRATION AND MOVEMENT ROUTES. THESE STUDIES SERVE TO IDENTIFY THE MOST SUITABLE LOCATIONS FOR WILDLIFE CROSSINGS, WHETHER OVERPASS, UNDERPASS, OR PENETRATION-TYPE CROSSINGS (ADAPTED FROM SAWYER, ROGERS, & HART 2016).	

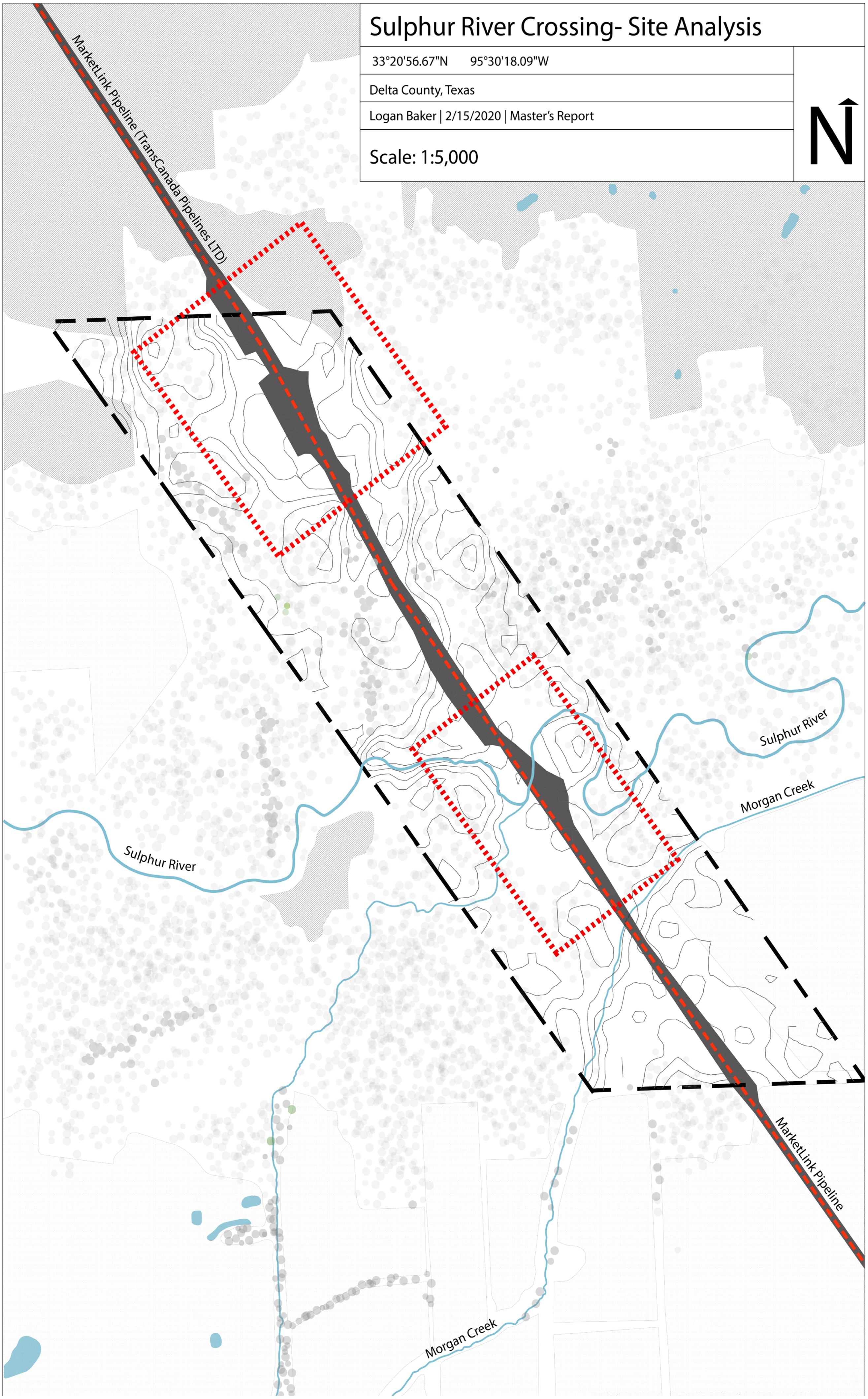
Table 6.04
ENERGY CORRIDOR &
INSTALLATION CONSERVATION
MANAGEMENT & PLANNING
GUIDELINES (BAKER 2020)

HABITAT PRESERVATION	EDUCATION & TRAINING
3A. ENCOURAGE THE CORPORATIONS OR ENTITIES WHO OWN PROPOSED ENERGY INFRASTRUCTURE TO DEVELOP A CONSERVATION PLANNING COMMITTEE. THIS COMMITTEE SHOULD INCLUDE DESIGN PROFESSIONALS SUCH AS LANDSCAPE ARCHITECTS, PLANNERS, AND ENGINEERS. THE GOAL OF THIS COMMITTEE SHOULD BE TO CREATE NEW ENERGY CORRIDOR PROPOSALS THAT UTILIZE SENSITIVE ECOLOGICAL HABITATS RESPONSIBLY AND SENSITIVELY (ADAPTED FROM SGI 2019 & LPCI-NRCS 2010).	4A. ALL INDIVIDUALS ENGAGED IN THE PLANNING, DESIGN, MAINTENANCE, OR OPERATIONS OF ENERGY INFRASTRUCTURE CORRIDORS SHOULD COMPLETE PROPER EDUCATIONAL AND TRAINING PROGRAMS PRIOR TO BEGINNING WORK. IT IS ENCOURAGED THAT THESE INDIVIDUALS COMPLETE CONTINUING EDUCATION AND TRAINING PROGRAMS ON AN ANNUAL BASIS (U.S. DEPARTMENT OF ENERGY, N.D.).
3B. CONDUCT ANNUAL REVIEWS ON EXISTING ENERGY CORRIDORS BY UTILIZING THE BUREAU OF LAND MANAGEMENT AND U.S. DEPARTMENT OF ENERGY'S REGIONAL REVIEW PROCESS. WHILE REGIONAL REVIEWS ARE NOT YET COMMON PRACTICE IN MIDWESTERN STATES, THEIR USE CAN IDENTIFY ENVIRONMENTAL CONCERNS WITHIN EXISTING ENERGY CORRIDORS (WEST-WIDE ENERGY CORRIDOR INFORMATION CENTER N.D., BLM N.D.).	

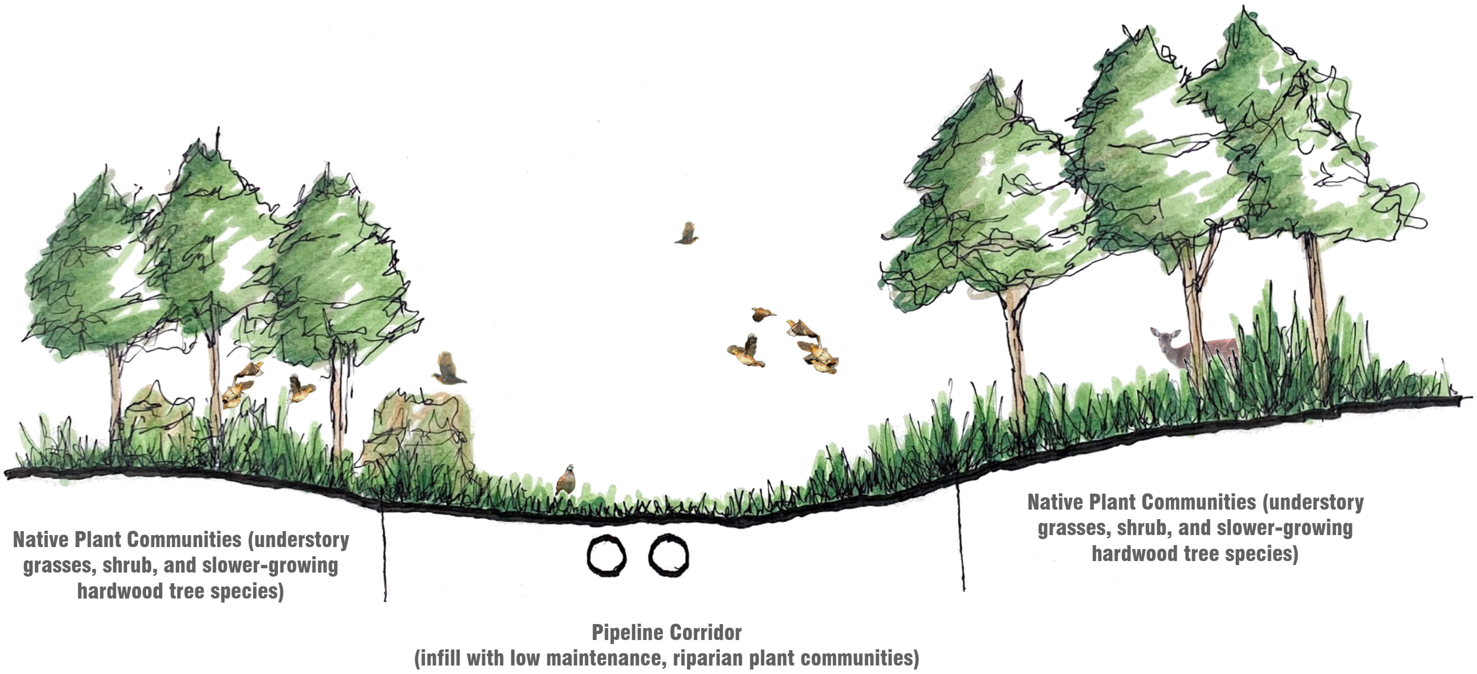
APPENDIX "B"



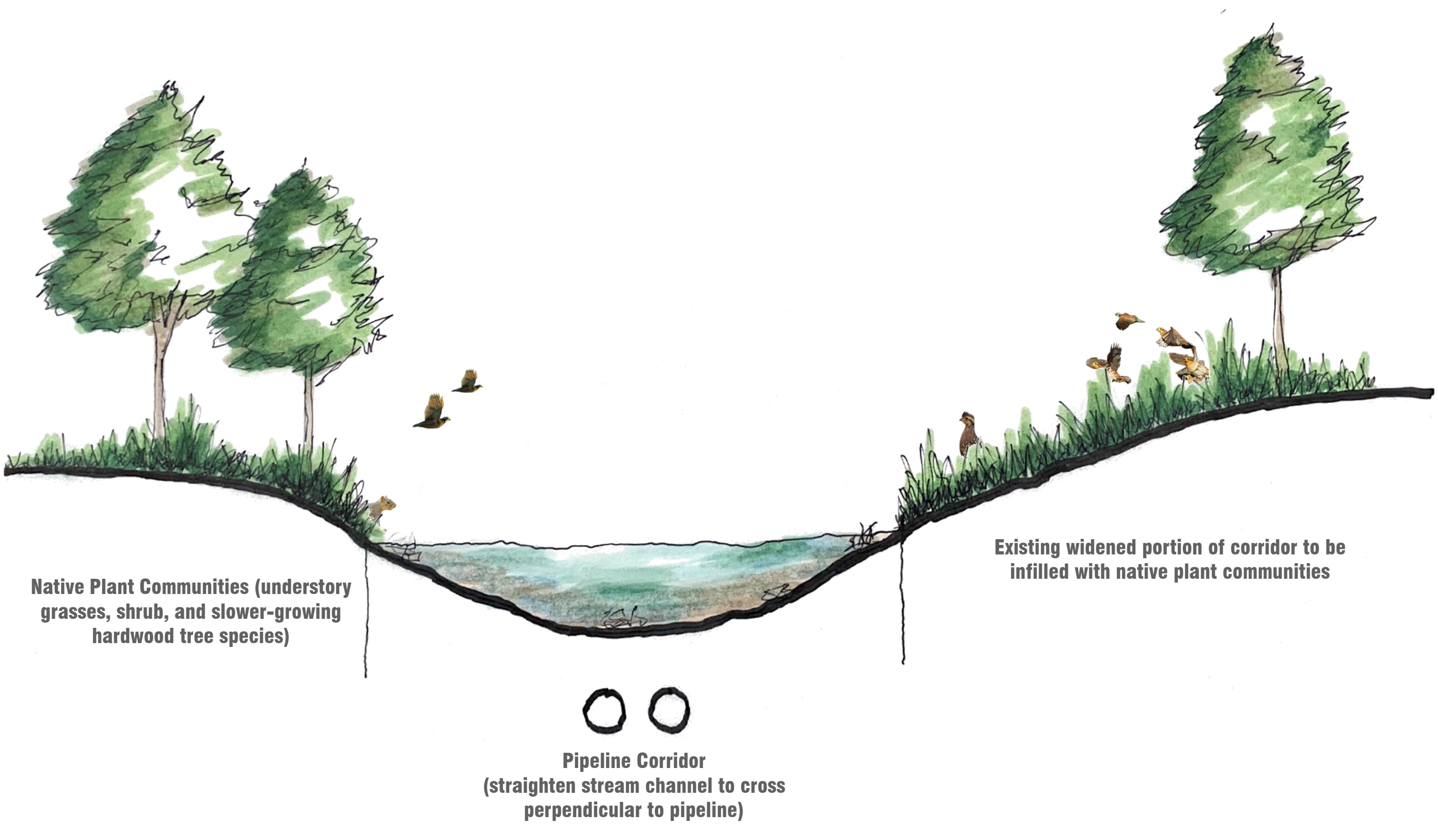
Sulphur River Crossing
Charleston, Texas (Delta county)
Sulphur River
-215' average corridor width
-1.6 linear miles of pipeline
-approx. 80' span of pipeline crossing Sulphur River
-access road east of pipeline in northern portion of study area
2,932.00 Ft
221'
978.00 Ft
256'
844.00 Ft
860.00 Ft
580.00 Ft
167'
2,293.00 Ft
Legend
MarketLink Pipeline
Study Area
3000 ft
N
Google Earth
©2019 Google



Sulphur River Crossing- Site Analysis
33°20'56.67"N 95°30'18.09"W
Delta County, Texas
Logan Baker | 2/15/2020 | Master's Report
Scale: 1:5,000
N
MarketLink Pipeline (TransCanada Pipelines LTD)
Sulphur River
Morgan Creek
Sulphur River
Morgan Creek
MarketLink Pipeline

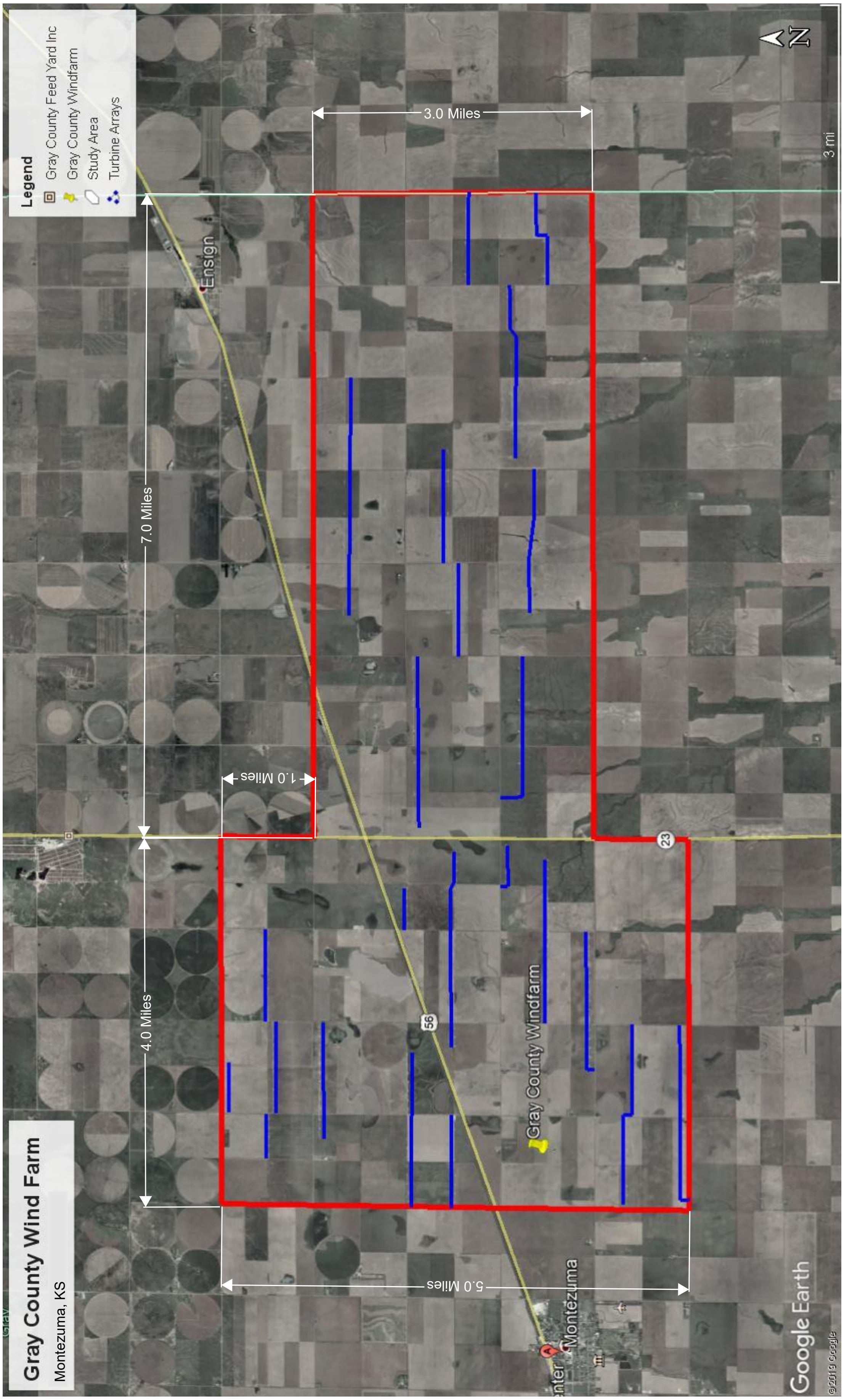


Native Plant Communities (understory grasses, shrub, and slower-growing hardwood tree species)
Native Plant Communities (understory grasses, shrub, and slower-growing hardwood tree species)
Pipeline Corridor
(infill with low maintenance, riparian plant communities)

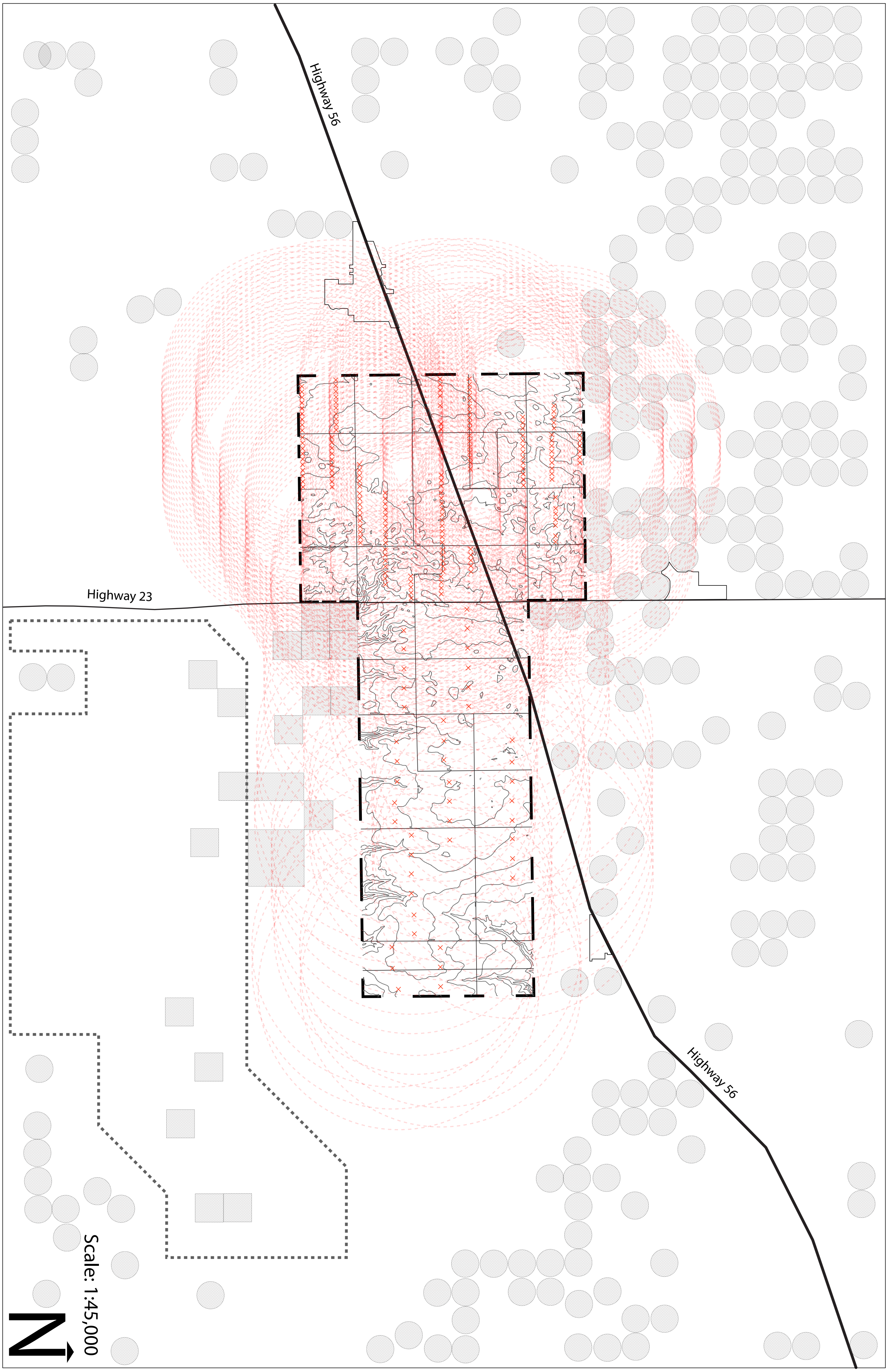


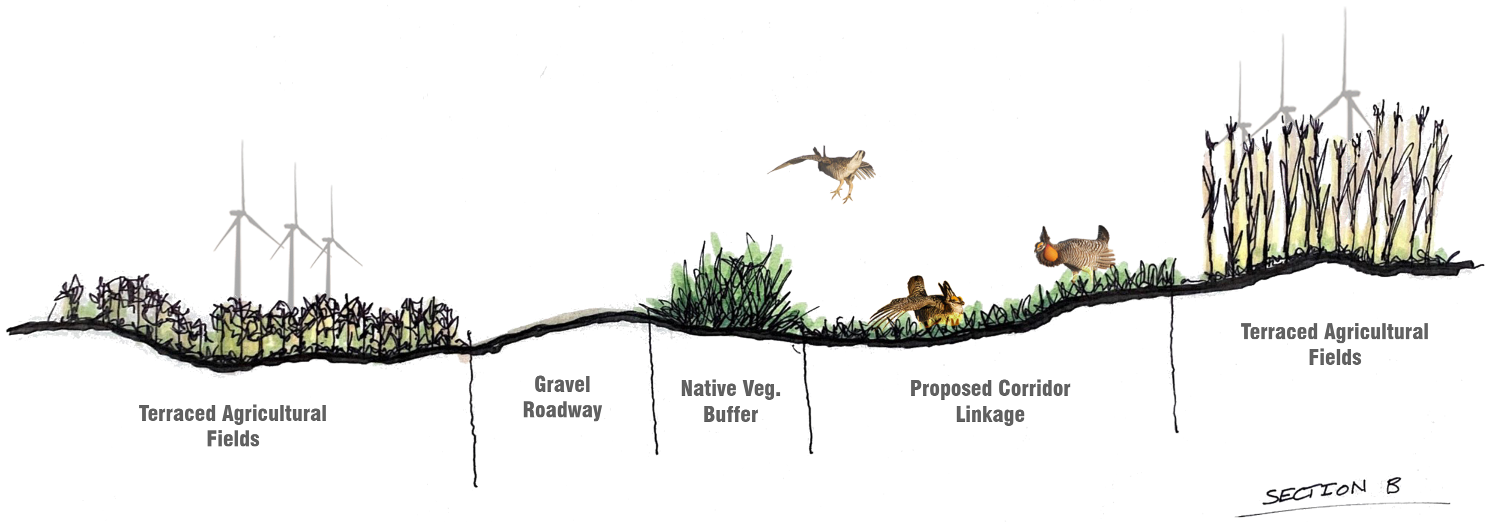
Native Plant Communities (understory grasses, shrub, and slower-growing hardwood tree species)
Existing widened portion of corridor to be infilled with native plant communities
Pipeline Corridor
(straighten stream channel to cross perpendicular to pipeline)

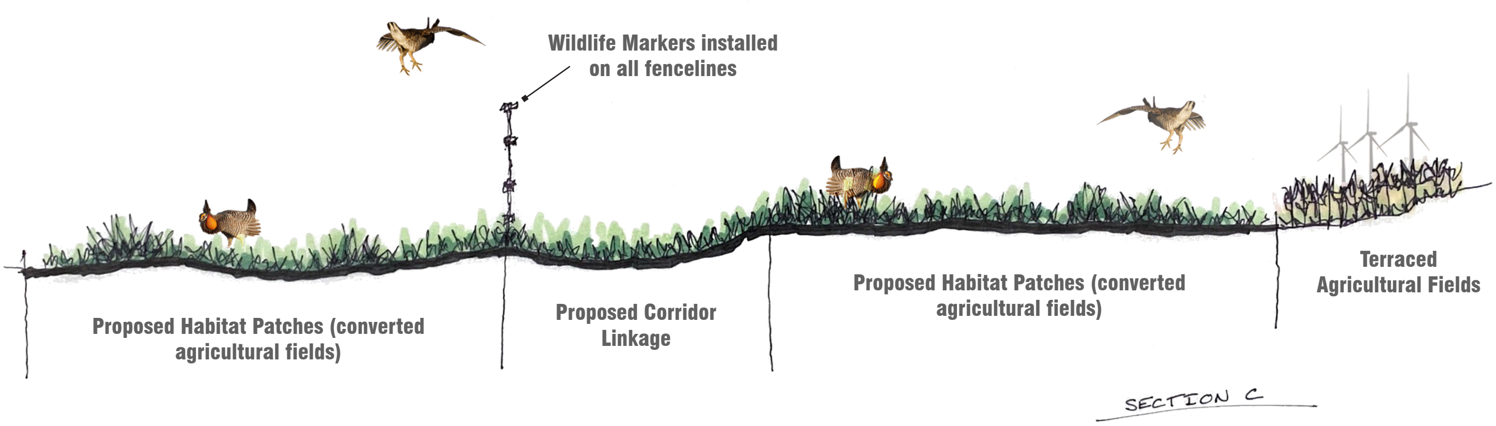

MarketLink Pipeline- Sulphur River Crossing
33°20'56.67"N 95°30'18.09"W
Delta County, Texas
Logan Baker | 2/15/2020 | Master's Report
Scale: 1:5,000
N
MarketLink Pipeline (TransCanada Pipelines LTD)
View A
View B
View C
Sulphur River
Sulphur River
Morgan Creek
Morgan Creek
MarketLink Pipeline

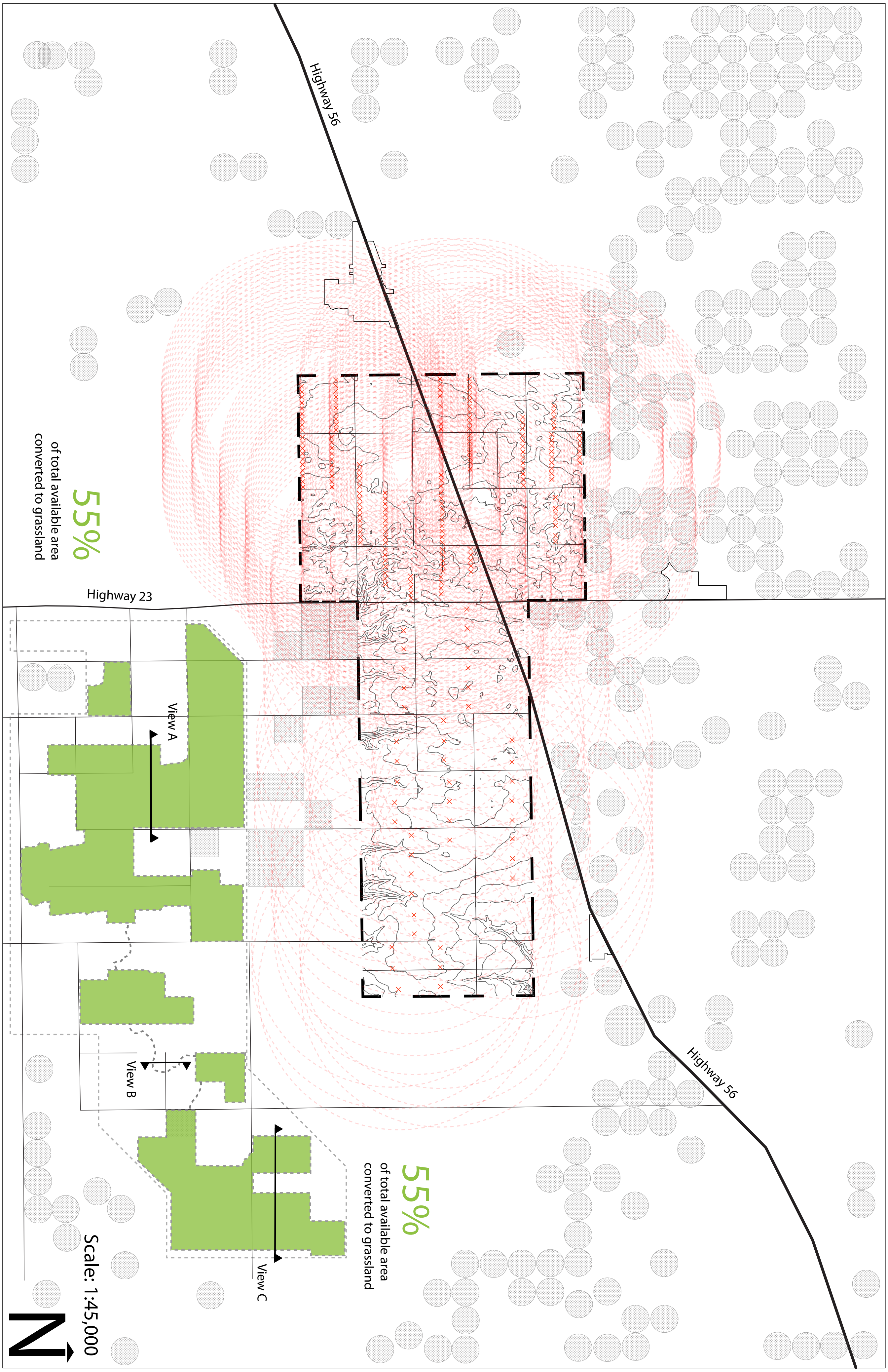


Gray County Wind Farm
Montezuma, KS
Legend
Gray County Feed Yard Inc
Gray County Windfarm
Study Area
Turbine Arrays
3.0 Miles
7.0 Miles
4.0 Miles
1.0 Miles
5.0 Miles
Ensign
Montezuma
Gray County Windfarm
56
23
N
3 mi
Google Earth
©2019 Google


Highway 56
Highway 23
Highway 56
Scale: 1:45,000
N


Terraced Agricultural Fields
Gravel Roadway
Native Veg. Buffer
Proposed Corridor Linkage
Terraced Agricultural Fields
SECTION B


Wildlife Markers installed on all fencelines
Proposed Habitat Patches (converted agricultural fields)
Proposed Corridor Linkage
Proposed Habitat Patches (converted agricultural fields)
Terraced Agricultural Fields
SECTION C



Highway 56
Highway 23
55%
of total available area
converted to grassland
View A
View B
View C
55%
of total available area
converted to grassland
Highway 56
Scale: 1:45,000
N