IMPLEMENTING ECOLOGICALLY-INSPIRED LANDSCAPE DESIGN RETROFITS WITHIN EXURBAN NEIGHBORHOODS

by

ALFONSO SANTIAGO LEYVA

A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture and Regional and

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Approved by:

Major Professor

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Abstract

Since the mid-1960s a paradigm shift in environmental values has been initiated in Europe, parts of the United States, and many other parts of the world, culminating in a focus on green infrastructure based development (Ahern et al., 2007b). During the 1980s and 1990s sustainability and landscape ecology began to be important aspects of landscape architecture education and practice (Swaffield, 2002; Ahern, 2005). The effort to create sustainable cities, neighborhoods, and sites is making a difference in urban areas, which is very important since global census data shows that a majority of the earth's population now lives in urban settlements (United Nations, 2014). Personal and cultural values reveal an environmental consciousness and strong interest in sustainability in many communities (Peiser & Hamilton, 2012). Nevertheless, many developments associated with landscape construction seem to implement few, if any, sustainable practices as new neighborhoods in many parts of the U.S. are developed.

This study develops a modified ecological approach and applies this outlook to an existing exurban neighborhood in Manhattan, Kansas. Quantitative and qualitative research includes: 1) a review of relevant literature and precedent studies; 2) a multi-tiered site analysis informed by landscape ecology principles; and 3) surveys of local homeowners regarding landscape maintenance practices and their willingness to install more ecologically appropriate landscapes. It is anticipated that sustainable design considerations for Lee Mill Heights and nearby areas will emerge to inform future neighborhood retrofits, helping move existing subdivisions towards more ecologically appropriate patterns and processes.

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Major Professor: Lee R. Skabelund
Supervisory Committee: Katie Kingery-Page and Gary Stith

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APDESIGN
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Photograph by Jonathan E Knight

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First and foremost I would like to thank my friends and family in helping me achieve this milestone in life. Dad—thanks for raising us right. Mom—thanks for being there later in life. Arturo—thanks for pushing me to always do better. Mario—I'm lucky to have you as a brother and miss the days we spent with our primos out on that field in southwest Kansas. I can't leave out my two little sisters, Yanessa and Idalis, I love you to the moon and back! I would also like to thank the Harden's and Weber's for putting up with me all these years; you're like family to me.

To all the faculty of LARCP; thanks for instilling in me the desire to make our living space a better place through the power of design. Howard—it was in your specialization studio that I realized, without a doubt, I was on the right path in my life. Stephanie—thank you for being there when I needed to confide in someone. Lee—environmental issues & ethics was eye opening for me and led me down a path of greater environmental consciousness. I would also like to thank you for continually aiding me as my major professor through this academic endeavor.

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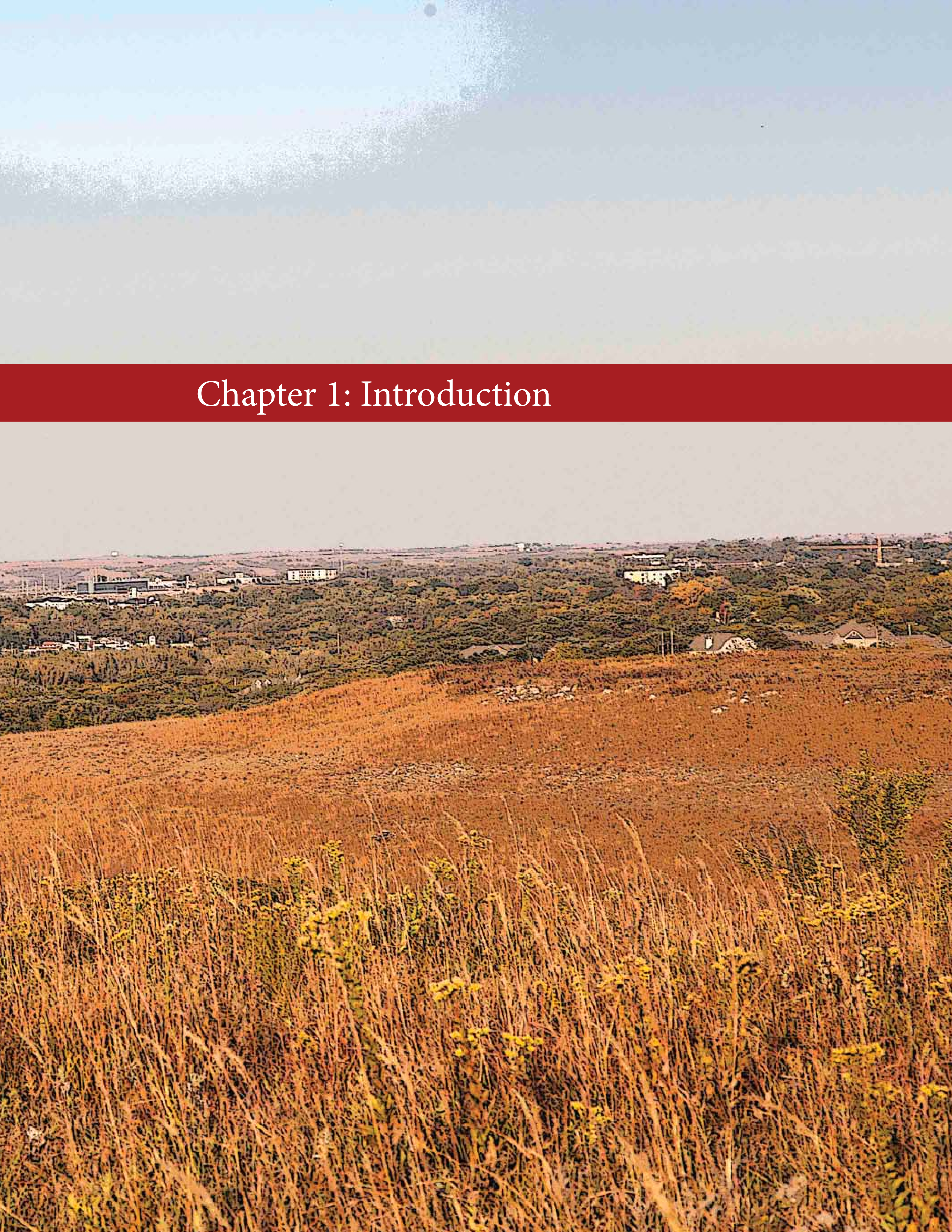
Chapter 1: Introduction



Introduction

Since the mid-1960s a paradigm shift in environmental values has been initiated in Europe, the United States, and many other parts of the world, culminating in a focus on green infrastructure based development (Thompson & Sorvig, 2000; Ahern et al., 2007b). During the 1980s and 1990s sustainability and landscape ecology began to be important parts of landscape architecture education and practice (Swaffield, 2002; Ahern, 2005). The effort to create sustainable cities, neighborhoods, and sites is making a difference in urban areas, and this is very important since global census data shows that a majority of the earth's population now lives in urban settlements (United Nations, 2014).

The United States is no exception to the trend of finding ways to integrate ecological processes and human settlement into more regenerative and sustainable land use patterns (Perlman & Milder, 2004; Ahern et al., 2007a; Dinep & Schwab, 2009). Major cities such as Portland, Oregon; Seattle, Washington; San Francisco, California; Minneapolis, Minnesota, and Austin, Texas are leading the way in sustainability in the U.S. and on the global stage (Light, 2013). Sustainability is also showing up in small-town America. A unique example is in the heart of the Great Plains in Greensburg, Kansas, where the combination of natural disaster and community leadership, has transformed this Midwestern town into the world's leading community in LEED-certified buildings per capita (Benfield, 2015), indicating that sustainable design can be implemented and succeed within smaller communities in the Midwestern United States when local commitment is strong.

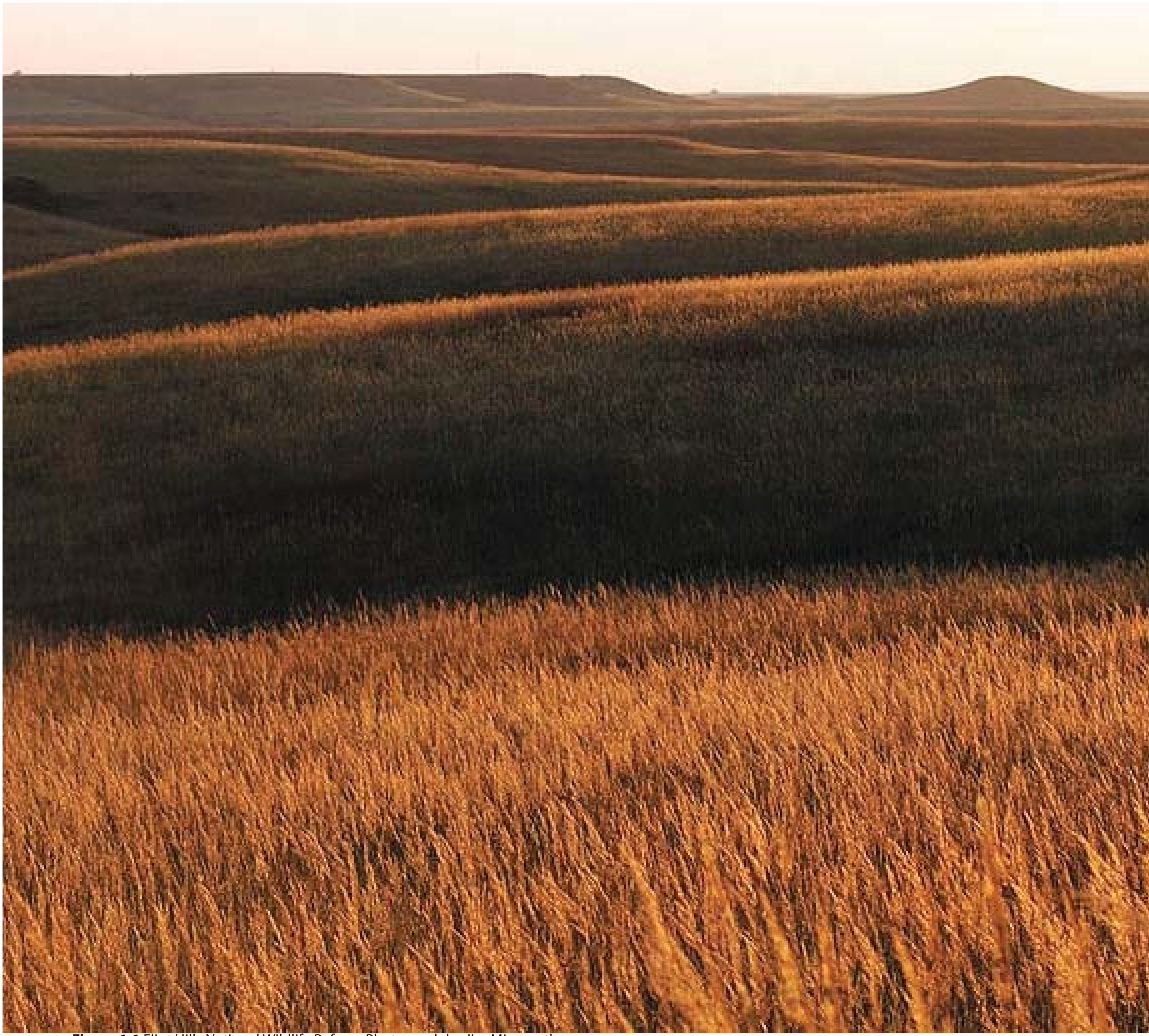


Figure 1.1 Flint Hills National Wildlife Refuge. Photograph by Jim Minnerath

Dilemma

Past and current construction of unwisely designed and implemented residential subdivisions in America has created an unsustainable pattern of development that frequently degrades nearby natural areas. The spread of lower density suburban and exurban development (known as sprawl) continues to encroach on local and regional ecological systems. Non-sustainable development, created in the name of 'progress' and 'giving citizens what they desire,' has impacted biodiversity through the introduction of invasive species, the loss and fragmentation of pollinator habitats, over-exploitation of living resources, and downstream flooding and water quality (Heywood, 1995). Traditional landscapes are introducing invasive plant species harmful to native ecosystems. The application of herbicides and pesticides to maintain resource-intensive landscapes combines with other factors to degrade living soils and native pollinator habitats which are both vital to sustaining diverse ecosystems and maintaining our food supply (Beck, 2013). This non-sustainable landscape aesthetic was a learned way of thinking and seeing landscapes, and that process needs to be changed.

Environmental values are changing in many communities and efforts to create more sustainable cities are on the rise. However, many areas associated with landscape construction do not seem to have sustainable practices in mind. This is true for many new neighborhoods in Kansas and other parts of the United States. The Lee Mill Heights development is a conventional single family subdivision on the southwest part of Manhattan, Kansas. Within this subdivision, limited conservation protections have been instituted via the development's bylaws pertaining to preserving and conserving streambanks and natural vegetation within designated drainage and conservation easements.

Beyond these limited protections, the Lee Mill Heights development can provide an opportunity to inform and engage homeowners about ecologically inspired landscape retrofits which in turn can further enhance the neighborhood's ecological functions while also strengthening its connectivity to local parks and natural resources in a meaningful way.

Thesis

Conservation developments are implemented mostly on greenfield sites. However, many of the same principles of 'conservation design' can be applied in the form of retrofits for existing developments. The key for this to be successful is understanding the regional ecology and knowing what kind of value the existing development has to offer for regional ecological patterns and processes (Arendt, 1996; Apfelbaum, 2015; Mensing, 2015).

Because of its close relationship to surrounding native tallgrass prairie and a new park consisting of prairie and woodland, Lee Mill Heights is an example of how ecologically informed landscape retrofits can be implemented in existing exurban subdivisions in Riley County and the surrounding region. It is suggested that this can be done by effectively informing and engaging neighborhood homeowners and then helping them create more sustainable landscape systems.

Research Question

How can ecologically-inspired landscape design retrofits be implemented in existing single-family neighborhoods located in exurban and suburban areas?

Sub-Questions

How do the homeowners regard ecological site design? How do the easements provide opportunities for innovative design?

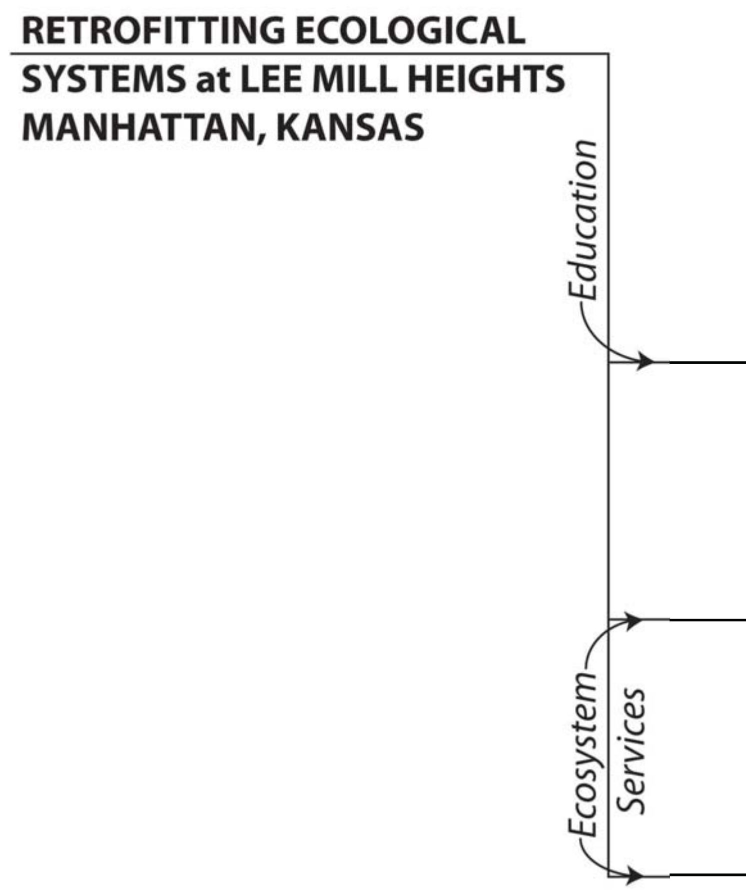
Project Goals and Objectives

Figure 1.2 was created to help guide the researcher through the goals and objectives of the research project. Key principles concerning restoration, conservation, ecological function and awareness were drawn from multiple sources to help frame the goals for the project (Arendt, 1996; Ndubisi, 2002; Perlman & Milder, 2004; AES, 2007; Ahern et al., 2007a; Dinep & Schwab, 2009; Selman, 2012; Beck, 2013; Sites, 2014; Apfelbaum, 2015; Mensing, 2015).

There are two over-arching categories in retrofitting ecological systems at Lee Mill Heights (LMH): education, and ecosystem services. Education about retrofitting opportunities involves increasing ecological awareness. Ecosystem services encompass many aspects; however, the two primary ecological services to be sought at LMH relate to biodiversity and stormwater management.

Biodiversity is the shortened form of biological diversity. It is important because it boosts ecosystem productivity where many different species play an important role. Greater species diversity keeps the earth healthy and provides food, medicine, and contributes to the global economy.

Water is essential for life and its movement aids many ecological processes. The handling of stormwater is important to address where development has interrupted the natural hydrologic cycle. Moving stormwater intentionally can create design opportunities by implementing rain gardens which increase infiltration and reduce runoff.



Specific project goals associated with these two broad sub-categories include: increasing homeowner ecological awareness, proactive learning through engagement, increasing pollinator plant species and corridors, decreasing invasive species, increasing infiltration, and deceasing water pollution.

The objectives shown in Figure 1.2 lists how the goals for retrofitting ecological systems at Lee Mill Heights can be accomplished. For example, this research project sought to engage homeowners by reaching out in the form of a survey. This first step opened the door to further inform homeowners on ecological processes, therefore, increasing homeowner ecological awareness. The next step would be to facilitate this complete document to residents of Lee Mill Heights.

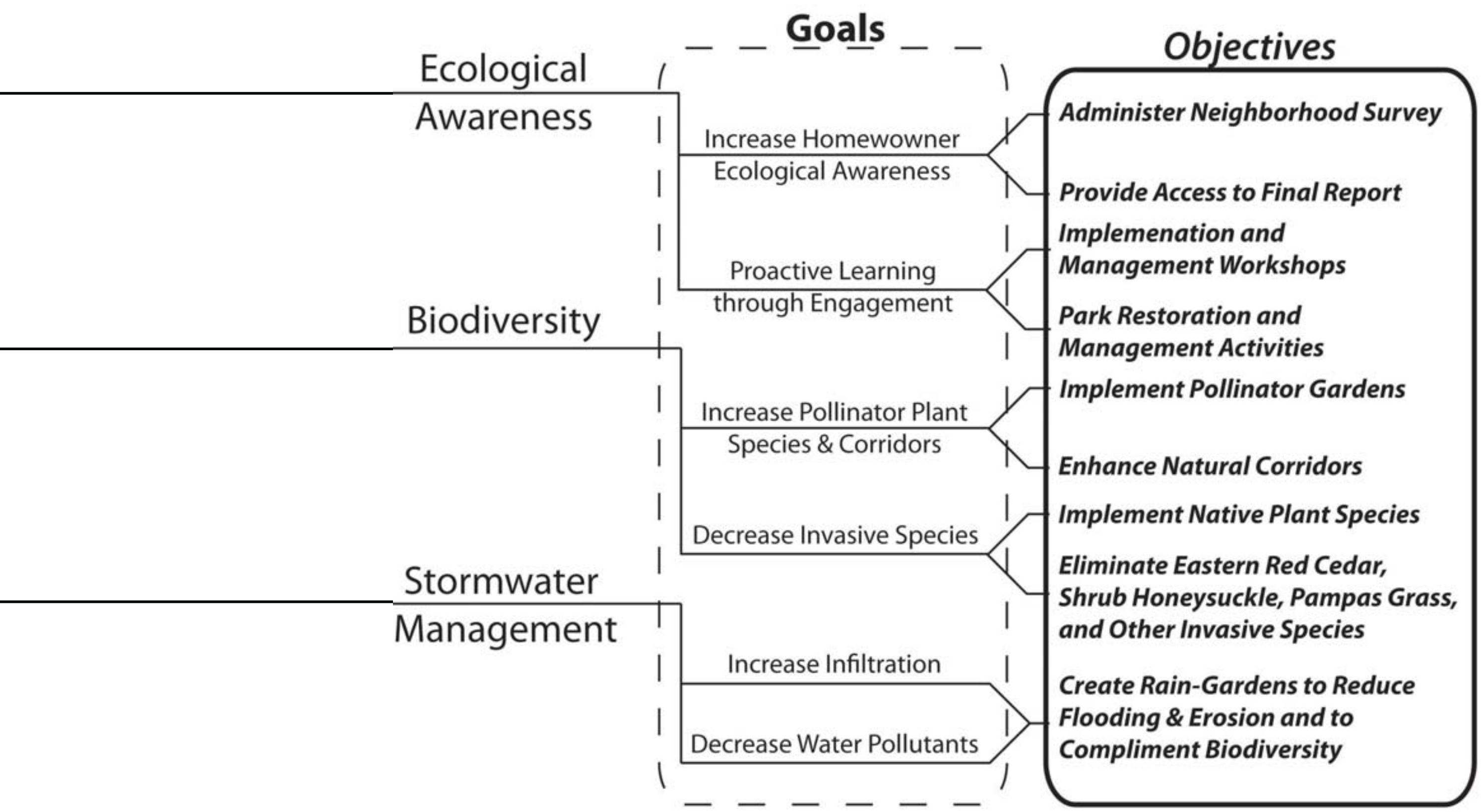


Figure 1.2 Goals and Objectives for Implementation of Ecologically Inspired Landscape Design. By Author

Relevance to Landscape Architecture

In 1967, Ian McHarg stated the following, "I believe that ecology provides the single indispensable basis for landscape architecture and regional planning. I would state in addition that it has now, and will increasingly have, a profound relevance for both planning and architecture" (as quoted in Swaffield, 2002, pg. 38). That relevance is still seen today through journal articles written by professionals like Makhzoumi (2000), Thompson (2002), Calkins (2005), and Nassauer (2012). In his article, *Ecology, Community and Delight: a Trivalent Approach to Landscape Education*, Thompson (2002) categorized the values within landscape architecture into three broad categories. Figure 1.3 shows the three categories and their relationship with one another.

Although this diagram was created by Thompson (2002), other authors discuss some of the same topics. For example, in the journal article, *Landscape as medium and method for synthesis in urban ecological design*, Joan Iverson Nassauer (2012) discusses two laws that landscapes integrate environmental processes and that landscapes are visible. These are related to Thompson's (2002) 'Optimal Trivalent' of design model subareas of Ecological Approach and Natural Aesthetics.

Thompson (2002) discusses in detail the relationship between the three arenas associated with aesthetic, social, and environment values. He then focuses on the center where all three values meet, calling this "trivalent design" and suggesting that this is the richest sort of design (Thompson, 2002, pg. 85). This research project strives to work within the trivalent design framework set forth by Thompson (2002).

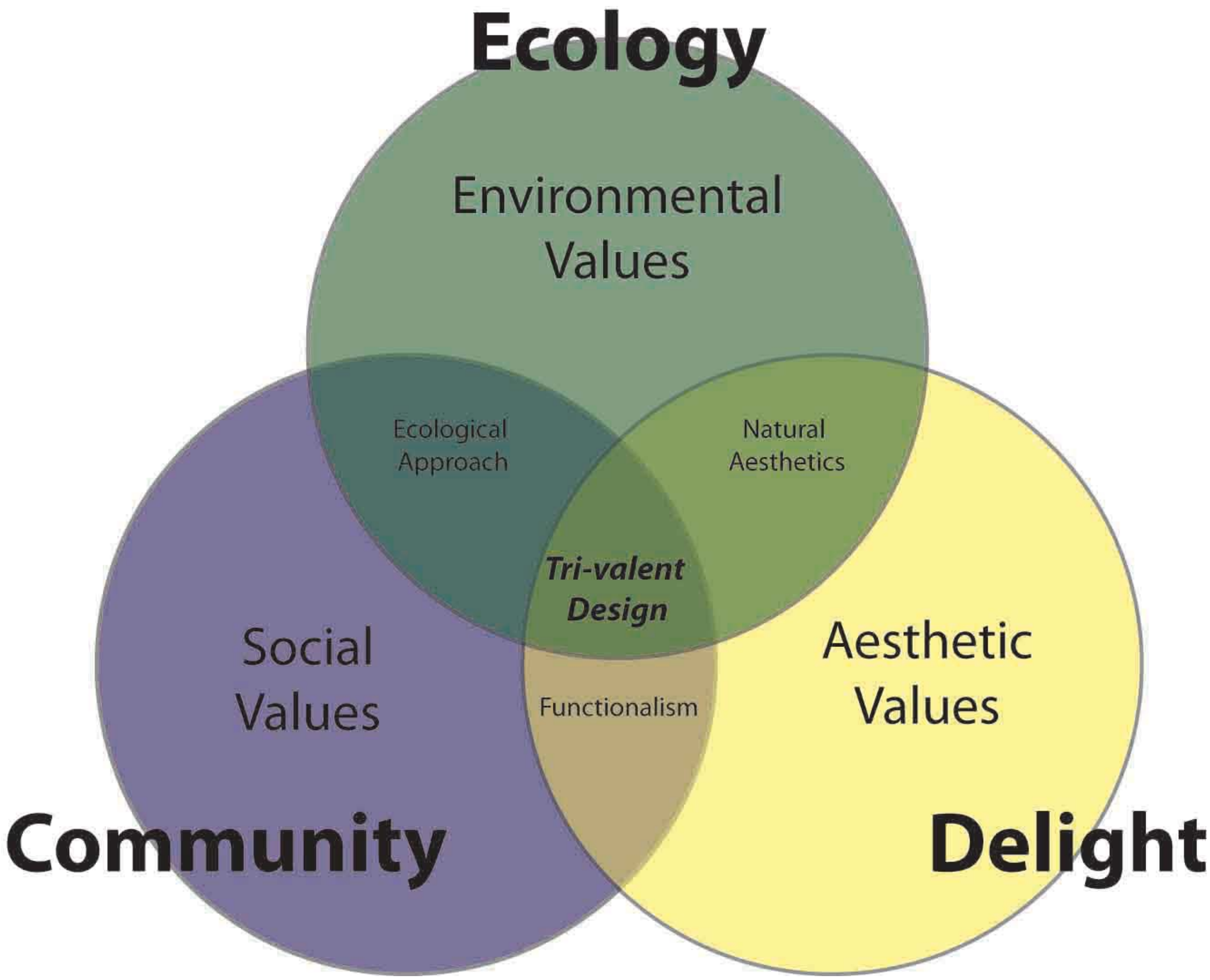
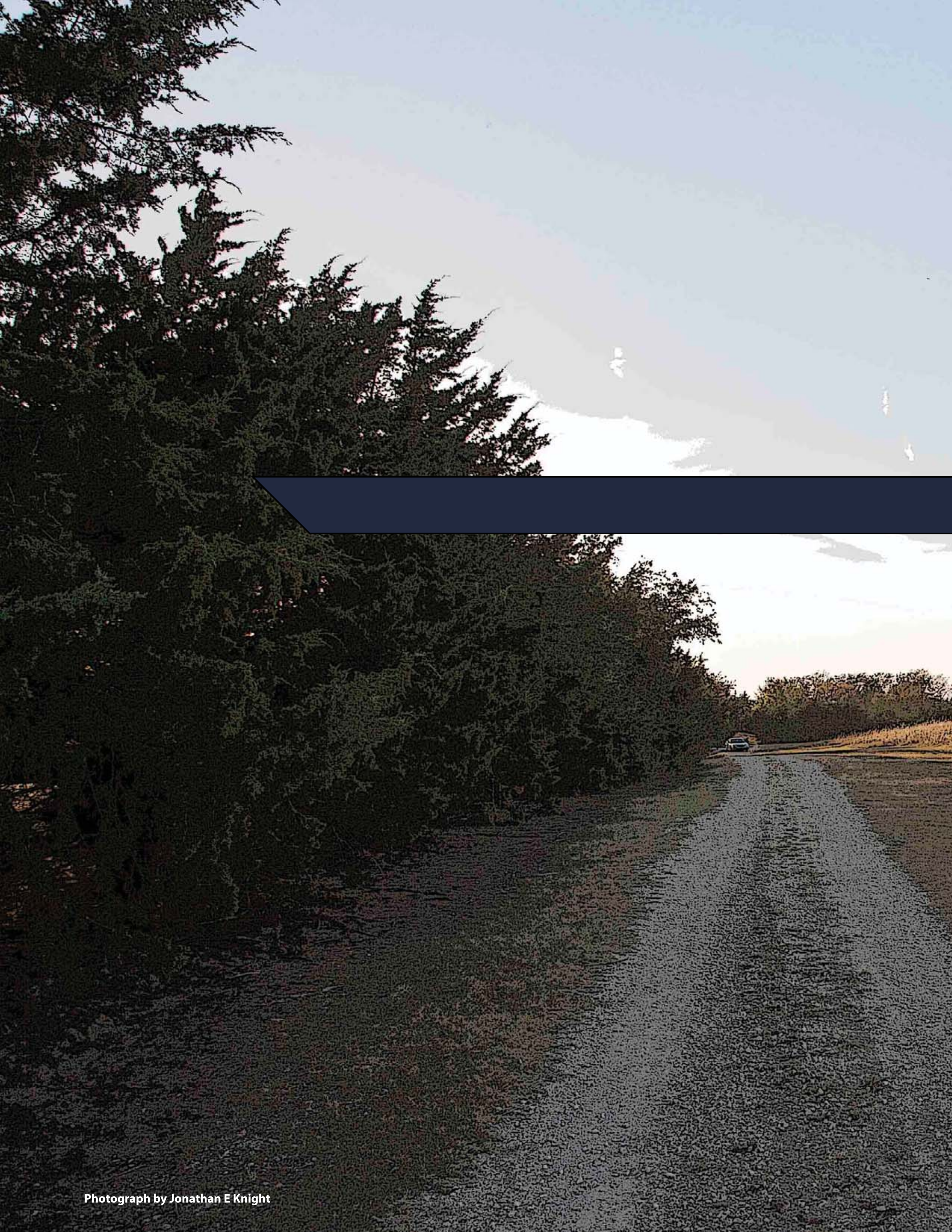


Figure 1.3 Conceptual Diagram Adapted from Thompson (2002) and the 'Optimal Trivalent' of Design. Adapted by Author



Photograph by Jonathan E Knight

Chapter 2: Background

Background

A call for 'greener' cities has been issued (Thompson & Sorvig, 2000; Saunders, 2008; Arendt, 2010; Coyle, 2011; Steward & Kuska, 2011; Grant, 2012). People are starting to acknowledge the importance of designing and developing with ecosystem services in mind — with goods and services supplied free of charge by the regenerative natural world. Grant (2012) states that, "this new approach recognises that restoration of the natural environment will be necessary and that this can and should happen everywhere, in the forests, fields, wetlands, rivers and seas, but also in the urban environment" (pg. 4), including in existing exurban areas. However, simply wanting a sustainable design is insufficient.

Public perception and participation in sustainable practice is an important factor to consider when suggesting sustainable design (Roseland, 1998; Nassauer et al., 2009; Ndubisi, 2002; Perlman & Milder, 2005; Rottle & Yocom, 2010; Coyle, 2011). Community engagement and education is also an important aspect of the design process as well. Steward and Kuska state, "we must believe that individual action matters, greatly, and that sustainability is a set of principles and values that deserve our utmost, constant, and personal attention" (2011, pg. 23). Steward and Kuska (2011) further discuss examples across the world were individuals influence their community to take action in projects concerning conservation action. This same kind of action can be taken in communities such as Manhattan, Kansas.

Figure 2.1 depicts the variety of scales addressed in this research project. Each scale serves a purpose in influencing the following step—down to neighborhood and site specific scales, which in this case focused on the neighborhood of Lee Mill Heights. At the regional scale, it was important to understand the physiographic province or regional ecological context. Figures 2.2 and 2.3 gave a generalized idea of the physiographic and vegetation regimes found in the Manhattan to Ft. Riley metropolitan region. Figure 2.2 shows the Manhattan regional area to be located within the Flint Hills Upland physiographic regime. Figure 2.3 depicts the historic vegetation regime to be Tallgrass Prairie. The next step of note was the sub-regional context or physical boundaries of Manhattan, Kansas. The key design drivers at the regional, city, and district scale are biodiversity & habitat connectivity and stormwater management. Figure 2.4 captures the various elements found on the southeastern periphery of Manhattan. The neighborhood scale of Lee Mill Heights is seen in Figure 2.5, and this was the functional scale that this research project primarily focused on.

The Lee Mill Heights (LMH) subdivision was chosen as the study site because of its unique location within the suburban and rural fabric of Manhattan.

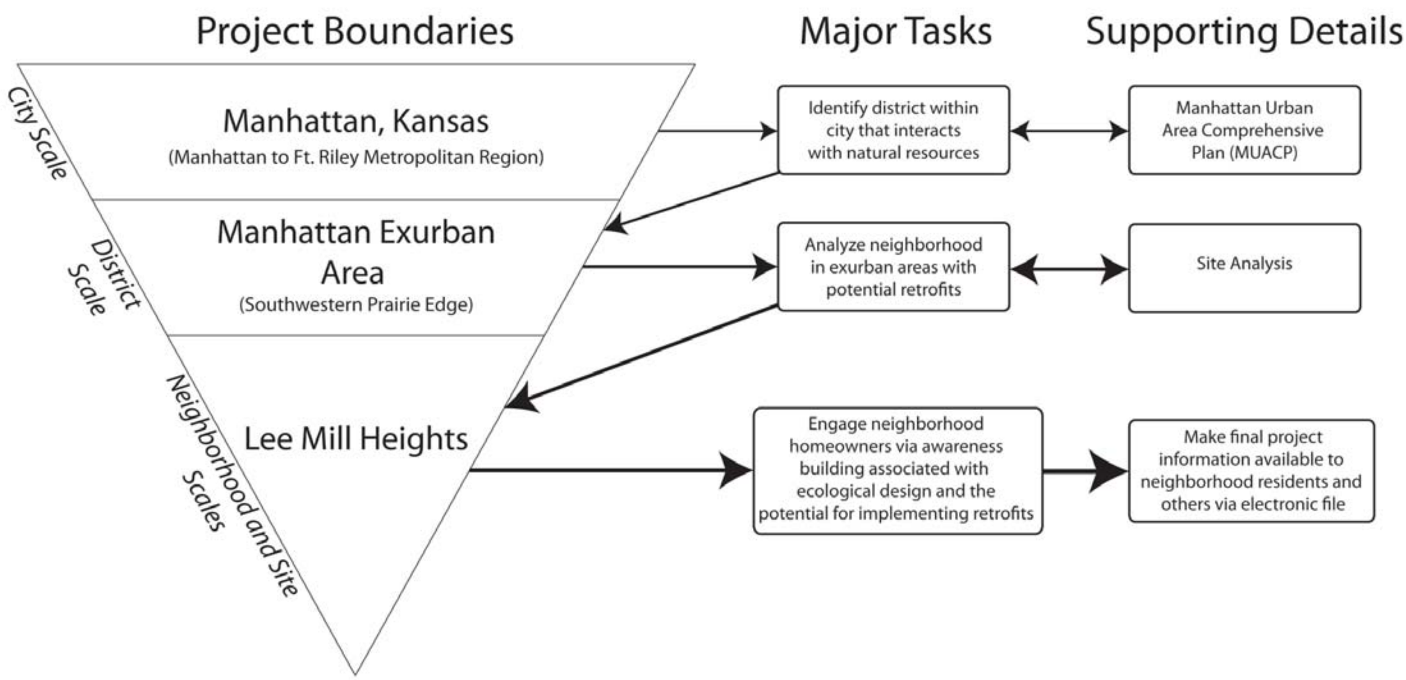


Figure 2.1 Physical Boundaries for Lee Mill Heights-Manhattan, Kansas. By Author

To the north of LMH, privately owned and maintained prairie portrays a glimpse of the native tallgrass prairie which once dominated the landscape in this region. The recently approved Park at Lee Mill Heights (http://mhkprd.com/167/Park-at-Lee-Mill-Heights) to the west of the subdivision offers a chance for the neighborhood to connect with the region's natural resources by creating residential landscape systems supportive of important ecological patterns and processes. This can be accomplished by the reduction of negative flows such as polluted, sediment-laden stormwater and invasive plant species. Pets (cats and dogs in particular) are an introduced species that can affect the local ecosystem when left unattended. Pesticides and herbicides are a concern for Monarch butterlies and other native pollinators.

LMH consists of multiple zoning districts and the whole subdivision is under the Airport Overlay. The zoning districts include: R-Single-Family Residential, R.1-Single-Family Residential, and R.2-Two-Family Residential. The difference between R and R.1 is the square footage per dwelling. R is designated for a density no greater than one dwelling unit per 10,000 sf and R.1 is designated at one dwelling per 6,500 sf. The Airport Overlay limits houses to two stories at grade. Currently, the homeowner's association of LMH only includes units one through four and part of eight (refer to Figure 2.5). The other units are not completely built, therefore, have not yet been added to the homeowners association.

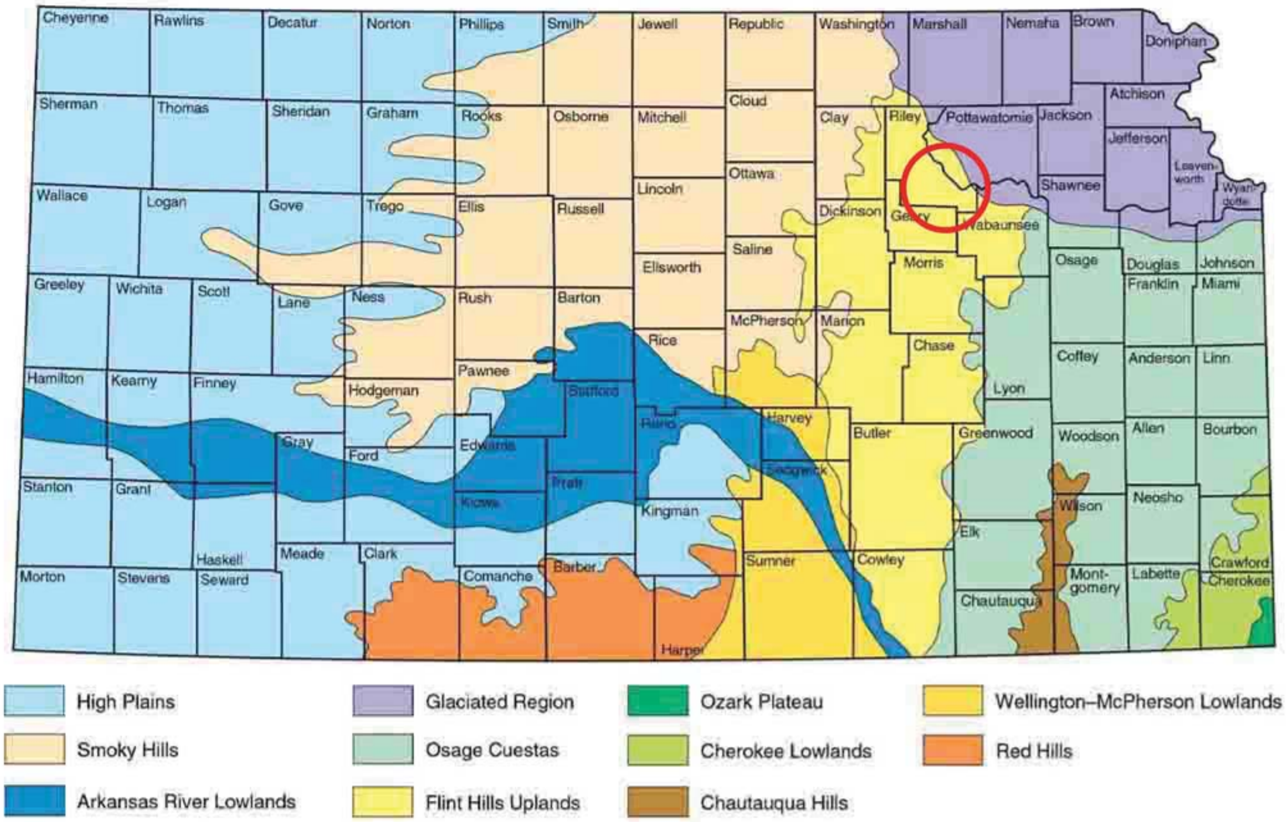


Figure 2.2 Physiographic Map of Kansas. Map by Kansas Geological Survey

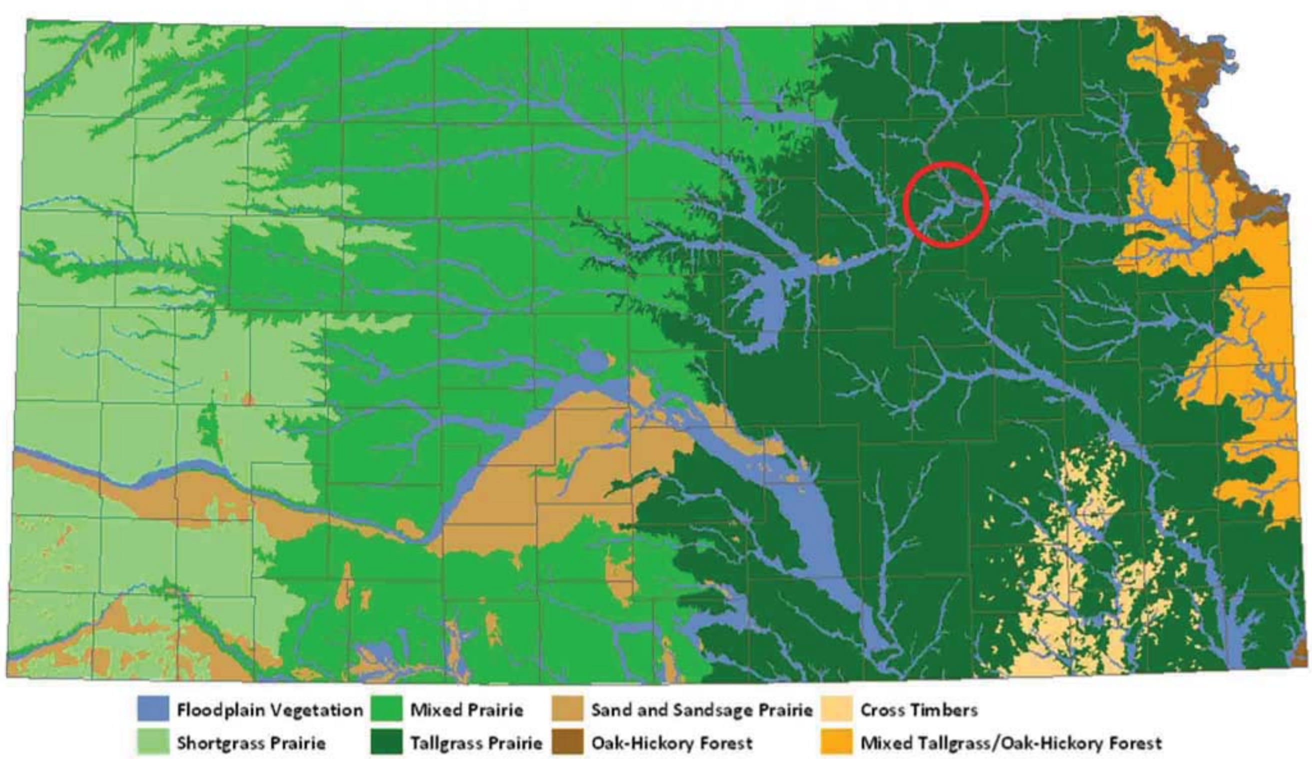


Figure 2.3 Kuchler's Map of the Potential Vegetation of Kansas. Map by University of Kansas Applied Remote Sensing Program

Figure 2.4 Sub-Regional Context of Southwestern Manhattan, Kansas. Base map from Google Earth. Modified by Author

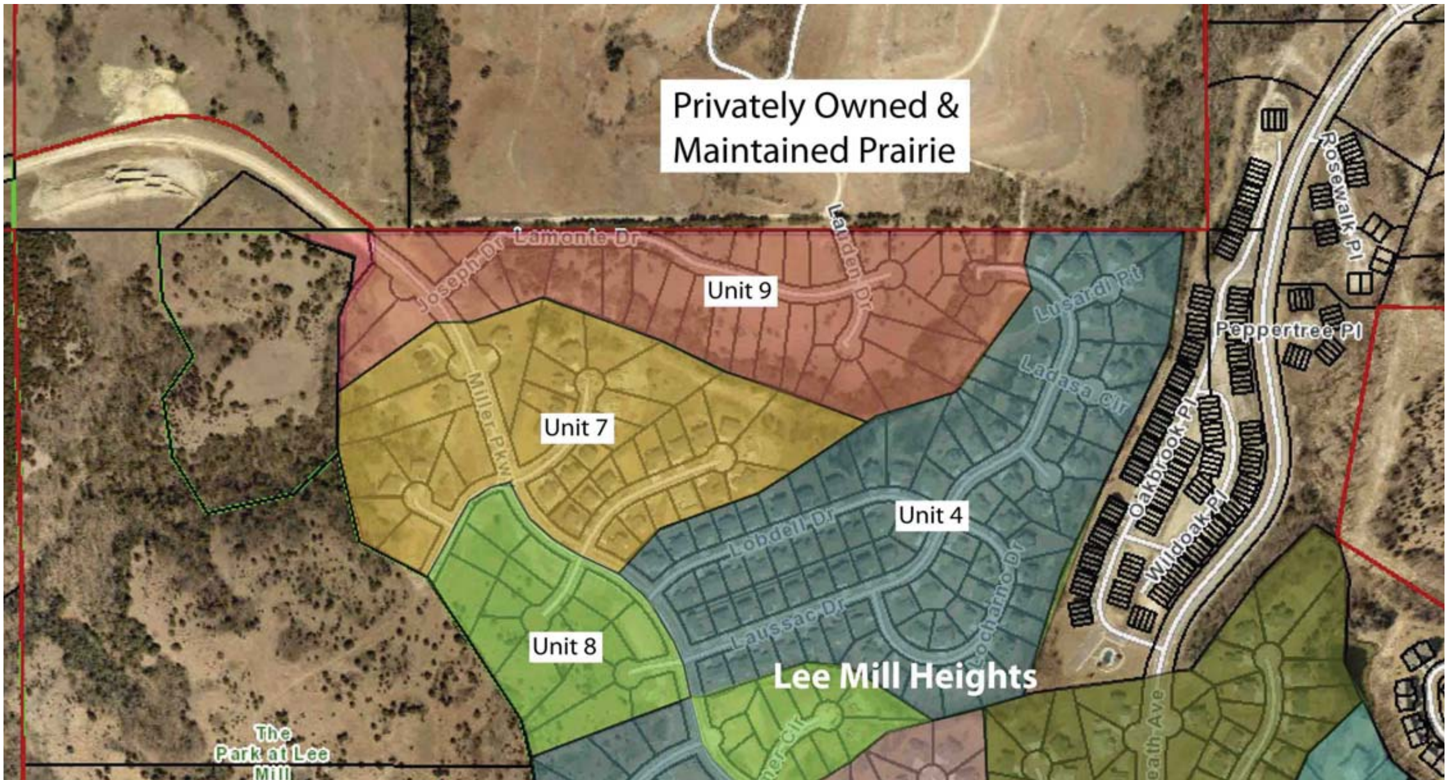


Figure 2.5 Lee Mill Heights Subdivision—Manhattan, Kansas. Base map from Google Earth. Modified by Author

Definition of Terms

To better understand the content of this research proposal, it would be beneficial to define key terms used throughout this project. Sustainability is defined by the Climate Change 2014—Synthesis Report as "a dynamic process that guarantees the persistence of natural and human systems in an equitable manner" (IPCC, 2014, pg. 127). Sustainable development is brought about by meeting the need of the present generations "without compromising the ability of future generations to meet their own needs" (IPCC, 2014, pg. 128). The foundation of this project is based firmly within the realm of sustainability and sustainable development.

Landscape ecology is another important concept. Ndubisi (2002) indicates that to understand the meaning of landscape ecology, one must break down the term to its individual words. "Landscapes are sustained by ecological processes that occur at a variety of spatial and temporal scales" (Ndubisi, 2002, pg. 173), while ecosystems, "are a part of a hierarchy of systems involving interacting the physical-chemical elements and their biotic (and cultural) features…connected through the flow of minerals, energy, and species across the landscape mosaic" (2002, pg. 173). Therefore, the combination of the two gives us the study of ecosystem functions at the landscape scale—or landscape ecology (Ndubisi, 2002). As previously discussed, the project seeks to address key ecological processes including the flows of species and stormwater at the sub-regional, city, and neighborhood scales.

A major part of this project involves applying principles found in landscape ecology to an existing site, therefore, design that is strongly influenced by an understanding of integrative ecological processes (including the conservation of living soils, native habitats, and clean water) is at the heart of the project. Rottle and Yocom (2010) define ecological design as, "the process of actively shaping the form and operations of complex environments in such a way that composition and processes help to maintain and, if possible, increase the integrity of a region's ecological relationship" (Rottle & Yocom, 2010, pg. 14). This research project promotes the creation of sustainable retrofits at the residential site scale thus supporting healthy ecosystems through the ecological design process.

Literature Review

Since the mid-1960s a paradigm shift in environmental values has been initiated in Europe, the United States, and many other parts of the world, culminating in a focus on green infrastructure based development (Thompson & Sorvig, 2000; Ahern et al., 2007b). During the 1980s and 1990s sustainability and landscape ecology began to be important parts of landscape architecture education and practice (Swaffield, 2002; Ahern, 2005). The effort to create sustainable cities, neighborhoods, and sites is making a difference in urban areas, and this is very important since global census data shows that a majority of the earth's population now lives in urban settlements (United Nations, 2014).

The United States is no exception to the trend of finding ways to integrate ecological processes and human settlement into more regenerative and sustainable land use patterns (Perlman & Milder, 2004; Ahern et al., 2007a; Dinep & Schwab, 2009). Major cities such as Portland, Oregon; Seattle, Washington; San Francisco, California; Minneapolis, Minnesota, and Austin, Texas are leading the way in sustainability in the U.S. and on the global stage (Light, 2013). Sustainability is also showing up in small-town America. A unique example is in the heart of the Great Plains in Greensburg, Kansas, where the combination of natural disaster and community leadership, has transformed this Midwestern town into the world's leading community in LEED-certified buildings per capita (Benfield, 2015), indicating that sustainable design can be implemented and succeed within smaller communities in the Midwestern United States when local commitment is strong.

Sustainable Community Development: Conservation Subdivision Design, Development, and Management

According to Peiser and Hamilton (2012), growing awareness of the environment has influenced some areas of real estate development. Conservation subdivision design is an effort to build sustainable residential neighborhoods. The advantages of conservation subdivision design are lower construction costs, marketing and sales advantages, and value appreciation of the property (Arendt, 1996). Arendt (2010) discusses procedures and design principles for conservation subdivisions, which include constructing a context map, creating an existing resources/site analysis map, performing a site walk, then creating a sketch plan. Arendt (2010) typically performs these design steps on a greenfield site, however, there are a number of procedures that can be applied to a site that has already been developed. One key procedure would be creating a well-informed existing resources/site analysis map.

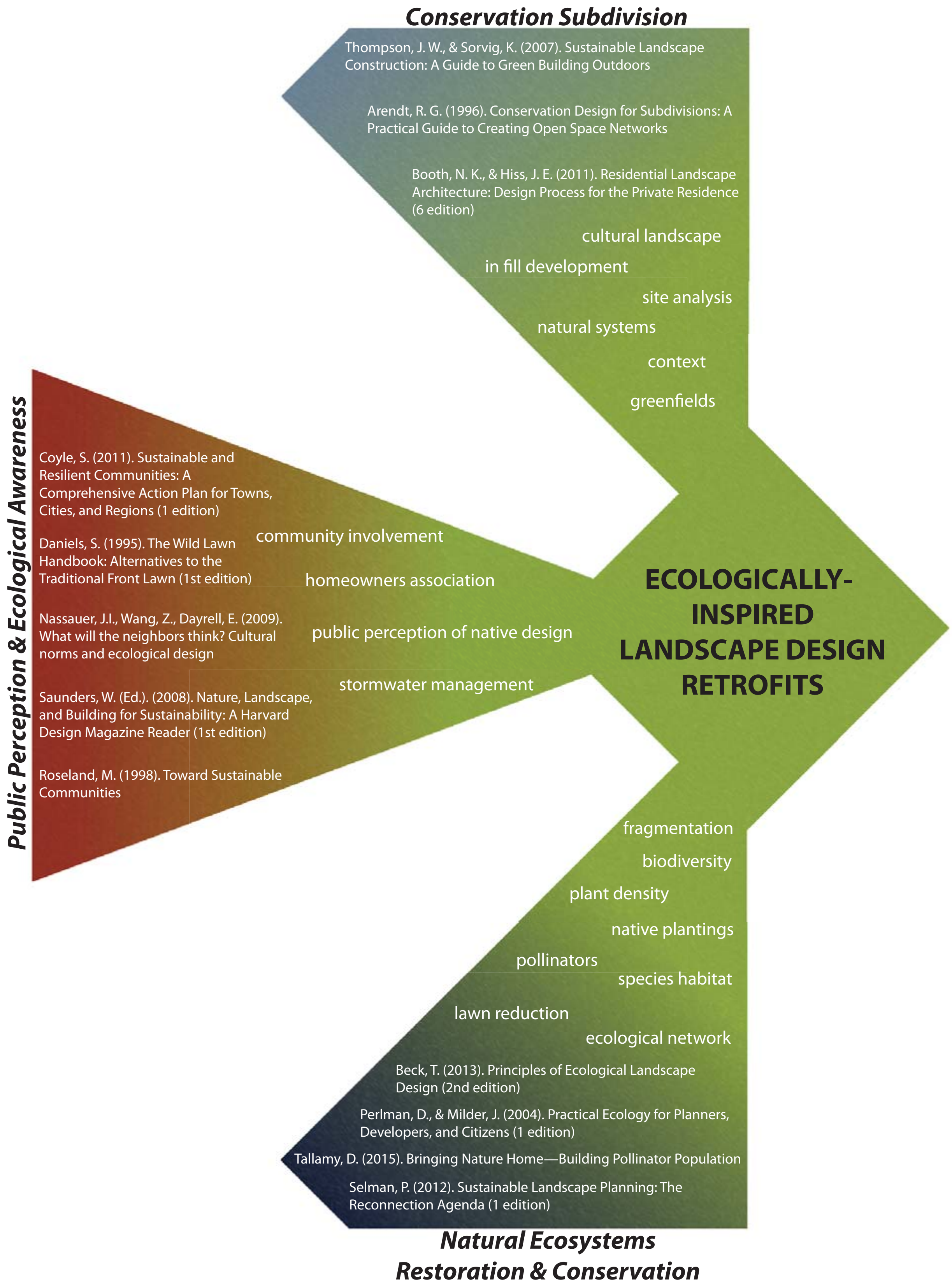


Figure 2.6 Literature Map. By Author

Thompson and Sorvig (2007) also values creating a well-informed existing resources/site analysis map. In part of their first Principle "Keeping Healthy Sites Healthy" Thompson and Sorvig (2007) stress the importance of locating vulnerable features before starting the design process. These items may hold ecological value, historic or cultural value, or personal importance to the owner/client. All features found to be of value will need protection during construction or ecological restoration.

On a slightly larger scale, understanding the context and edge of the neighborhoods is important in respecting the cultural landscape (Arendt, 2004). Arendt further discusses principles addressing issues that may arise when designing infill development. These principles include: designing around existing features, creating multiple greens and commons, street trees, and creating design opportunities with stormwater management. Although Arendt (2004) is applying these principles to infill development, retrofitting is similar and could be applied to an existing exurban neighborhood.

Knowledge of the natural systems and cycles is key in a sustainable design for residential neighborhoods (Booth & Hiss, 2011). In Perlman and Milder's book, *Practical Ecology for Planners, Developers, and Citizens*, ecologically based planning and design techniques include using ecological data to create land suitability analysis maps (2004). In relation to Lee Mill Heights, site assessments, GIS data, and historic aerial photos are important in the creation of analysis maps and/or documents that depict invasive species, soil types, and existing drainage systems. Mapping of ecological data also includes two geomorphic units: regions and watersheds.

Rottle and Yocom (2010) describe regions and watersheds as the broadest scale in which design and planning procedures are implemented. Regions can be identified by landform, climate, biological communities, and land cover/land use type. Watersheds are hydrological catchment areas and "a hierarchy of watersheds can be identified, from the smallest site to the largest conflation of river systems that drain to a sea" (Rottle & Yocom, 2010, pg. 128). Emulating, preserving, or conserving ecological processes will require a broader look at the systems and landscape dynamics. One must consider vegetation types (including invasive plant species and species supporting native pollinators and songbirds), landform and slope (which help in determining feasibility of construction without too much cut and fill), and patterns of water flow at the sub-regional and local scales (so that interventions can be planned and designed to slow and infiltrate stormwater in appropriate places).

Natural Ecosystem Restoration & Conservation

One of the basic principles of ecological landscape design is biodiversity (Beck, 2013). High-functioning landscapes flourish with a diverse palette of flora and fauna. Biodiversity supports ecosystem functioning and creates diverse ecosystems. Invasive species of either flora or fauna threatens biodiversity within an ecological system; therefore, ecological landscape design must be implemented in a manner to support biodiversity (Beck, 2013). When biodiversity is mentioned in this literature review, it is "generally referring to native biodiversity—populations, species, and ecosystems that are indigenous to a given area and were not transported there by humans" (Perlman & Milder, 2004, pg. 31). Realistically, the reestablishment of a pre-European settlement ecosystem is unobtainable. However, achieving an ecosystem similar to ones that existed prior to the nineteenth century is plausible. Perlman and Milder (2004) mention this specific time because it was an era when humans were able to interact and influence the landscape without being highly destructive in the process.

There are more than 200,000 species of plants and animals within the U.S. which contains 21 of the 28 types of ecosystems found on Earth. Over 1,200 different types of species, both plants and animals, are on the endangered species list, and as of the year 2000, most of the nation's ecosystems had lost three-quarters of their original area (Daniels & Daniels, 2003). In Doug Tallamy's presentation, Bringing Nature Home—"Building Pollinator Populations", he discusses the importance of pollinators to human health/well-being and biological diversity. Around 80% of plants require pollinators to assist in the pollination process. Human beings continue to dominate the landscape in the U.S. with 43% of the landscape being suburban and urban. Tallamy (2015) offers ways to improve and support pollinator specialists by reducing lawns, increasing plant density, and native plantings.

Fragmentation of species habitat and ecological networks has also affected biodiversity (Selman, 2012; Beck, 2013). In order to enhance ecological networks, Selman (2012) suggests the use of multiple components, which include: mapping core areas of habitat, creating corridors between the cores, restoring areas between the cores found within the newly created corridor, and implementing buffer zones around core areas and corridors. These corridors can be part of the woodland drainage areas and extend into the existing fabric of neighborhoods. However, once native landscapes start to encroach upon the human environment, ecological awareness is important in understanding the benefits. Part of this research project is understanding public perceptions of ecological processes with the use of a homeowner survey.

Public Perception and Ecological Awareness

Public perception of native plantings and ecological landscape patterns is important to understand for the design to be accepted (Roseland, 1998; Daniels & Daniels, 2003; Nassauer, 2009; Coyle, 2011). Roseland (1998) discusses how communities must be involved with citizens from their neighborhoods and local governing entities in order for sustainable design to be effective. These governing entities can also involve residential homeowners associations. Furthermore, Daniels & Daniels (2003) say a balance occurs between all parties involved in the construction process that must agree on environmental quality if sustainability is to be achieved in the long run. Generally, the following five interests or parties must come to an agreement: 1) landowners, 2) the development community, 3) lending institutions, 4) elected officials, and 5) the general public.

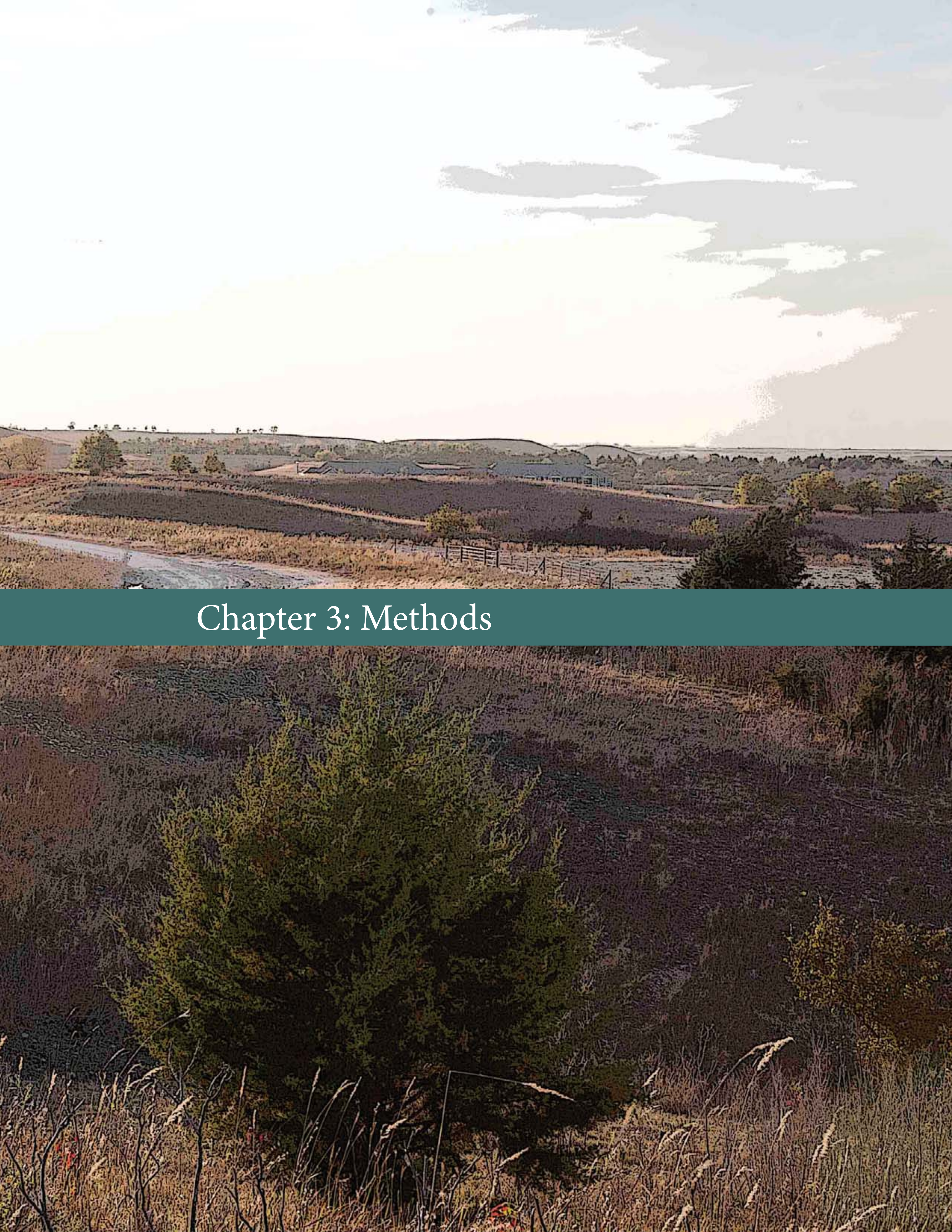
Some people typically consider native plantings as weeds. However, what some people call a weed, may very well be a "plant whose virtues have yet to be discovered." Calling a native plant a weed is "a defect of our perception" (Saunders, 2008, pg. 69). Appreciation for native plants can be cultivated through understanding, including showing how the use of native plantings can be done in beautiful ways (with mowed edges that show care and order even if the plantings are a bit wild).
Traditional turf-grass landscapes often require more time and effort to maintain than native plantings (Applied Ecological Services, 1997; Roth & Associates, 2009). The overall benefits of implementing native plants are the increase of biodiversity, cost savings, and a healthier more aesthetically pleasing landscape. For fire safety reasons, it is understandable why the use of traditional turf-grass landscapes are installed adjacent to housing structures. Therefore, a hybrid design of traditional and native landscapes can be implemented and still be considered a sustainable design.

In *The Wild Lawn Handbook* by Daniels (1995), there are examples of homeowners installing native planting designs only to be fined by city ordinance or harassed by neighbors, but the homeowners prevailed. Local activists and leaders were able to influence policy change concerning water conservation and reduced lawn area incentives (Daniels, 1995). Can similar policy changes be implemented effectively in a mid-western city like Manhattan, Kansas? What are the local perceptions regarding the use of native plantings in residential landscapes? What firms are currently involved in ecological landscape design work? These questions were explored in the survey presented to homeowners within Lee Mill Heights.

Figure 2.7 Prairie Grassland North of LMH. By Jonathan E Knight

Photograph by Jonathan E Knight

Chapter 3: Methods



Methods

Overview

The project utilized both qualitative and quantitative methods (Figure 3.1). Qualitative methods included a summarization of relevant literature to guide the researcher in developing survey questions to be asked of homeowners within already developed portions of the Lee Mill Heights subdivision. The homeowner survey was both qualitative and quantitative since both open-ended and multiple choice questions were asked. In order for the survey to be administered efficiently, initial communication with the Lee Mill Heights neighborhood Homeowners Association was important. Survey questions were used to gauge homeowner's knowledge of ecologically sustainable designs and willingness of homeowners in implementing ecologically sustainable designs. The primary goal and purpose of the survey was to build awareness of ecological issues and concerns. To build awareness, the researcher met with the LMH Homeowners Association, interacted extensively with four homeowners, and will make the project report available to LMH homeowners.

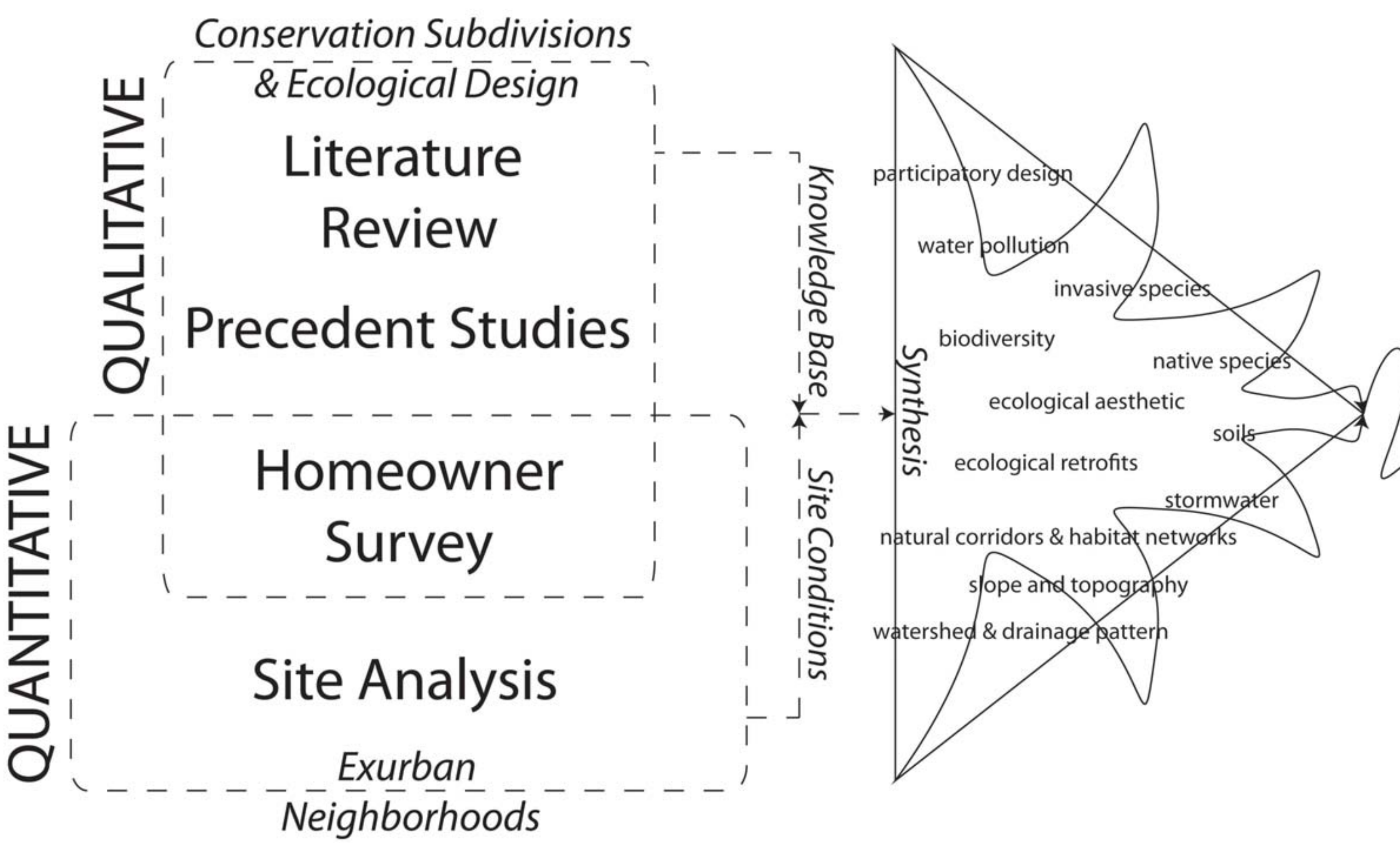
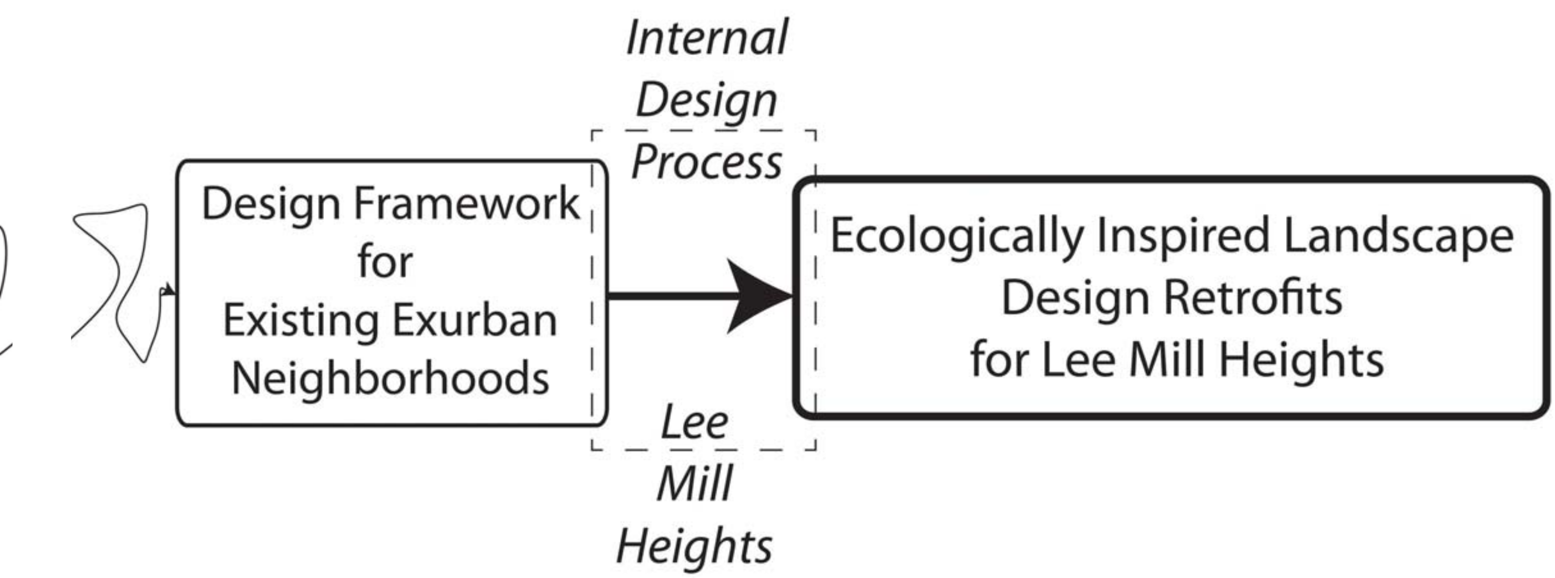


Figure 3.1 Project Methodology. By Author

The literature review supplied key terms and ideas used to develop a design framework that was applied to Lee Mill Heights and guide retrofit design efforts. Several precedent projects were analyzed as a way to inform residents of retrofits that could be implemented at Lee Mill Heights. The selection of appropriate precedent studies were based on criteria highlighted in the Comparative Guidelines for Sustainable & Ecological Landscape Design section of the sustainable design guidelines shown in Table 3.8. Precedents were selected based one or more of the following criteria: 1) a clear process prior to design in the form of site analysis/mapping of ecological resources; 2) communication and education of interested and potentially affected parties in the design process; 3) fostering biodiversity; 4) retrofitting derelict or otherwise poorly functioning lands; 5) enhancing human well-being, and 6) strengthening community. Three precedent studies were selected, one each from Conservation Design Forum, Andropogon Associates, and Applied Ecological Services. These precedent studies were used to identify key design principles and strategies that supported the design framework that was applied to Lee Mill Heights.



Site Analysis
Stormwater Drainage Ways

Site analysis was performed on Lee Mill Heights (LMH) using 2014 GIS data for the Manhattan, Kansas area. Within the site analysis, identification of the localized watershed or drainage area, overland drainage patterns, vegetation patterns and types (identifying primary invasive plants that can be readily identified is important), and proximity to surrounding natural resources were documented and analyzed in relation to one another. From this analysis, a better understanding of these processes occurring at LMH began to take shape.

The Stormwater Drainage Ways analysis reveals that most of LMH was developed on top of a ridge (Figure 3.2). Several intermittent streams have been formed over time and water concentrating in each drainage allows for abundant woody vegetation.

Miller Parkway is the dividing element when it comes to which way water will flow from the neighborhood. The runoff from the housing north of Miller Parkway flows north toward Wildcat Creek. The flow of water south of Miller Parkway moves toward the Kansas River. A majority of the drainage ways have been undisturbed through the use of drainage 'conservation easements' on properties. There are, however, a few areas that have been disturbed and concrete flumes have been installed. This disturbance has also fragmented the native drainage ways.

The fragmentation tends to occur the closer the drainage ways get to Miller Parkway. These native drainage ways host a variety of ecological processes that must remain undisturbed or restored where possible. Since many drainage ways are overcrowded with Eastern Red Cedar, buffers of actively managed native grasses and wildflowers in upland areas could be a great benefit to reduce stormwater flows and increase biodiversity. One way to handle the cedars would be implementing a cutting program. This would reduce the chance of torch-like fires, while also promoting more diversity of native herbacesous plants.

Figures 3.3 and 3.4 show variation in soil types and slope at LMH. The topographical map (Figure 3.4) shows how the lot placement of LMH avoided high construction costs by developing on gentler sloping areas. The natural drainage ways range from 5-40% in slope. These areas were designated as drainage and conservation easements. The soil map (Figure 3.3) depicts the types of soils found in the area and tend to vary depending on slope. This information on soils can give a clearer picture on what types of vegetation would thrive according to various conditions.

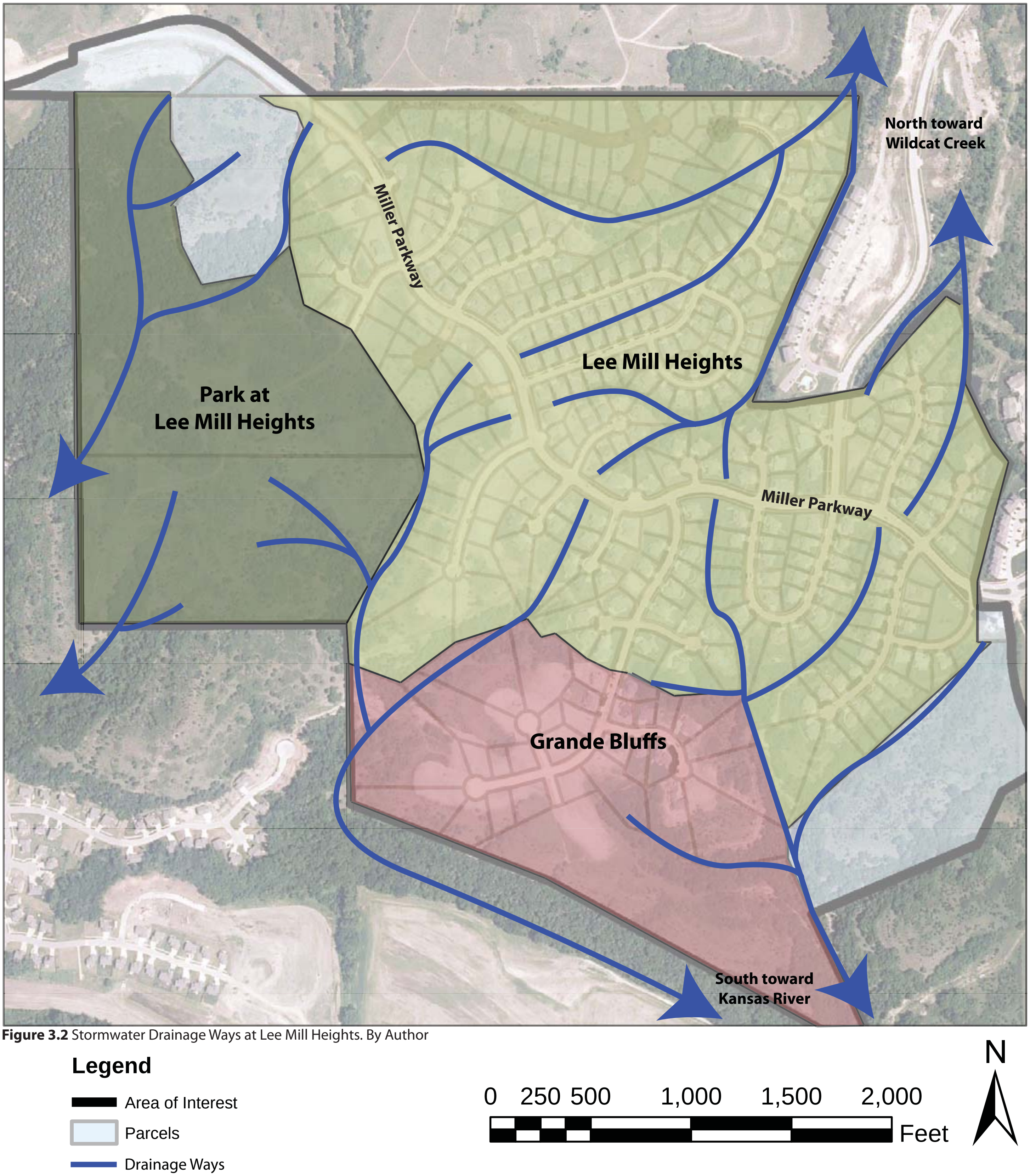


Figure 3.2 Stormwater Drainage Ways at Lee Mill Heights. By Author

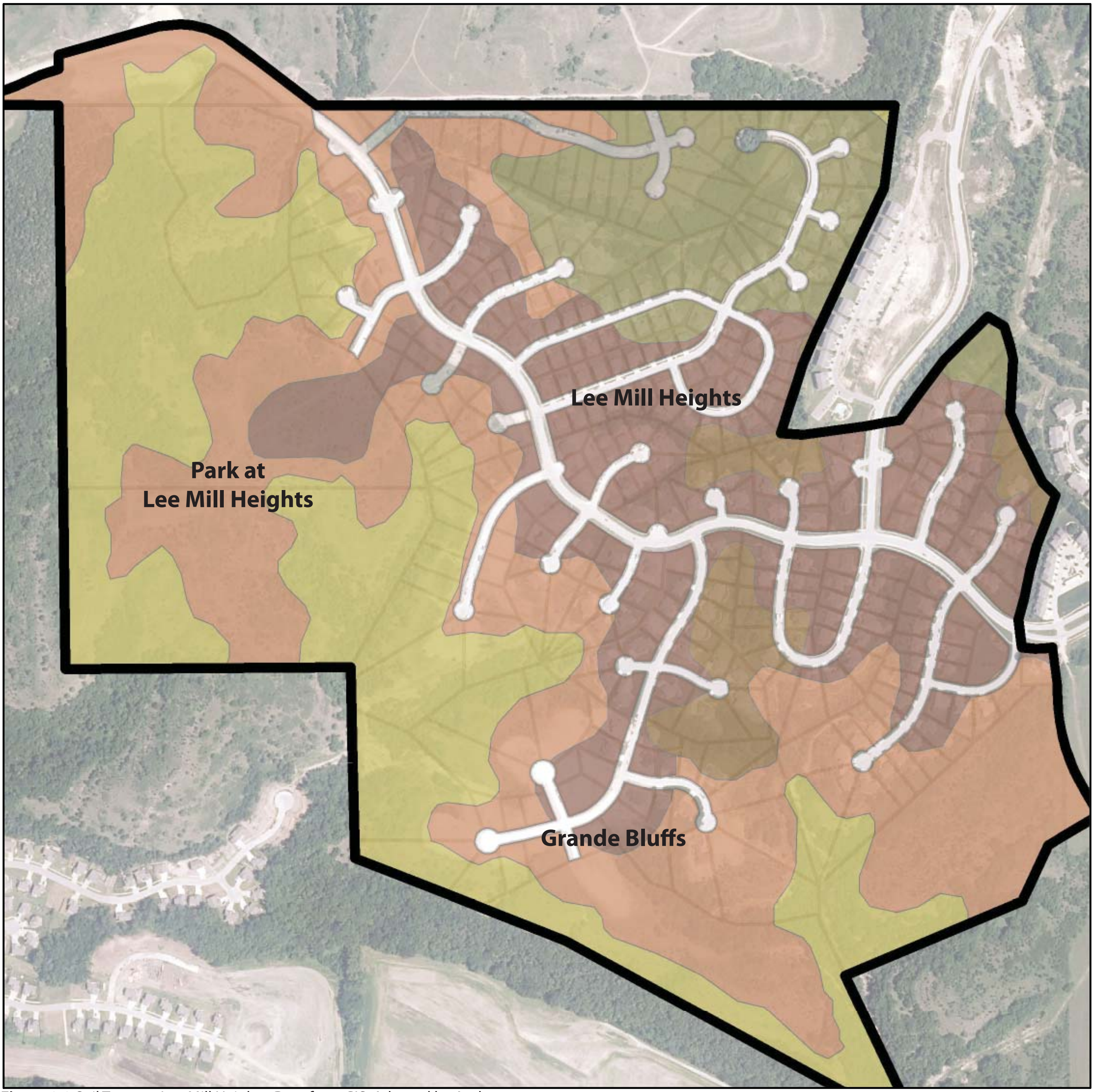
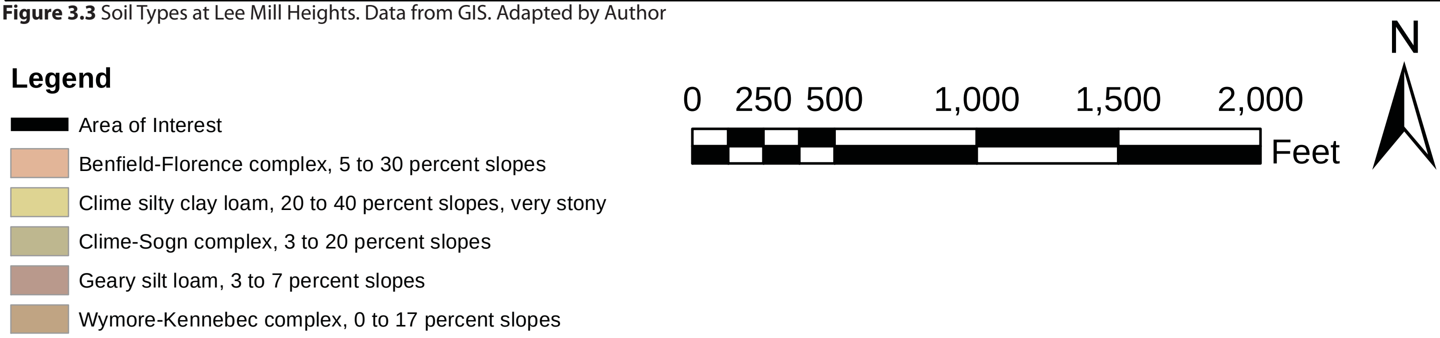


Figure 3.3 Soil Types at Lee Mill Heights. Data from GIS. Adapted by Author



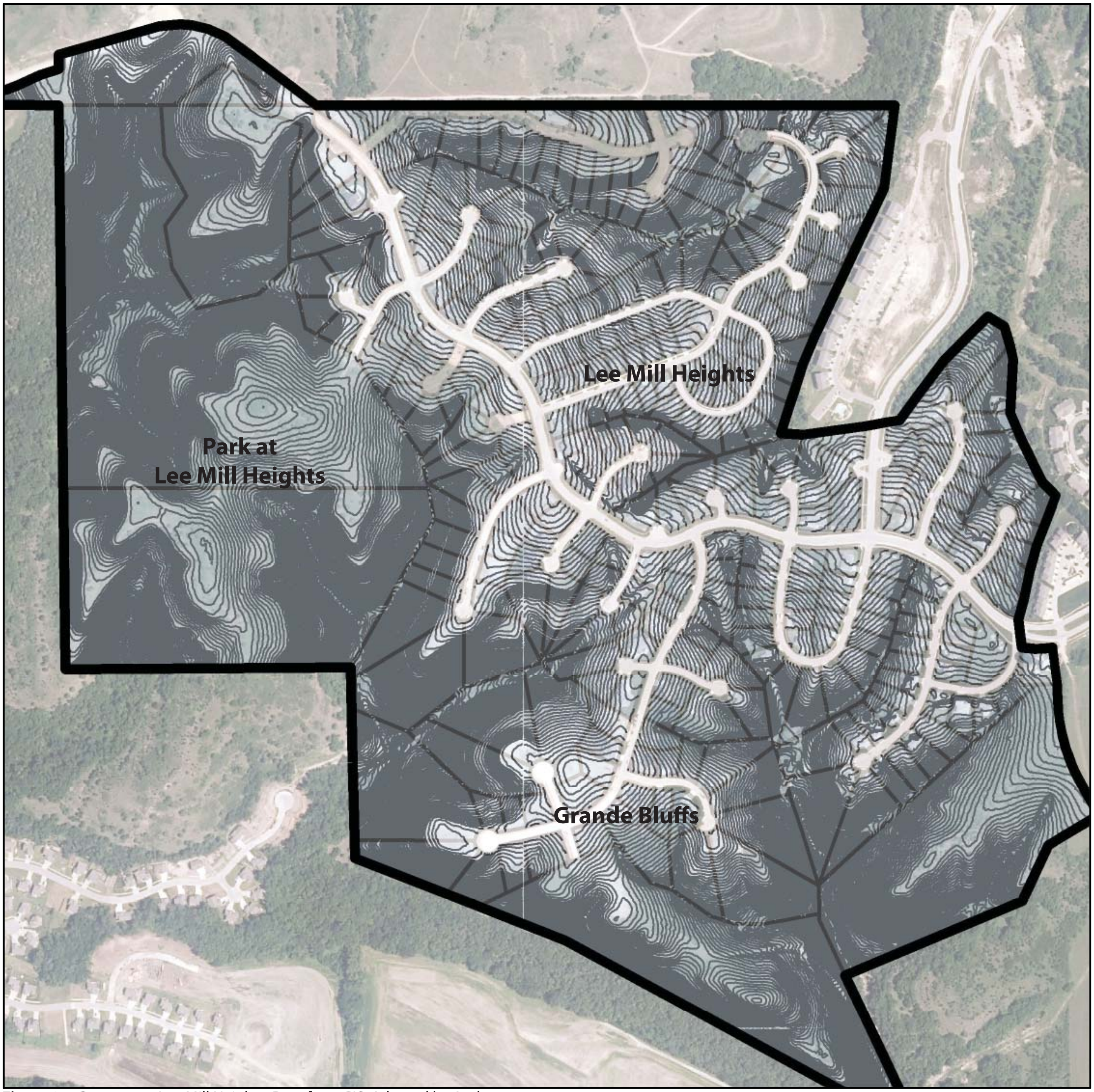
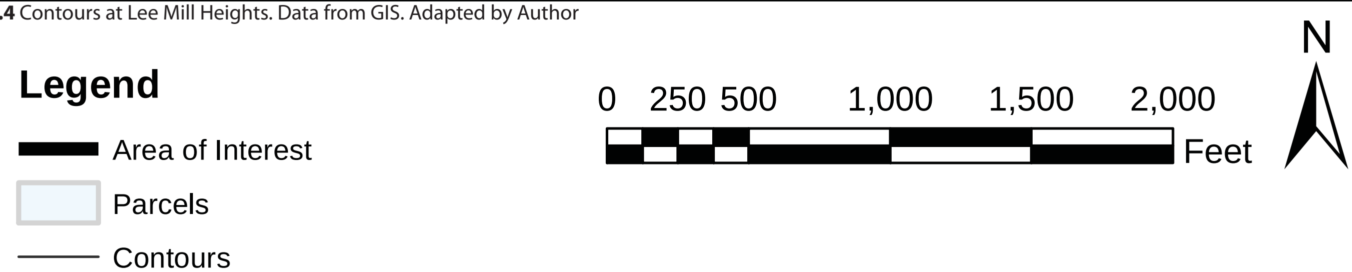


Figure 3.4 Contours at Lee Mill Heights. Data from GIS. Adapted by Author



2014 Land Use and Land Coverage

Another element analyzed was the 2014 land use and land coverage of Lee Mill Heights (Figure 3.5). The grey in the map depicts developed and disturbed areas. Disturbed areas are mostly new development occurring in the neighborhood. The yellowish tan color shows where the native grassland (prairie vegetation) is present within and around LMH. The light green represents deciduous trees mostly found within the native drainage ways. The dark green with red edging shows how prevalent the invasive Eastern Red Cedar has become in this area.

The Park at Lee Mill Heights demonstrates a perfect example of what an unattended prairie ecosystem can look like in a matter of years. The prominent prairie vegetation is slowly being consumed by the invasive Eastern Red Cedar. The new park presents an opportunity to restore the vibrant prairie ecosystem that once existed on site. Efforts by the city planning office are being made to design the park in a manner that engages the neighborhood and Manhattan area residents through outreach workshops and other educational methods.

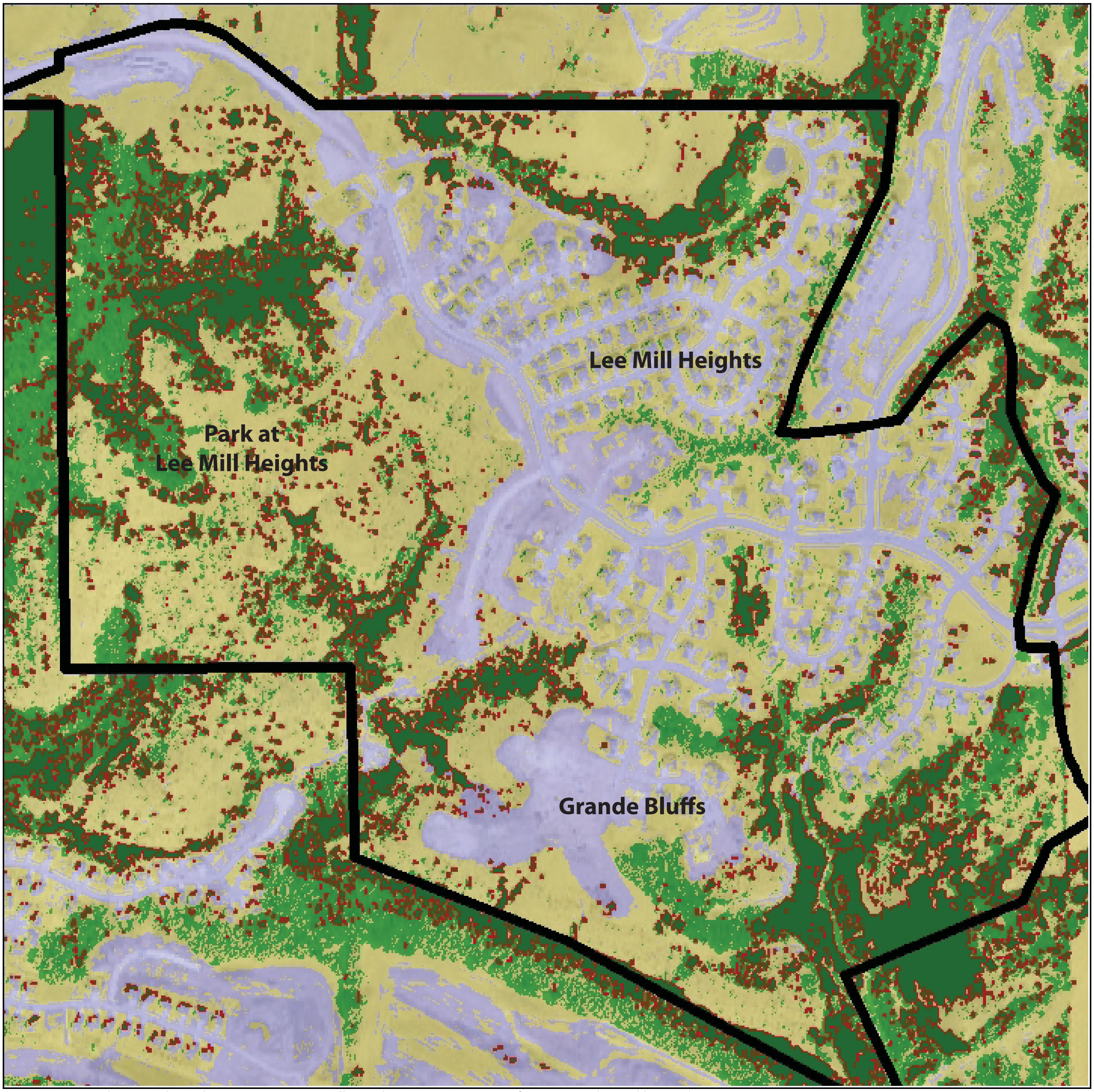
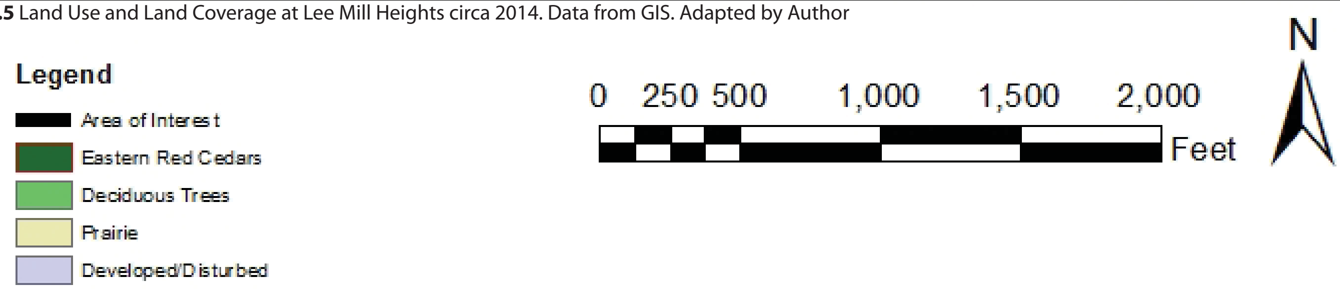


Figure 3.5 Land Use and Land Coverage at Lee Mill Heights circa 2014. Data from GIS. Adapted by Author



Historical Land Use and Land Coverage

Historical imagery from Google Earth PRO paints a picture on the past land use and coverage for the neighborhood of Lee Mill Heights. The oldest satellite image of the area was captured in 1991. The latest image was taken in 2014. This 23 year span shows a gradual change between 1991 and 2002. Four years later, in 2006, signs of construction can be seen. In the 2010 image, further expansion of LMH is shown. The last image taken in 2014 depicts most of what is now constructed today. Through the study of these images, the rational runoff method can be used on the five images to calculate the estimated amount of stormwater runoff.

The rational runoff method predicts peak runoff rates from data on rainfall intensity and drainage basin characteristics (Singh, 1992; Corbitt, 1999). Ideally, this method should be used only on areas of less than 200 acres. The total acreage of the LMH neighborhood is 195 acres. The rational runoff method was sufficient in expressing the estimated amount of stormwater runoff throughout the past 20 years.

Stormwater runoff is calculated using the formula Q=ciA. 'Q' is the peak rate of runoff in cubic feet per second. Some accepted values of 'c' are listed in Table 3.1. These values take into consideration land use and coverage of an area. In calculating and comparing the stormwater runoff of each chosen year, the 1991 image was used as the baseline condition.

Rainfall intensity (i) is chosen using the precipitation frequency table corresponding to the geographical area. In this case, Table 3.2 shows the precipitation frequency of various storm events. For the calculation at LMH, a storm event occurring every year and lasting 60 minutes was chosen for consistency.

The area (A) of each value corresponding to the specific coefficient was measured from each of the images captured in 1991, 2002, 2006, 2010, and 2014 (Figures 3.9 through 3.13). These maps display the measured area and how many acres per value for each ground cover type.

These calculations are used at the end of Chapter 5 for a comparison between past stormwater runoff totals and the change in runoff that may occur with the implementation of proposed landscpe retrofits.

Table of Coefficients for the Rational Runoff Method	
Ground Cover	**Runoff Coefficient**
Proposed Rain Garden	0.1
Proposed Native Vegetation	0.2
Prairie Grassland	0.2
Woodland	0.25
Residential	0.6

Table 3.1 Table of Coefficients for the Rational Runoff Method (Singh, 1991; Corbitt, 1999). Adapted by Author

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.414 (0.332-0.523)	0.484 (0.389-0.613)	0.605 (0.484-0.767)	0.711 (0.565-0.904)	0.863 (0.665-1.13)	0.986 (0.740-1.31)	1.11 (0.806-1.51)	1.25 (0.865-1.72)	1.44 (0.955-2.02)	1.59 (1.02-2.25)
10-min	0.605 (0.487-0.766)	0.709 (0.569-0.897)	0.886 (0.709-1.12)	1.04 (0.827-1.32)	1.26 (0.973-1.66)	1.44 (1.08-1.91)	1.63 (1.18-2.21)	1.83 (1.27-2.52)	2.10 (1.40-2.97)	2.32 (1.50-3.30)
15-min	0.738 (0.593-0.934)	0.865 (0.694-1.09)	1.08 (0.864-1.37)	1.27 (1.01-1.61)	1.54 (1.19-2.02)	1.76 (1.32-2.33)	1.99 (1.44-2.69)	2.23 (1.54-3.08)	2.57 (1.71-3.62)	2.83 (1.82-4.02)
30-min	1.04 (0.839-1.32)	1.23 (0.983-1.55)	1.53 (1.23-1.95)	1.80 (1.43-2.29)	2.19 (1.69-2.88)	2.51 (1.88-3.33)	2.84 (2.05-3.83)	3.18 (2.20-4.39)	3.66 (2.43-5.16)	4.04 (2.60-5.74)
60-min	1.36 (1.10-1.73)	1.60 (1.28-2.02)	2.00 (1.60-2.54)	2.36 (1.88-3.00)	2.89 (2.23-3.82)	3.33 (2.50-4.43)	3.80 (2.75-5.14)	4.29 (2.98-5.93)	4.99 (3.32-7.04)	5.54 (3.57-7.88)
2-hr	1.68 (1.37-2.10)	1.97 (1.59-2.46)	2.47 (1.99-3.09)	2.92 (2.34-3.67)	3.59 (2.81-4.70)	4.16 (3.16-5.47)	4.76 (3.48-6.38)	5.40 (3.78-7.40)	6.32 (4.24-8.84)	7.05 (4.59-9.93)
3-hr	1.88 (1.53-2.33)	2.19 (1.79-2.73)	2.76 (2.24-3.43)	3.27 (2.64-4.08)	4.04 (3.18-5.26)	4.69 (3.59-6.15)	5.39 (3.97-7.20)	6.14 (4.33-8.38)	7.22 (4.88-10.1)	8.09 (5.30-11.3)
6-hr	2.22 (1.82-2.72)	2.59 (2.13-3.18)	3.27 (2.68-4.02)	3.88 (3.16-4.79)	4.80 (3.81-6.17)	5.57 (4.30-7.21)	6.39 (4.75-8.44)	7.28 (5.18-9.82)	8.54 (5.83-11.8)	9.56 (6.33-13.3)
12-hr	2.55 (2.12-3.09)	3.00 (2.49-3.64)	3.79 (3.13-4.60)	4.48 (3.69-5.46)	5.50 (4.39-6.95)	6.33 (4.92-8.08)	7.20 (5.40-9.38)	8.13 (5.84-10.8)	9.43 (6.50-12.8)	10.5 (7.00-14.4)
24-hr	2.94 (2.47-3.52)	3.42 (2.87-4.09)	4.23 (3.54-5.08)	4.95 (4.12-5.96)	6.00 (4.84-7.49)	6.86 (5.38-8.64)	7.75 (5.87-9.97)	8.70 (6.31-11.5)	10.0 (6.98-13.5)	11.1 (7.48-15.0)
2-day	3.40 (2.88-4.01)	3.85 (3.26-4.55)	4.64 (3.92-5.50)	5.36 (4.50-6.37)	6.42 (5.24-7.93)	7.31 (5.81-9.12)	8.25 (6.33-10.5)	9.27 (6.80-12.1)	10.7 (7.54-14.3)	11.8 (8.09-15.9)
3-day	3.63 (3.10-4.25)	4.15 (3.54-4.87)	5.05 (4.29-5.94)	5.84 (4.93-6.90)	7.00 (5.74-8.56)	7.95 (6.35-9.82)	8.94 (6.88-11.3)	9.99 (7.37-12.9)	11.4 (8.11-15.2)	12.6 (8.67-16.9)

Table 3.2 Table of Precipitation Frequency: Manhattan, Kansas. Table from NOAA 2014

Rational Method Runoff Coefficients

The values for the coefficients can reflect various types of elements. These include soil type, topography, surface roughness, vegetation, and land use. For the purpose of these runoff calculations, a few of the coefficients were modified to better represent existing/proposed vegetation, land use, and topography.

Figure 3.6 shows the density of the woody vegetation found within the drainage ways. This image also shows the amount of slope that consistently occurs in this area. Although woody vegetation captures a lot of rainfall above and below ground, these areas lack abundant grasses and forbs and bare soil is not uncommon, leading to higher runoff rates than would be common in woodlands with abundant perennial understory conditions. A coefficient of 0.25 is used for the woodland value.

At one point, the prairie grassland covered most of what is now the Lee Mill Heights neighborhood. Since 2006, that has changed drastically as residential development began. Figure 3.7 depicts prairie grassland that is maintained just north of LMH. This type of vegetation contains an extensive root system that supports infiltration of stormwater. A coefficient of 0.2 is used to represent the prairie grassland.

The highest coefficient used in these calculations was the residential value. The reason for the higher coefficient was because of the increased runoff that is produced by the residential construction (Figure 3.8). Impervious elements such as roofs, concrete streets, and sidewalks affect the amount of stormwater runoff discharged from residential areas. Large open lawns help some with runoff but the standard fescue used on these properties have very short root systems (which doesn’t help much with infiltration). Many homeowners use a variety of herbicides, pesticides, and fertilizers to keep their lawns neat and tidy looking, presenting concerns in regards to water quality and pollinators. This is important to acknowledge since higher runoff rates can increase downstream pollution. A coefficient of 0.6 is used in the calculations for the residential value.

The proposed native vegetation has a similar coefficient as the prairie grassland with a 0.2 value. Rain gardens, which have shallow basins work well for slowing and holding stormwater runoff. The types of plants proposed (native grasses, sedges, and wildflowers) in tandem with the shallow basins have root systems which infiltrate the runoff faster than any other vegetation type on the coefficient table. Therefore, the proposed rain gardens are designated a coefficient of 0.1 in the calculations for stormwater runoff.

Figure 3.6 Woodland Example at LMH. By Lee R Skabelund

Figure 3.7 Prairie Grassland Example North of LMH. By Jonathan E Knight

Figure 3.8 Residential Example at LMH. By Jonathan E Knight

The image taken in 1991 depicts a great example of the native prairie found in the Flint Hills (Figure 3.9). At this point in time, the area was used for cattle grazing and much of the woody vegetation was contained within the steeper areas of the native drainage ways. The area of prairie grassland measured about 140 acres. The woodland vegetation measured approximately 55 acres. Applying the equation Q=ciA, the prairie grassland area discharges 38.08 cfs and the woodland 18.70 cfs (Table 3.3). This totals to 56.78 cubic feet per second of stormwater runoff. There are 7.47 gallons at 1 cfs. This means that the peak discharge for an intense rainfall of 1.36 inches in 60 minutes would have been equal to just over 420 gallons per second of stormwater runoff. This calculation assumes that all water goes to one point, but in fact there are multiple drainage ways, therefore, the volumes would be divided up per the size of each sub-basin.

Rational Method Equation for Stormwater Runoff Applied to Lee Mill Heights circa 1991		
	Rational Equation: Q=ciA	
	Q=Peak Discharge, cfs	
	c=Rational Method Runoff Coefficient	
	i=Rainfall Intensity, inch/hour	
	A=Drainage Area, acre	
Precipitation Frequency Curves for Manhattan, Kansas (NOAA,2014)		
i	One Year-60 Minute Rain Event in Inches	1.36
Rational Method Runoff Coefficients (Singh, 1991; Corbitt, 1999)		
c	Prairie Grassland	0.2
c	Woodland	0.25
c	Residential	0.6
Lee Mill Heights circa 1991		
A	Prairie Grassland Area in Acres	140
A	Woodland Area in Acres	55
A	Residential Area in Acres	0
	Peak Discharge (cfs) for Prairie Grassland Area =	**38.08**
	Peak Discharge (cfs) for Woodland Area =	**18.70**
	Peak Discharge (cfs) for Residential Area =	**0.00**
	Total Runoff in cfs =	**56.78**

Table 3.3 Rational Method Equation for Stormwater Runoff Applied to LMH circa 1991. By Author

1991

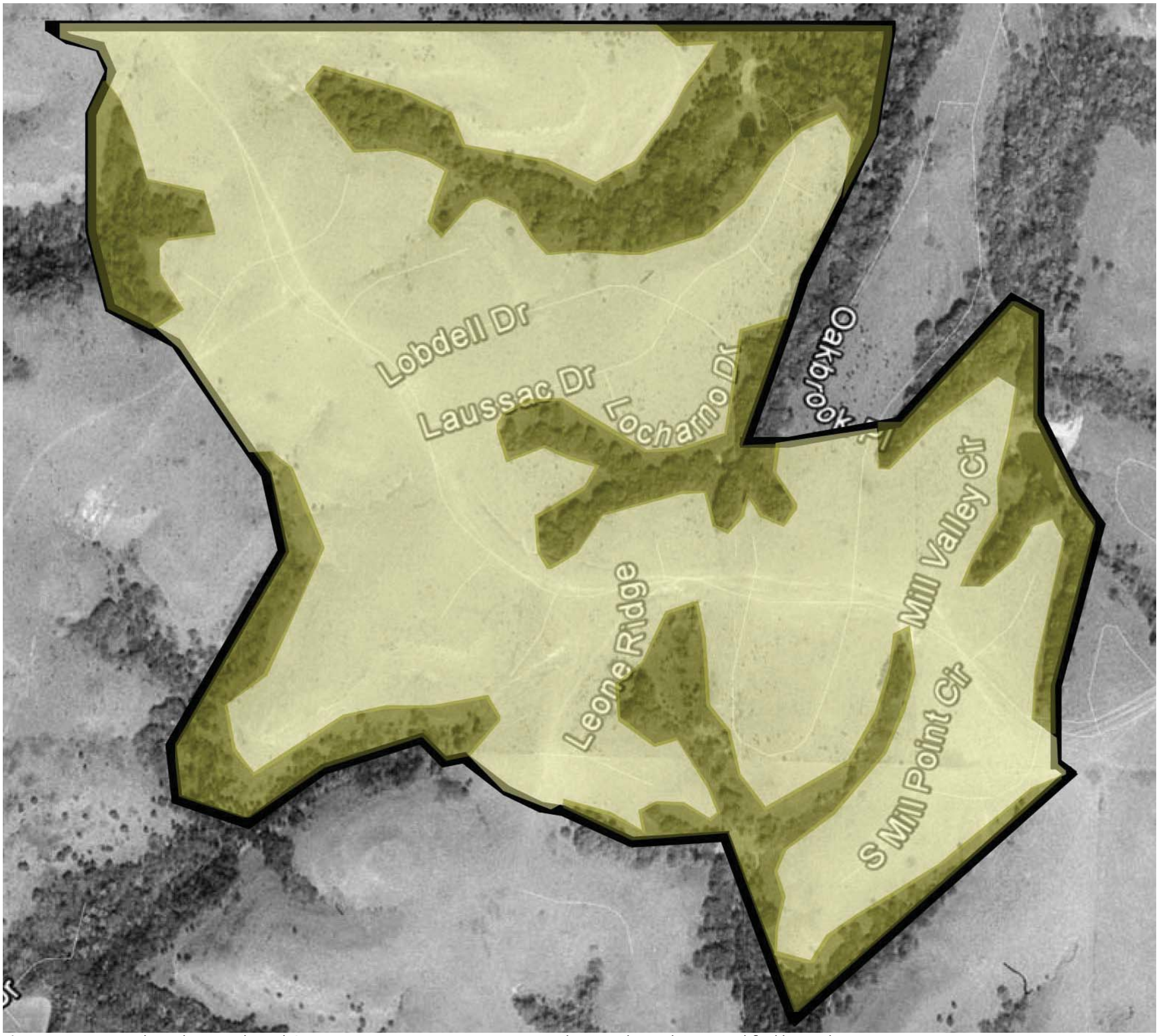


Figure 3.9 Historical Land Use and Land Coverage at LMH circa 1991. Base Map by Google Earth Pro. Modified by Author

Prairie Grassland: 140 acres

Woodland: 55 acres

Change in land use occurred sometime between 1991 and 2002. This can be seen from the clear appearance of Eastern Red Cedar (Figure 3.10). This invasive evergreen tends to spread when prairie grassland is no longer burned or regularly grazed. Due to the increase of cedar, total area of woodland vegetation increased by about 8 acres. The invasive woody vegetation, if left unmanaged can create a monoculture, and increase runoff from the site. With the values updated to incorporate the increase of woodland material and the decrease of prairie grassland, the total runoff was calculated to be at around 57.32 cfs (Table 3.4). Runoff rates in 2002 were thus estimated to be slightly higher than those in 1991.

Rational Method Equation for Stormwater Runoff Applied to Lee Mill Heights circa 2002		
	Rational Equation: Q=ciA	
	Q=Peak Discharge, cfs	
	c=Rational Method Runoff Coefficient	
	i=Rainfall Intensity, inch/hour	
	A=Drainage Area, acre	
Precipitation Frequency Curves for Manhattan, Kansas (NOAA,2014)		
i	One Year-60 Minute Rain Event in Inches	1.36
Rational Method Runoff Coefficients (Singh, 1991; Corbitt, 1999)		
c	Prairie Grassland	0.2
c	Woodland	0.25
c	Residential	0.6
Lee Mill Heights circa 2002		
A	Prairie Grassland Area in Acres	132
A	Woodland Area in Acres	63
A	Residential Area in Acres	0
	Peak Discharge (cfs) for Prairie Grassland Area =	**35.90**
	Peak Discharge (cfs) for Woodland Area =	**21.42**
	Peak Discharge (cfs) for Residential Area =	**0.00**
	Total Runoff in cfs =	**57.32**

Table 3.4 Rational Method Equation for Stormwater Runoff Applied to LMH circa 2002. By Author

2002

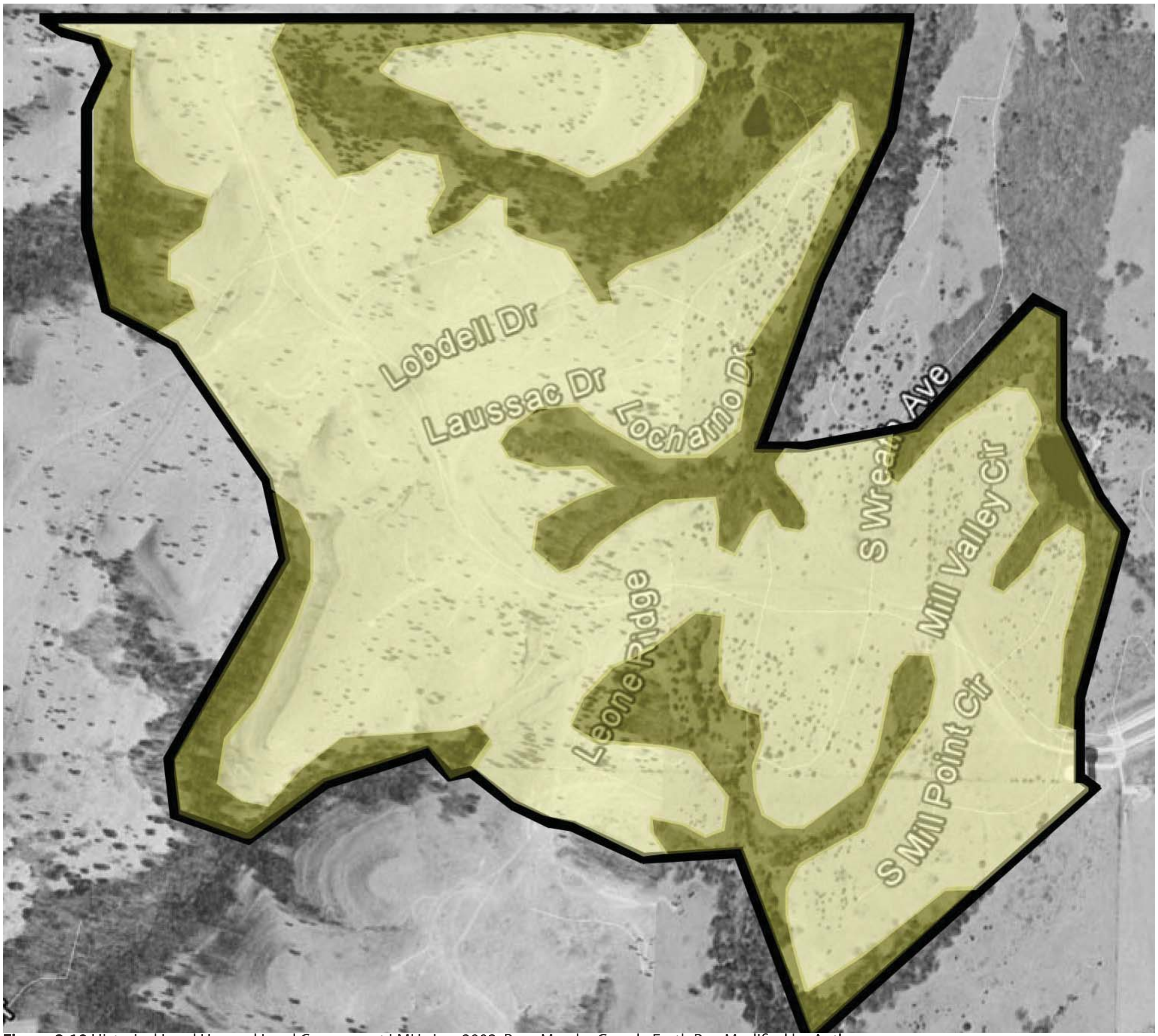


Figure 3.10 Historical Land Use and Land Coverage at LMH circa 2002. Base Map by Google Earth Pro. Modified by Author

Prairie Grassland: 132 acres

Woodland: 63 acres

As seen in Figure 3.11, site work and some residential housing began to take shape in 2006. Roughly 36 acres of prairie grassland was substituted with residential construction. Conservation of the woodland drainage system was left intact for the most part in 2006. The area of prairie grassland was measured at 94 acres. This was a decrease of 33% in comparison to the prairie measured in the 1991 image. The woodland vegetation increased by a few acres to 65. With these new parameters, the stormwater runoff was calculated to be 77.04 cfs (Table 3.5). Between 1991 and 2006, the runoff increased by 36% through the addition of 36 acres of residential construction.

Rational Method Equation for Stormwater Runoff Applied to Lee Mill Heights circa 2006		
	Rational Equation: Q=ciA	
	Q=Peak Discharge, cfs	
	c=Rational Method Runoff Coefficient	
	i=Rainfall Intensity, inch/hour	
	A=Drainage Area, acre	
Precipitation Frequency Curves for Manhattan, Kansas **(NOAA,2014)**		
i	One Year-60 Minute Rain Event in Inches	1.36
Rational Method Runoff Coefficients **(Singh, 1991; Corbitt, 1999)**		
c	Prairie Grassland	0.2
c	Woodland	0.25
c	Residential	0.6
Lee Mill Heights circa 2006		
A	Prairie Grassland Area in Acres	94
A	Woodland Area in Acres	65
A	Residential Area in Acres	36
	Peak Discharge (cfs) for Prairie Grassland Area =	**25.57**
	Peak Discharge (cfs) for Woodland Area =	**22.10**
	Peak Discharge (cfs) for Residential Area =	**29.38**
	Total Runoff in cfs =	**77.04**

Table 3.5 Rational Method Equation for Stormwater Runoff Applied to LMH circa 2006. By Author

2006

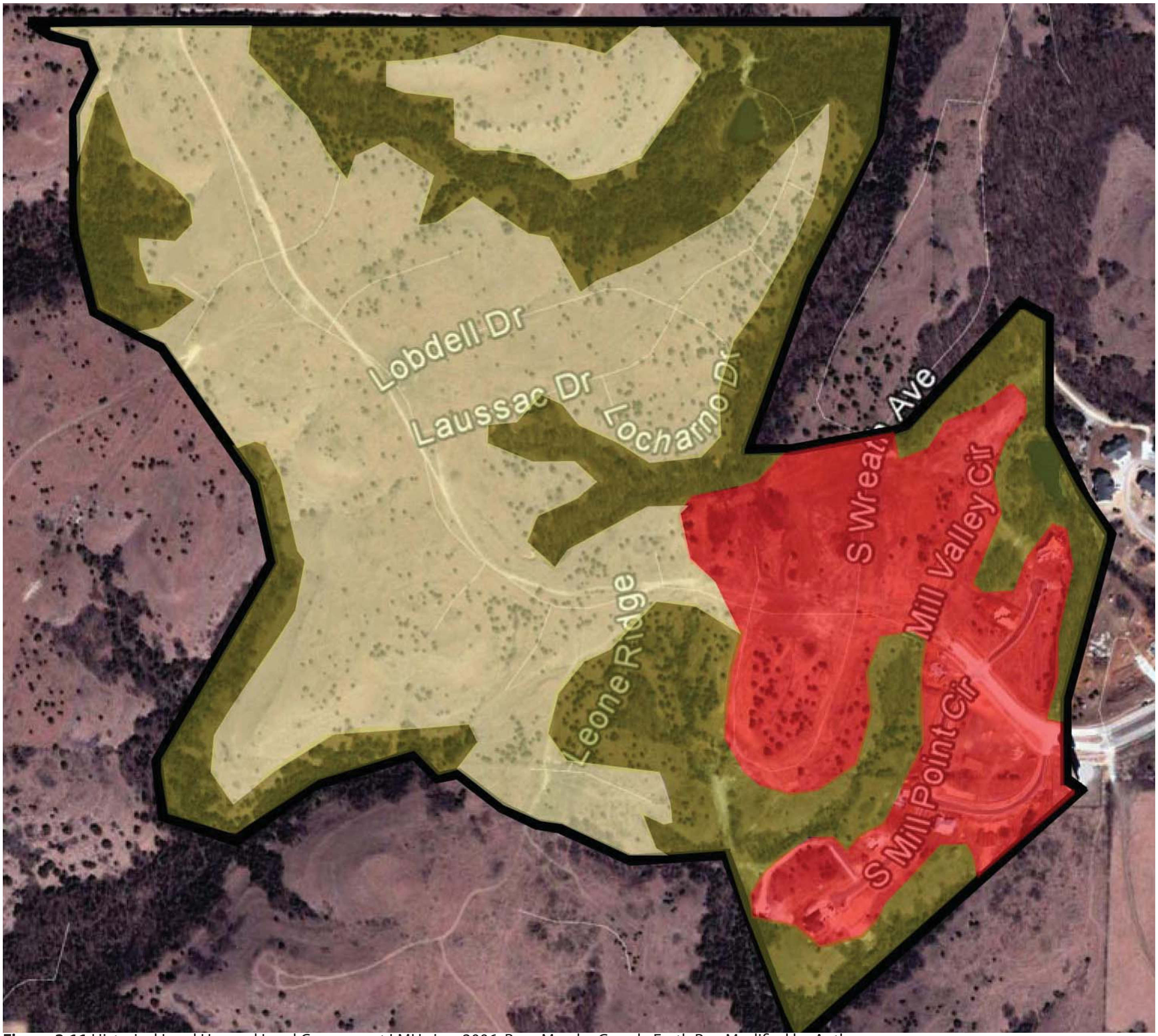


Figure 3.11 Historical Land Use and Land Coverage at LMH circa 2006. Base Map by Google Earth Pro. Modified by Author

- Prairie Grassland: 94 acres
- Woodland: 65 acres
- Residential: 36 acres

The greatest expanse of residential construction occurred in the four years between 2006 and 2010 (Figure 3.12). Roughly 57 additional acres were developed for LMH. Prairie grassland was reduced to about 52 acres and woodland vegetation to around 50 acres. By 2010, 48% of the area designated as LMH was now covered with residential housing.

Plugging these new parameters into the rational method for runoff equation provided an obvious increase in stormwater runoff with 107.03 cfs (Table 3.6). In comparison to the runoff from 1991, that is an 89% increase of stormwater generated from the 93 acres of residential construction.

Rational Method Equation for Stormwater Runoff Applied to Lee Mill Heights circa 2010		
	Rational Equation: Q=ciA	
	Q=Peak Discharge, cfs	
	c=Rational Method Runoff Coefficient	
	i=Rainfall Intensity, inch/hour	
	A=Drainage Area, acre	
Precipitation Frequency Curves for Manhattan, Kansas **(NOAA,2014)**		
i	One Year-60 Minute Rain Event in Inches	1.36
Rational Method Runoff Coefficients **(Singh, 1991; Corbitt, 1999)**		
c	Prairie Grassland	0.2
c	Woodland	0.25
c	Residential	0.6
Lee Mill Heights circa 2010		
A	Prairie Grassland Area in Acres	52
A	Woodland Area in Acres	50
A	Residential Area in Acres	93
	Peak Discharge (cfs) for Prairie Grassland Area =	**14.14**
	Peak Discharge (cfs) for Woodland Area =	**17.00**
	Peak Discharge (cfs) for Residential Area =	**75.89**
	Total Runoff in cfs =	**107.03**

Table 3.6 Rational Method Equation for Stormwater Runoff Applied to LMH circa 2010. By Author

2010

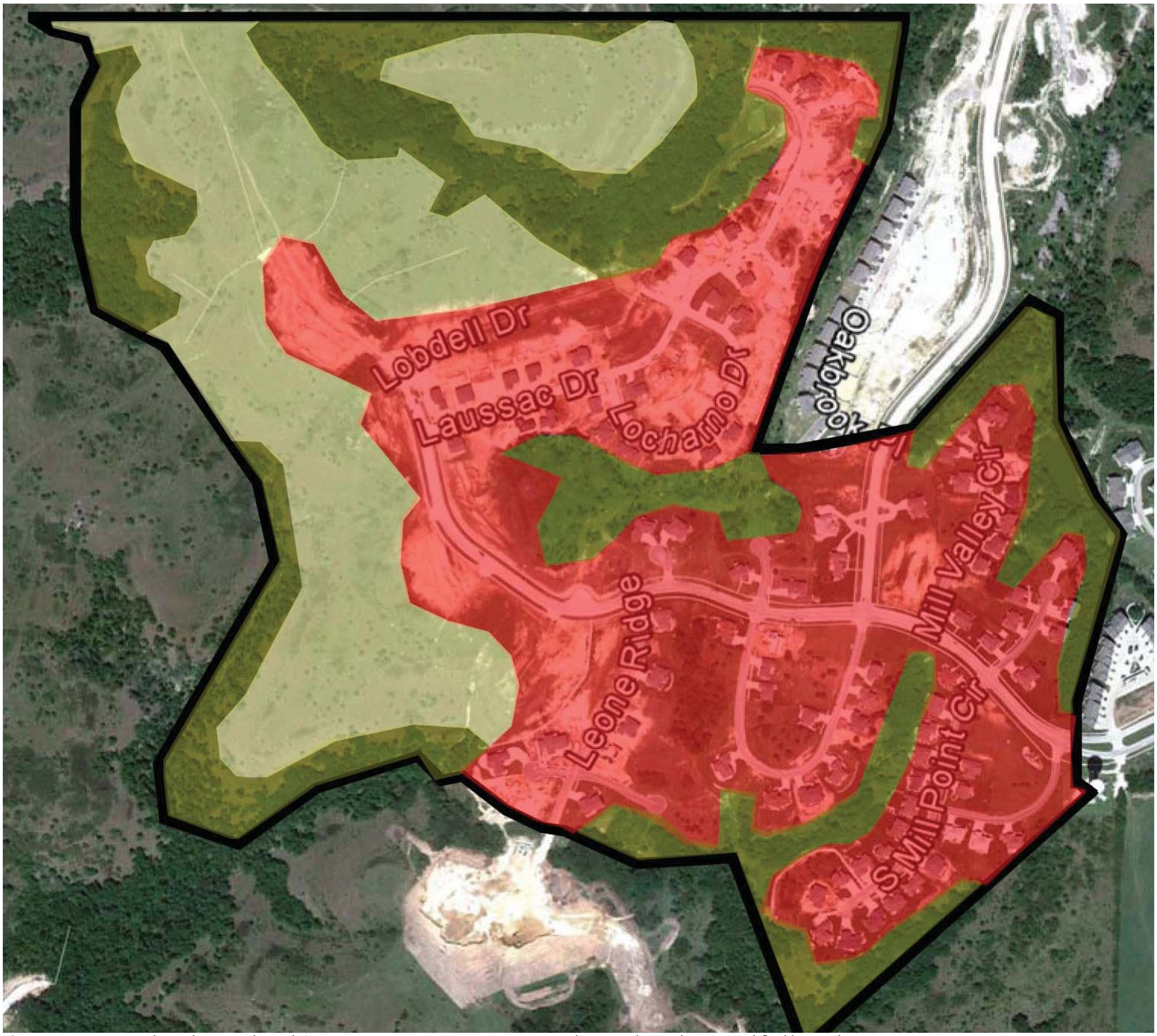


Figure 3.12 Historical Land Use and Land Coverage at LMH circa 2010. Base Map by Google Earth Pro. Modified by Author

Prairie Grassland: 52 acres

Woodland: 50 acres

Residential: 93 acres

The latest image available was from 2014 (Figure 3.13). In the four years since the previous image, construction continued with an additional 29 acres of residential housing and totaling 122 acres. Prairie grassland area was reduced to 28 acres and woodland to about 45 acres. At this point, the native prairie grassland is almost non-existent on site. For the most part, the use of conservation easements during the residential construction saved most of the woodland native drainageways. However, with these new numbers for each value, total runoff from the site was about 122.47 cfs. In comparison to the calculation from the 1991 image, an increase in stormwater runoff of 116% occurred between 1991 and 2014. This percentage continued to increase as more of LMH was developed between 2014 and 2016.

Rational Method Equation for Stormwater Runoff Applied to Lee Mill Heights circa 2014		
	Rational Equation: Q=ciA	
	Q=Peak Discharge, cfs	
	c=Rational Method Runoff Coefficient	
	i=Rainfall Intensity, inch/hour	
	A=Drainage Area, acre	
Precipitation Frequency Curves for Manhattan, Kansas (NOAA,2014)		
i	One Year-60 Minute Rain Event in Inches	1.36
Rational Method Runoff Coefficients (Singh, 1991; Corbitt, 1999)		
c	Prairie Grassland	0.2
c	Woodland	0.25
c	Residential	0.6
Lee Mill Heights circa 2014		
A	Prairie Grassland Area in Acres	28
A	Woodland Area in Acres	45
A	Residential Area in Acres	122
	Peak Discharge (cfs) for Prairie Grassland Area =	**7.62**
	Peak Discharge (cfs) for Woodland Area =	**15.30**
	Peak Discharge (cfs) for Residential Area =	**99.55**
	Total Runoff in cfs =	**122.47**

Table 3.7 Rational Method Equation for Stormwater Runoff Applied to LMH circa 2014. By Author

2014

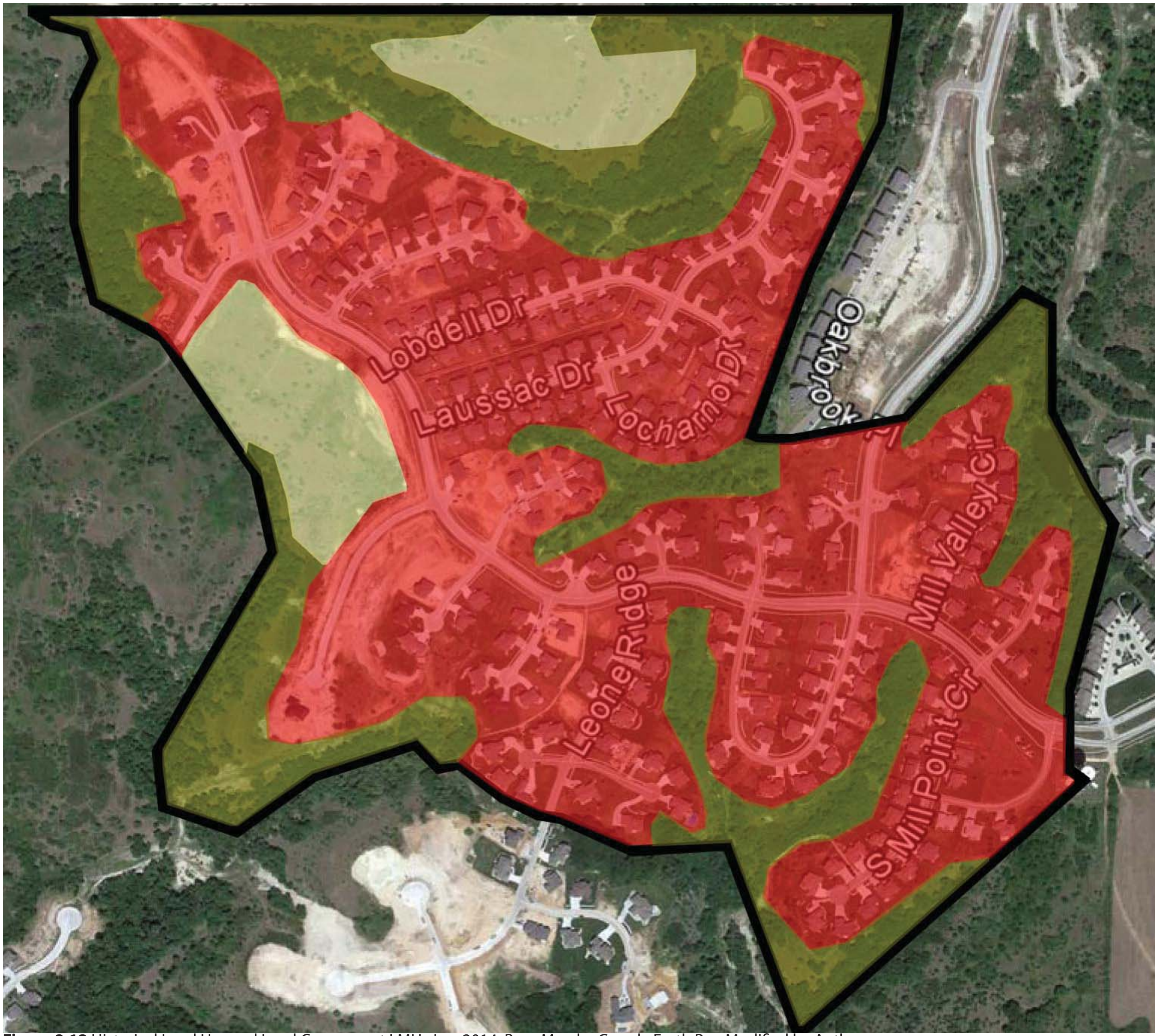


Figure 3.13 Historical Land Use and Land Coverage at LMH circa 2014. Base Map by Google Earth Pro. Modified by Author

Prairie Grassland: 28 acres (these two areas were built out by 2016)

Woodland: 45 acres

Residential: 122 acres

Precedent Studies

Firms such as the Conservation Design Forum, Andropogon Associates, Applied Ecological Services (AES), are designing with a strong foundation in relation to the science of ecology. The reason these three firms were chosen is because of their experience with prairie systems and native landscape planning, design, and ecological restoration and management.

AES developed what they call an Ecological Systems Approach. Mensing (2004) lists the AES conservation development principles as follows:

1. Preserve the integrity, vitality and sustainability of natural systems;
2. Integrate natural resource protection with development;
3. Employ environmental engineering principles to manage stormwater runoff (i.e., mimic natural systems);
4. Restore damaged ecological systems;
5. Buffer natural resources;
6. Ensure protection and management over the long term;
7. Encourage native landscaping; and
8. Provide opportunities for ecological education and volunteer stewardship.

Doug Mensing, AES Senior Ecologist, stressed the importance of each site's intended functions (Mensing, pers. comm. October 2015). Intended uses and landscape functions are key concerns to discuss with each homeowner as part of the retrofit design process.

Andropogon Associates is a firm that provides a variety of services which include: landscape architecture, regional planning, LEED strategies, and master planning. This firm is committed to the principle of designing with nature through the creation of beautiful landscapes inspired by the careful observation of natural processes and informed by the best environmental science (ARW, 2014).

Dinep and Schwab (2010) list the firm's framework for sustainable design as follows:

1. Create a participatory design process;
2. Preserve and re-establish landscape patterns;
3. Reinforce the natural infrastructure
4. Conserve resources;
5. Make a habit of restoration;
6. Evaluate solutions in terms of their larger context;
7. Create model situations based on natural processes;
8. Foster biodiversity;
9. Retrofit derelict lands;
10. Integrate historic preservation and ecological management;
11. Develop a monitored landscape management program; and
12. Promote an ecological aesthetic.

Andropogon Associates' goal is to understand and express the character of each location they are working on. Their "approach is to build dynamic, holistic systems and establish a healthy web of relationships" (ARW, 2014). Many of these design principles can be applied to existing exurban neighborhoods such as Lee Mill Heights.

Conservation Design Forum (CDF) is another firm worth investigating for design principles that can be applied to existing landscapes. CDF believes in strengthening the relationships between humans and their natural environments through creative design. They also strive to deliver the highest quality service and products to their clients through ecological land planning, design, engineering, and management (CDF, 2015). CDF's approach to design focuses on the following:

1. Collaboration
2. Uniqueness of place
3. Rainwater
4. Human integration

CDF is able to integrate ideas because it offers a multi-disciplinary team that includes landscape architects, planners, botanists, biologists, ecologists, civil engineers, hydrologists, artists, and craftsmen. The firm's unique approach to planning and design is founded in an appreciation for freshwater ecosystems. The CDF "is a nationally recognized design firm that explores and creates integrated, water-based design strategies that promote economic, social, and ecological sustainability" (CDF, 2015). CDF's integrative use and management of water is of value to any neighborhood or community looking to conserve water and create resilient landscape systems.

Figure 3.14 Applied Ecological Services. By AES

Figure 3.15 Conservation Design Forum. By CDF

Figure 3.16 Andropogon Associates. By AA

Applied Ecological Services
Prairie Crossing-Grayslake, Illinois

Prairie Crossing is a conservation subdivision that occupies 40% of a 677-acre site northwest of Chicago, Illinois (Figure 3.17). The other 60 percent of the development is protected open land used by its residents and wildlife. The land that is now Prairie Crossing was purchased in the late 1980s with the intention to preserve open space and farmland. Prairie Crossing was founded with ten principles established by the community's founders. These principles are: environmental protection and enhancement, healthy lifestyle, sense of place, sense of community, economic and racial diversity, convenient and efficient transportation, energy conservation, lifelong learning and education, aesthetic design and high-quality construction, and economic viability (Prairie Crossing, 2009).

Although they are very different types of residential developments, there are some similarities between Lee Mill Heights and Prairie Crossing. Both developments are within a prairie ecological regime and also contain conservation easements. LMH does not have the extent of extensive conservation easements as Prairie Crossing but there is the recognition of the need to conserve drainageways and associated vegetation along drainage and conservation easements. Prairie Crossing is a prime example of what can be achieved when collaborators have a clear goal before construction commences.

Prairie Crossing Development Goals

- Treatment of stormwater runoff
- Conserve natural processes occurring on site
- Restore over 200 acres back to native prairie
- Involve community in the conservation process

Similarities between Prairie Crossing and Lee Mill Heights

- Conservation easements
- Prairie ecological regime

Differences between Prairie Crossing and Lee Mill Heights

- Prairie Crossing was a greenfield project; Lee Mill Heights would require infill of ecologically-inspired retrofits
- Grade (elevation) changes at LMH are greater than that of Prairie Crossing
- Prairie Crossing is part of a natural and forest preserve; Lee Mill Heights is far less compact in regards to housing density and is within the city limits of Manhattan, Kansas

Figure 3.17 Prairie Crossing-Graylake, Illinois. By AES

Applied Ecological Services used their trademark Stormwater Treatment Train in the construction of Prairie Crossing. This system is composed of open swale stormwater conveyance and upland prairie biofiltration. These methods help remove pollutants through biological and mechanical means. The Stormwater Treatment Train system is designed to emulate the hydrologic behavior of the pre-settlement landscape. "Whether on a watershed scaled or on any specific site, alternative stormwater management systems can be designed using natural systems such as wetlands, prairies, and bioswales to clean the water of our waterways, to mitigate flooding impacts, and to provide healthy fish and wildlife habitat. In short, alternative stormwater management uses healthy natural landscapes to provide a higher quality of life in our communities" (Stormwater Management, 2013). Similar design elements can be used on developments like Lee Mill Heights (Figure 3.18).

Figure 3.18 Prairie Crossing-Bioswale. By AES

AES also took this opportunity to increase wildlife and pollinator habitat by reestablishing native prairie grasses and wildflowers (Figure 3.19). Well-established native grasses don't typically support many pollinators but they have many other values (they shade and protect soils, prevent erosion, sequester carbon, and provide seed and cover for a variety of wildlife). The inclusion of native plants through the use of meadow landscapes replaces areas disturbed by development and helps revitalize and restore essential ecological processes. Meadow restoration within homeowner association common areas lowers maintenance requirements and is a sustainable transformation from the monoculture of traditional turfgrass. Seasonal interest happens with the changing colors that occur throughout the year and blooms from spring to fall. From a safety perspective (fire and snakes) separation of larger areas of native grasses and wildflowers from homes (with a turfgrass fire-break) would be helpful at LMH.

Figure 3.19 Prairie Crossing-Native Plantings. By AES

Andropogon Associates

Ray and Joan Kroc Corps Community Center-Philadelphia, Pennsylvania

The Ray and Joan Kroc Corps Community Center in Philadelphia, Pennsylvania was constructed in partnership with the architecture firm MGA Partners, Inc (Figure 3.20). The whole project cost over $54 million with the landscaping costing $6.8 million. The 12-acre site was a contaminated brownfield previously used for industrial purposes. Andropogon Associates tried a zero net waste approach to the site construction. Most of the site's pavement was recycled and reused within the construction. Contaminated soil was intentionally buried using a complex grading scheme but some toxic soil had to be removed off-site completely due to EPA regulations (Andropogon, 2015).

Figure 3.20 The Ray and Joan Kroc Corps Community Center-Aerial View. By AA

A major concept for this project was stormwater management. A variety of components were used such as: rain gardens, bioswales, porous asphalt, porous pavement, and rainwater cisterns (Figure 3.21). The stormwater system captures almost 100% of the first two inches of stormwater runoff from the site and building (Figure 3.22). The landscape design uses native plants to create upland, lowland, and wetland habitats. Pollinators and some bird species have been seen on site since the implementation of the project. The design strategies implemented on site have increased the ecological quality by 34 times that of the former site (Andropogon, 2015).

Ray and Joan Kroc Corps Community Center Development Goals

- Recreational facilities
- Job training
- Educational and spiritual programs for the adjacent neighborhoods
- Involve community in the conservation process
- Treatment of stormwater runoff

Similarities between Ray and Joan Kroc Corps Community Center and Lee Mill Heights

- Stormwater runoff treatment

Differences between Ray and Joan Kroc Corps Community Center (RJKCCC) and Lee Mill Heights (LMH)

- LMH is a residential project; RJKCCC is a commercial project
- RJKCCC was a brownfield project; LMH would be an infill project

The RJKCCC project utilizes rain gardens, bio-swales, permeable hardscapes, and rainwater cisterns. These same design components can be applied to residential projects but at a smaller scale. Rain gardens can be applied to areas of all kinds of terrain and conditions as they can be designed to fit soils, slopes, and existing topography. If necessary, regrading can be done in order to better handle the flow of water from each site.

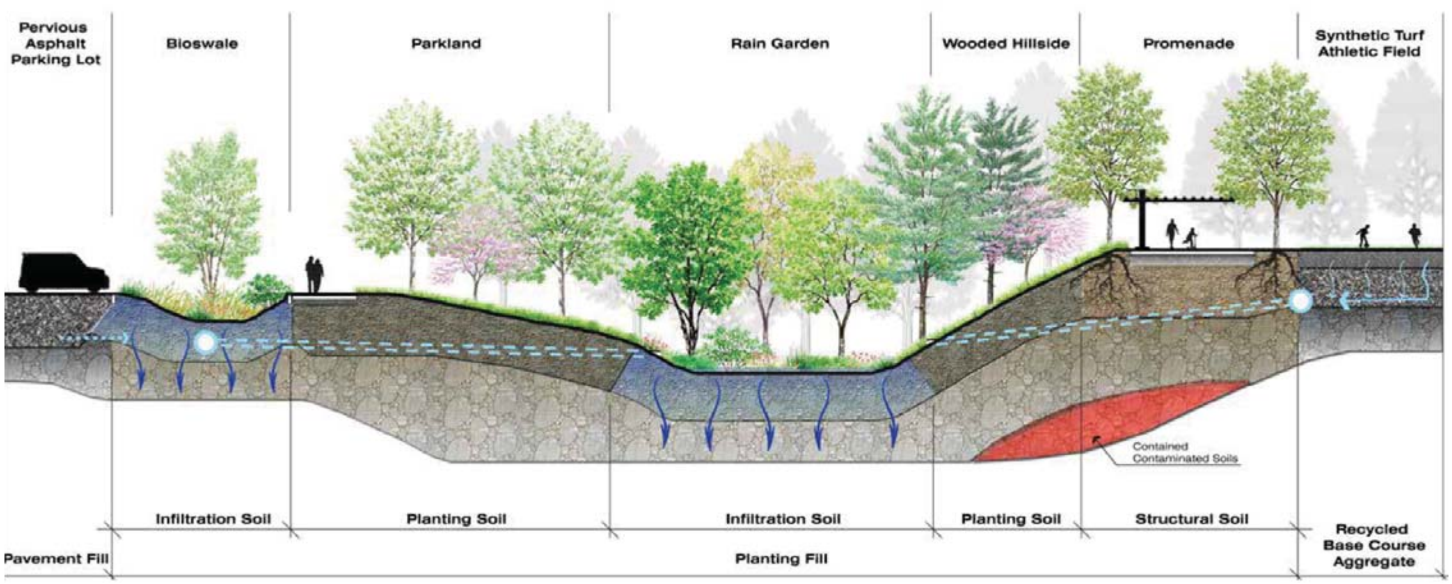


Figure 3.21 The Ray and Joan Kroc Corps Community Center-Soils Cross Section. By AA

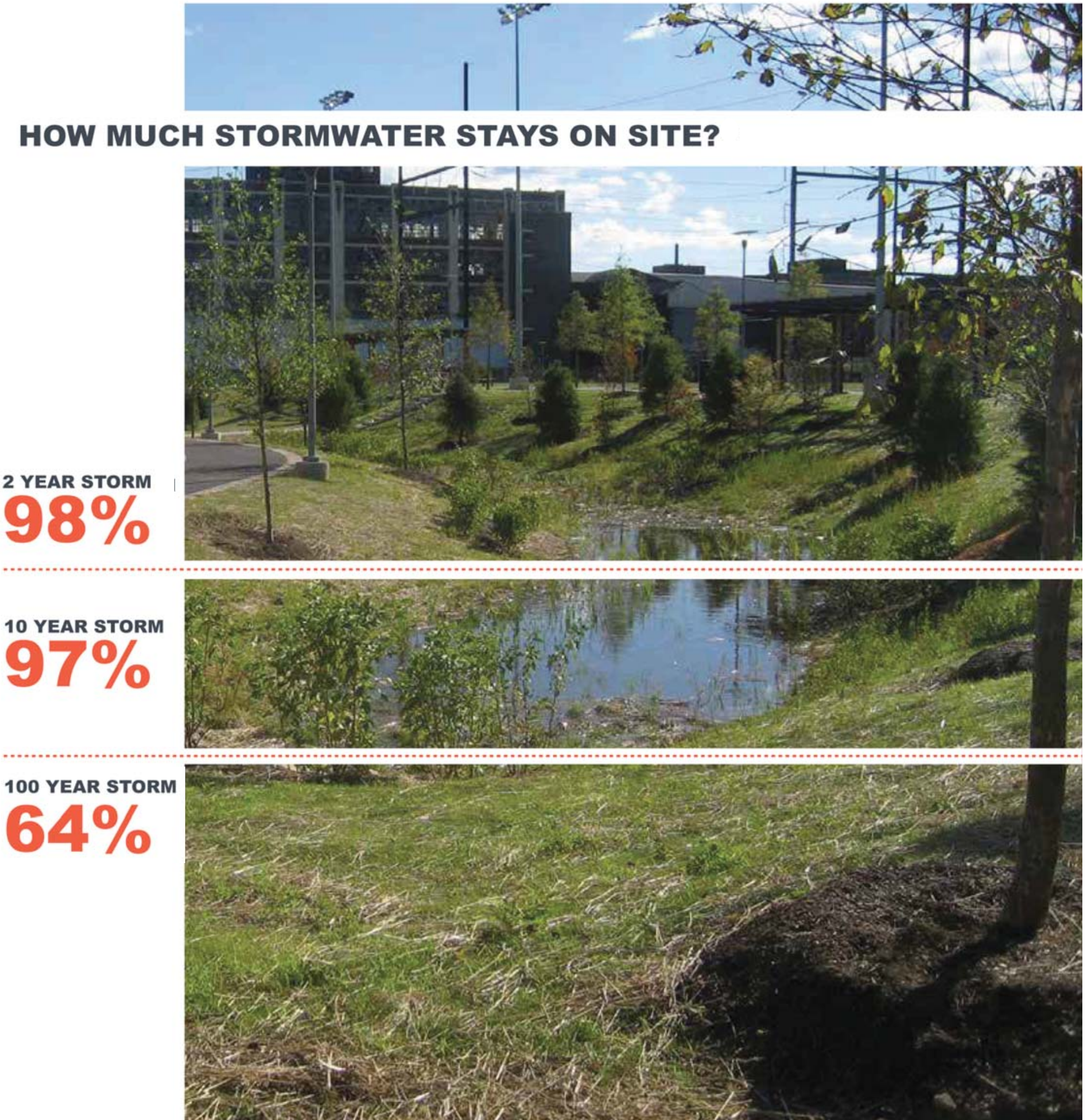


Figure 3.22 The Ray and Joan Kroc Corps Community Center-Stormwater Statistics. By AA

Conservation Design Forum
Dailey Road Neighborhood-Dowagiac, Michigan

The Dailey Road Neighborhood project by Conservation Design Forum (CDF) won the HUD Best Practices in Innovation in 2005. CDF was contracted by the Pakagon Band of Potawatomi Indians from Dowagiac, Michigan, to plan and implement the Band's first housing community. Part of the Band's Tribal Mission strives to provide a high quality of life to its members while preserving Mother Earth. CDF and the Pakagon Band worked together in the creation of a community master plan that highlights the restored natural woodlands, prairies, and wetlands (Dailey, 2015).

The master plan was designed to be implemented in multiple phases (Figure 3.23). The first phase is located at Dailey Road and it incorporates green infrastructure components including bioswales, rain gardens, and flat-curbed streets to maximize stormwater cleansing and infiltration (Figure 3.24).

The homes were arranged in a manner to view the restored natural landscapes within the neighborhood. Figure 3.25 shows how CDF deliberately extends native vegetation from the surrounding prairie near and into homeowner properties. Front porches provide space for outdoor enjoyment, visits with neighbors, and native landscape systems in the form of pollinator meadows (see Figures 3.26 & 3.27).

Figure 3.23 Dailey Road Neighborhood-Community Master Plan. By CDF

Figure 3.24 Dailey Road Neighborhood-Phase 1. By CDF

Dailey Road Neighborhood Development Goals

- Bioswales
- Native landscape systems
- Rain gardens
- Remnant landscape restoration

Similarities between Dailey Road Neighborhood and Lee Mill Heights

- Residential project
- Prairie ecological regime

Differences between Dailey Road Neighborhood and Lee Mill Heights

- Dailey Road Neighborhood was a greenfield project; Lee Mill Heights would require infill of ecologically-inspired retrofits
- Native plants extend into the properties within Dailey Road; LMH currently maintains a traditional landscape
- Dailey Road contains more pedestrian pathways and trails than LMH

The Dailey Road Neighborhood development goals are similar goals proposed for Lee Mill Heights. Both projects are residential in nature and are within a similar prairie ecological regime.

Figure 3.25 Dailey Road Neighborhood-Aerial View. By CDF

Figure 3.26 Dailey Road Neighborhood-Front Porch Pollinator Plantings. By CDF

Figure 3.27 Dailey Road Neighborhood-Multiple Houses with Pollinator Plantings. By CDF

Homeowner Survey and Post-Survey Interviews

Hard-copies of the survey were distributed at the annual Lee Mill Heights homeowner's association meeting. The meeting took place on February 2nd, 2016. Electronic correspondence with the executive council gave the researcher the opportunity to ask for permission to attend the meeting. The executive council granted permission and gave the researcher five minutes at the end of the meeting to discuss the project and cover a few details about the survey. The purpose of the survey was briefly discussed and a deadline of February 27th, 2016 set for the return of the surveys.

Forty-four surveys were distributed at the HOA meeting. Seven more were distributed a few days after the HOA meeting while the researcher was in the neighborhood during five visitations with homeowners. Of the fifty-one surveys distributed, 20 surveys were returned. That is a 39% return rate. Granted, the initial distribution was a small sample geared mostly toward those in attendance at the HOA meeting; but the researcher finds that the returned surveys convey a wide range of homeowner attitudes in regards to sustainable design.

The final topic discussed at the end of the meeting was that if any homeowners were willing to allow the researcher access to their property. Five self-selected homeowners approached the researcher after the meeting. Contact information was exchanged and meetings were set up for that following weekend. Of the four properties that were examined on Saturday, February 6th, three were found to be excellent examples that could be used for design examples at the property scale. On Monday, the 8th of February 8th, the fifth meeting took place with a homeowner who had a "blank canvas" in regards to what can be done with their property landscape. Therefore, of the five homeowners that were willing to aid in this process, four were chosen to create a more detailed design in conjunction with the conceptual plan for Lee Mill Heights.

At each meeting, the researcher discussed with each homeowner concerns or issues they were having on their property. Some issues that were discussed included stormwater erosion and landscape maintenance. Potential design recommendations were also discussed with the homeowners. A few homeowners shared ideas they would like to see on their property (Refer to Chapter 5 for a discussion of how these concerns were addressed and fit with the larger conceptual plan for LMH).


Figure 3.28 Lee Mill Heights-Aerial View. By Author

Framework

There are many existing frameworks relating to sustainable landscape design. The frameworks tend to fall under two categories: "those that offer qualitative, theoretical, or values-based criteria; and those that prescribe specific quantitative or standards based criteria" (Dinep & Schwab, 2009, pg. 5). Dinep and Schwab list eight different types of frameworks that exist for sustainable design. These frameworks are: 1) Andropogon Associate's Ecological Site Design Guidelines; 2) Sanborn Principles—Urban Design Foundation for Sustainable Communities; 3) Values of Place—Essence of Timeless Design, Human-Centered Building, and Personal Responsibility; 4) Principles of Smart Growth—www.smartgrowth.org; 5) Sustainable Landscape Construction Principles—Thompson and Sorvig; 6) LEED—New Construction v2.2; 7) LEED-Neighborhood Development—Pilot Program; and 8) the Sustainable Sites Initiative.

Dinep and Schwab indicate that "an essential characteristic of these types of frameworks—and what makes them so eminently attractive and useful—is that they can be applied to nearly any project, regardless of site or its place within the urban to rural transect of the developable environment" (2009, pg. 5). The versatility of these frameworks makes them useful and applicable at nearly any sustainable landscape design project.

Along with the Andropogon Associate's Ecological Site Design Guidelines, two other firms where chosen to compare their guidelines for sustainable and ecological landscape design. These two firms are Applied Ecological Services and Conservation Design Forum. These were chosen because they provided excellent approaches to integrated ecological restoration design and development practices. Table 3.8 lists the three firms and their respective guidelines. The light purple boxes highlight concepts that can be applied to existing exurban neighborhoods. Figure 3.29 shows a more graphical representation of the framework and depicts the relationship between the three firm's guidelines and the design guidelines for existing exurban neighborhoods.

Upon further review of the three existing frameworks, a set of sub-questions arose in response to applying these guidelines to existing exurban neighborhoods. These questions include: under what physiographic province or sub-regional ecological context and potential vegetation regime is Lee Mill Heights (LMH) located? What ecological processes are occurring or need to be restored at LMH? What can be done to improve ecological functions at LMH? How can LMH homeowners be engaged in improving ecological function? What types of specific design solutions can be implemented at LMH? These sub-questions helped form the design framework for existing exurban neighborhoods.

COMPARATIVE GUIDELINES FOR SUSTAINABLE & ECOLOGICAL LANDSCAPE DESIGN			Design Framework for Existing Exurban Neighborhoods	
Applied Ecological Services (AES, 2007)	**Andropogon Associate's Ecological Site Design Guidelines** (Dinep & Schwab, 2009)	**Conservation Design Forum** (CDF,2015)	**Lee Mill Heights Manhattan, Kansas**	
Inventory and map the ecological resources	Create a participatory design process	Sustainable results	Identify neighborhood sub-regional ecological context	Mapping & Site Analysis
Describe the site's history and map it where possible	Preserve and re-establish landscape patterns	Stable, healthy, water-rich habitats	Map existing neighborhood ecological resources	
Develop a hypothesis of how the original system worked	Reinforce the natural infrastructure	Remnant native landscapes	Determine desired function of the final design	Literature Review
Develop goals for each management unit	Conserve resources	Authentic Context	Develop goals for the restoration & conservation for the neighborhood	
Develop an implementation plan to accomplish the goals	Make a habit of restoration	Water conservation	Engage neighborhood homeowners through ecological process awareness	Survey
Design a monitoring program to evaluate the success of the restoration	Evaluate solutions in terms of their larger context	Green Infrasturcture	Synthesize homeowner perceptions and concerns	
Implement the restoration program	Create model solutions based on natural processes		Develop guidelines to respond to individual sites, neighborhood, context, and residents	Design Process for Multiple Site Scales
Prepare reports and papers that explain the project and describe results	Foster biodiversity		Create retrofit design solutions based on gathered information	
Periodically evaluate the program	Retrofit derelict lands		Implementation and maintenance of retrofit design solutions proposed	Proposed Design
Communicate and educate interested and potentially affected parties to provide basic information and comfort with the restoration process	Integrate historic preservation and ecological management			
	Develop a monitored landscape management program			
	Promote an ecological aesthetic			

Table 3.8 Design Framework fo Existing Exurban Neighborhoods-Tabular Form. By Author

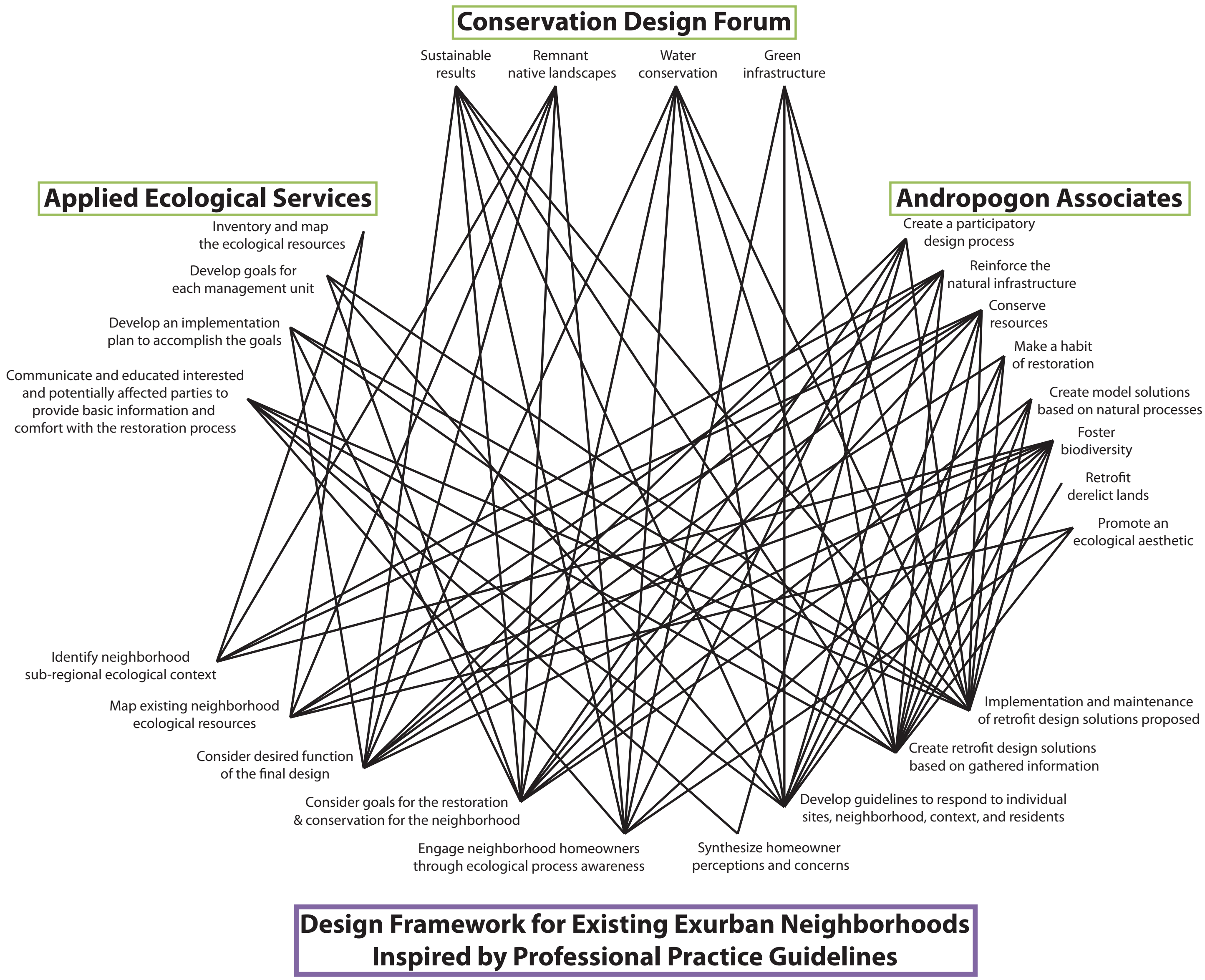


Figure 3.29 Design Framework for Existing Exurban Neighborhoods Inspired by Professional Practice. By Author

Framework Application: Design Process for Lee Mill Heights-Neighborhood and Site Scale Landscape Retrofits

1) Biodiversity & Habitat Connectivity

a) Neighborhood Scale

i) Increase connectivity between fragmented natural drainage ways.

(1) Make strong native plant connections to the Park at Lee Mill Heights (develop and manage native plant corridors along easements).

(2) Place trails for people to connect the neighborhood to the park only in locations where topography will allow for this without significant disturbance to drainage-ways, leaving some corridors undisturbed (except for annual mowing of grasses/wildflowers along grassed swales and filtration strips and for invasive species plant removal).

ii) Create and manage large pollinator meadows and small to large rain-gardens and naturalized detention/infiltration areas using a range of drought-tolerant native grasses and wildflowers.

iii) Reduce the amount of potable water used for irrigation by allowing turfgrass to grow 4-5 inches in height and mowing grass at a height of 2.5-3 inches (so that deeper roots will eliminate the need for daily irrigation). Fescue with deeper roots can tolerate more stress and may only need irrigating once a week or less.

iv) Eliminate herbicides and pesticides to protect butterflies, dragonflies, bees, and other pollinators. For example, remove wasp nests near homes using strong water sprays during cool temperatures.

v) Eliminate or manage invasive species. Keep eastern red cedar from spreading and eliminate honeysuckle via active removal when plants are young, before they go to seed, or dispose of berries and remove larger plants where these are found and removed by a neighborhood conservation/management team.

vi) Avoid disturbing nesting bird species by mowing late fall to late winter (thus allowing for structurally valuable fall and winter habitat/shelter as well as the beautiful fall and early winter colors of native grasses and forbs).

b) Property Scale

i) Create pollinator/butterfly gardens close to drainage ways and conservation easements. Manage gardens by regularly removing (gently hand-weeding) young trees, invasive shrubs and perennials, and clipping seedheads for species that may be over-abundant.

ii) Avoid creating favorable conditions for Copperhead snakes by substituting shredded hardwood mulch in beds instead of well gravel (which snakes like to warm themselves on). To avoid gravel removal costs, homeowners can test spreading mulch on top of existing stone.

iii) Keep plant masses ten or more feet away from walkways and entrances where snakes are a concern.

iv) Plant more trees (ideally drought-tolerant native species) within City of Manhattan easements along streets (especially Miller Parkway).

2) Stormwater Management

a) Neighborhood Scale

i) Consider large gestures that can make a real difference in reducing rapid, intense stormwater flows that create gullies and down-cut intermittent streams/drainage-ways; use portions of open lots for bio-retention purposes and naturalized detention areas; plant and maintain native grasses (grassed swales or upland bands) for surface water filtration and infiltration.

b) Property Scale

i) Send rooftop, driveway, and sidewalk stormwater runoff into appropriately sized, designed, and managed rain gardens, native plant meadows, and pollinator gardens; keep rain gardens 10 feet from building and ensure that high-water flows from each rain-garden move away from foundations and basements; use level-spreaders to slow and help infiltrate stormwater into gardens, meadows, and naturalized easements; maintain vegetation for ecological function and aesthetics by clipping or mowing in late winter.

ii) Reduce additional impervious surfaces by using porous paving (with gravel subgrades to hold, slow, and help cleanse stromwater) in areas where paved outdoor spaces are desired. Insure positive subsurface grades away from homes beneath porous paving.

iii) Create non-compacted, healthy, living soils so that microorganisms can thrive and help create more permeable soils in tandem with roots from native grasses, wildflowers, shrubs, trees, and other non-invasive plants.

iv) Use rain-barrels and/or cisterns to collect and re-use water from rooftops.

Figure 3.30 Lee Mill Heights Neighborhood. By Jonathan E Knight

Photograph by Jonathan E Knight

Chapter 4: Findings

Findings

Lee Mill Heights Homeowner Survey

The purpose of this survey was to inquire about current landscape maintenance practices at Lee Mill Heights, homeowner understanding of HOA restrictive covenants, and gauging homeowner's ecological awareness. Fifty-one surveys were distributed and twenty were returned, for a 38% return rate. The survey is divided in three sections: Current Landscape Maintenance Practices, Awareness of Lee Mill Heights Homeowner Association Restrictive Covenants, and Gauging Landscape Perceptions & Awareness.

The first section seeks to explore the homeowner's maintenance tendencies. As a majority, watering takes place three times a week between June 1st and September 30th (Table 4.1). Herbicides and pesticides are typically applied twice a year (Table 4.2). Lawns are mowed four or more times a month during the summer and at a height of three (3) inches (Table 4.3). Maintenance (weeding perennials and/or pruning and clipping shrubs and perennials) is done two to four (2-4) times a year.

The second part of the survey was the "Awareness of Lee Mill Heights Homeowner Association Restrictive Covenants." Homeowner familiarity with the restrictive covenants was 50% yes, 30% answered 'Somewhat', and 15% responded 'No' (Table 4.4). Half of the respondents actually knew they had a conservation easement, 30% didn't know if they did or not, and 20% did not have a conservation easement. The greatest gap in response was the question concerning the homeowner's knowledge of the process involved in making changes to the HOA restrictive covenants. Of those surveyed, 80% of homeowners were unaware of the process.

How often do you typically water your lawn between June 1st and September 30th?

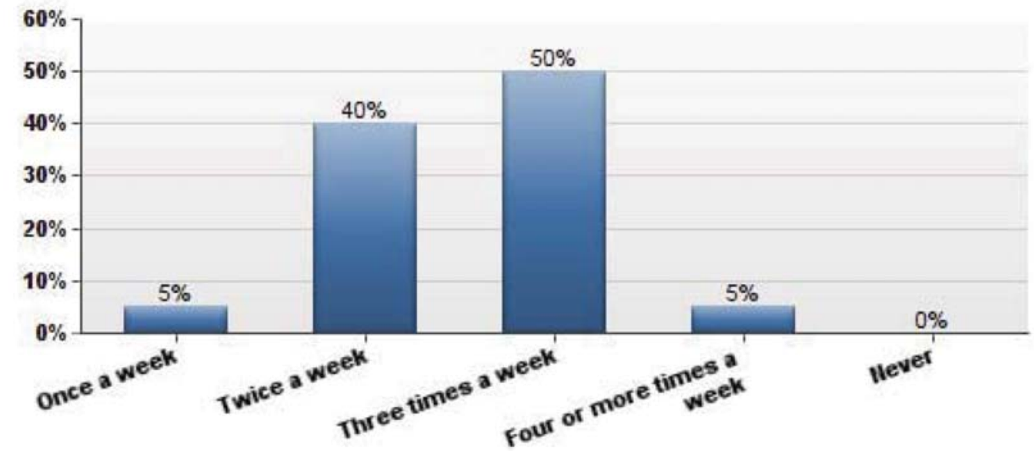


Table 4.1 LMH Homeowner Survey Results-Watering Frequency. By Author

How often do you use an herbicide or pesticide on your yard/landscaping?

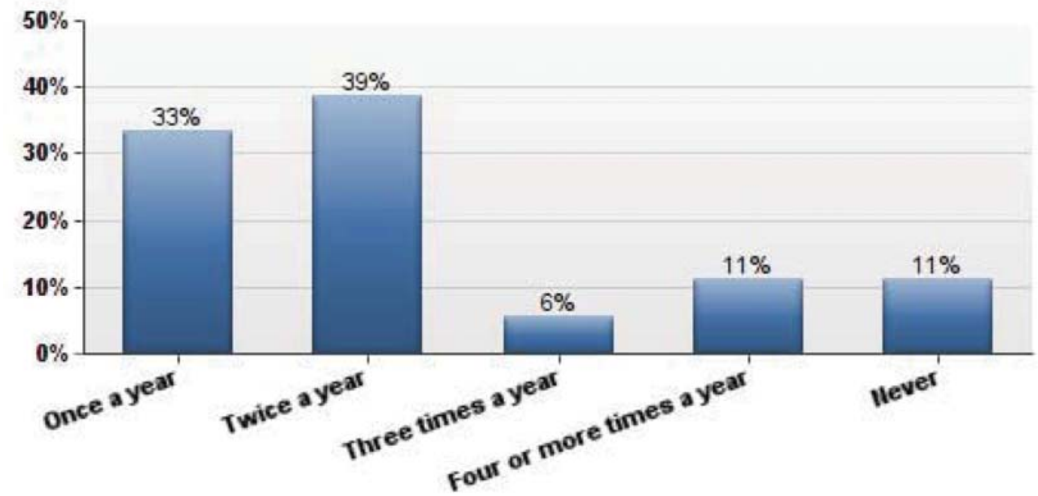


Table 4.2 LMH Homeowner Survey Results-Herbicide/Pesticide Frequency. By Author

How often to you typically mow your lawn between June 1st and September 30th?

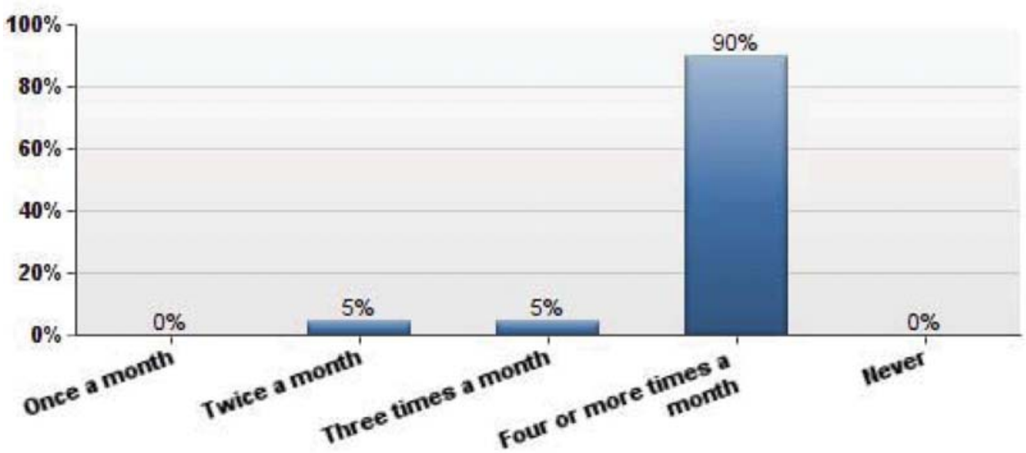


Table 4.3 LMH Homeowner Survey Results-Mowing Frequency. By Auhor

The final section of the survey was "Gauging Landscape Perceptions & Awareness" of homeowners. Question eleven dives into homeowner preference in regards to the aesthetics of four different types of landscape planting designs (Table 4.5). Image A (Figure 4.1) and image B (Figure 4.2) were the top two choices. The most favorable of all four was image A. This image was the representation of a traditional landscape. Landscape ecology was a topic not familiar to 75% of respondents. Knowledge of the benefits of a well-designed native planting, and the cost benefits in both resources and time, was known by 70% of those surveyed. Yet 68% were still not willing to implement a native planting design on their property. This may be due to aesthetics since 70% of homeowners responded with some level of concern in regards to their neighbor's opinion if a native planting design was installed. However, 58% of those surveyed said that they would be willing to install one or more stormwater retrofits, in the form of rain gardens, on their property.

Are you aware that with 80% support of other homeowners within Lee Mill Heights HOA, amendments within the restrictive covenants can be changed?

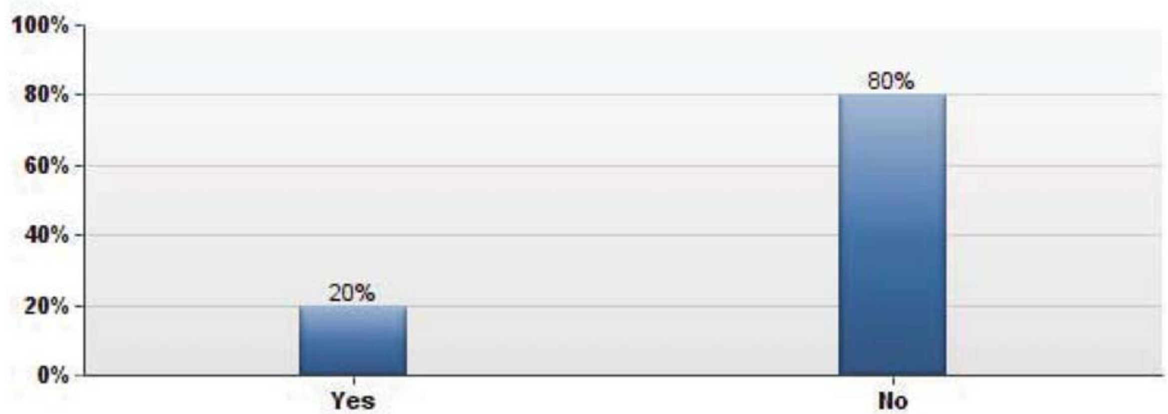


Table 4.4 LMH Homeowner Survey Results-Restrictive Covenants Familiarity. By Author

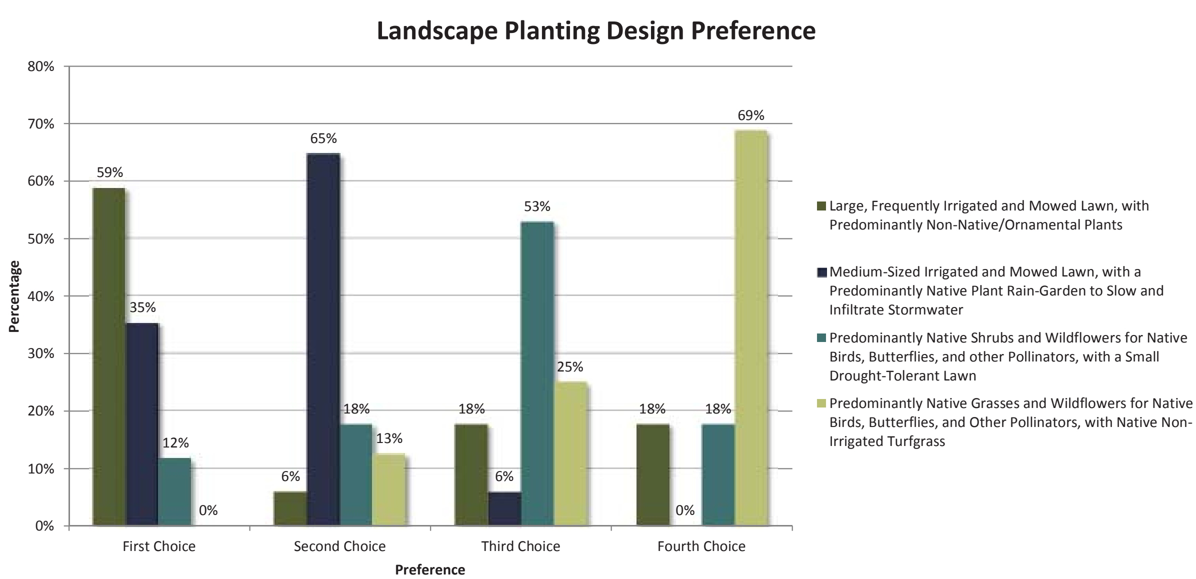


Table 4.5 LMH Homeowner Survey Results-Landscape Planting Design Preference. By Author

Figure 4.1 Large, Frequently Irrigated and Mowed Lawn, With Predominantly Non-Native/Ornamental Plants-Image A.

Figure 4.2 Medium-Sized Irrigated and Mowed Lawn, with a Predominantly Native Plant Rain Garden to Slow and Infiltrate Stormwater-Image B.

Figure 4.3 Predominantly Native Shrubs and Wildflowers for Native Birds, Butterflies, and other Pollinators, with a Small Drought-Tolerant Lawn-Image C.

Figure 4.4 Predominantly Native Grasses and Wildflowers for Native Birds, Butterflies, and Other Pollinators, with Native Non-Irrigated Turfgrass-Image D

The last section of the survey asked an open-ended question in regards to any concerns the homeowners may have about implementing native planting designs. Table 4.6 provides a synthesized content analysis of key phrases that homeowners used in their response. This table was also used to synthesize responses from question twelve, which offered the homeowner an opportunity to express why they preferred the image they ranked highest. The table lists key terms and phrases that were expressed in the two open-ended questions regarding preferences of landscapes and concerns about implementing native planting designs. The full survey results can be found in Appendix C-Homeowner survey data.

Perceptions & Concerns Related to the Preferred Landscape Images in the Lee Mill Heights Neighborhood Survey		
Categories	*Preferences (terms used by participants)*	*Concerns (ideas expressed by participants)*
Aesthetics	blooming plants, clean cut look, cleaner look, like the look, clean looks, cleanest looking, elegant, very green, colorful!, open, color throughout the seasons	image D is too "busy" looking
Maintenance & Irrigation	orderly bed, nice week free grass lawn, less messy, low maintenance, orderly, clean, well kept, easy to care for, neat, well pruned, easily maintained	diverse native plantings may be harder to maintain (time required to prune or weed), trash may collect in natural planting areas, lawns require irrigation & fertilization
Native Plants	consider using one of the native landscape designs for the backyard, like the 'idea' of native planting	look of overgrown & messiness, curb appeal
Natural	want to attract birds & butterflies,	don't like too many flowers that attract bees, copperhead snakes (seen in the area) may hide in native vegetation
Use & Cost	want place (lawn) for outdoor play/use	not wanting to spend more $ for landscaping, irrigation & fertilization costs

Table 4.6 LMH Homeowner Survey Results-Content Analysis. By Author

Lee Mill Heights Homeowner Post-Survey: Content Analysis

The Lee Mill Heights Homeowner Post-Survey was only administered to the four homeowners who were self-selected and volunteered to allow the researcher access to their property. This survey was done in person right after the second meeting with the homeowners. In the second meeting, homeowners were shown the proposed retrofits on their property. All four participants received the proposed designs rather well. For example, the homeowners at North Mill Point were attracted to the benefits a rain garden could have on their property. This was further reinforced when they saw the various vegetation and aesthetic appeal of Image B (Figure 4.2).

The content analysis of the post-survey can be seen in Table 4.7. Three of the four homeowner's opinions of sustainable design through the implementation of native vegetation and rain gardens changed throughout the process of interacting with the researcher. From the outset, the fourth homeowner felt comfortable with sustainable design and was ecologically aware of the importance of these types of designs.

The four main topics brought up in the post-survey included: the fear of snakes (which was also present in the initial survey), maintenance concerns of native plantings, visual aesthetics (some homeowners were still concerned about their neighbor's perception of native planting design), and the importance of ecological function. Of the four homeowners, three of them were interested in more literature and sources on the benefits of ecologically-inspired landscape design.

Post-Survey Homeowner Interview Content Analysis

Homeowner	Between completion of the survey and presentation of the potential design, has your opinion of ecologcially-inspired landscape design retrofits changed?	Why or why not?	Would you like to receive more sources on the topic of native planting designs and their benefits?	What do you see as the major opportunities & barriers in implementing ecological design strategies?
Leone Ridge	Opinion has not changed. Still positive attitude toward sustainable design	Homeowner feels aware of the natural systems and benefits they provide for us.	Would like more information on the topic of native plantings.	Neighbor perception is still a concern with this homeowner. Maintenance is also a concern.
West Park Grove	Opinion has changed from skeptical to positive.	Likes rain garden concept for a section of her property. Concerned about maintenance.	Would like more information on the topic of native plantings. Enjoys learning about the topic.	Care, cost, and safety. Snakes brought up in this answer.
East Park Grove	Opinion has changed from skeptical to positive.	Design is 'gorgeous', thinks the idea behind sustainable design is 'lovely'. Homeowner brought up fear of snakes being an issue.	Would NOT like more information.	Anything ecologically friendly is enjoyed by homeowner. Brought up fear of snakes again.
North Mill Point	Opinion has changed from skeptical to positive.	Opened eyes to how the drainage on their property works. Changes made on their property has positive effect away from property.	Would like more information on topic of cost effective differences.	Barriers: startup cost, not status-quo Opportunities: cost effective over time yet visually attractive

Table 4.7 LMH Homeowner Post-Survey Results-Content Analysis. By Author

Photograph by Jonathan E. Knight

Chapter 5: Design

Design

Neighborhood Scale Conceptual Plan

Biodiversity, habitat connectivity, and stormwater management are the big ideas for the conceptual plan of Lee Mill Heights (LMH). Fragmentation of existing native drainage ways occurred during the construction of the neighborhood (Figure 5.1). During the construction of LMH, an effort was made in conserving drainage ways with the use of conservation and drainage easements. However, these easements are found on only 38% of LMH lots. In Figure 5.2, existing conservation easements are shown in light olive. The proposed extensions of these conservation and drainage easements are depicted in olive. The extensions would nearly double the total lots containing conservation and drainage easements.

Figure 5.3 is an example of what the proposed extensions would look like in section view. The swales on private property would consist of rain garden vegetation while the upland vegetation would be made up of native pollinator plantings. In this particular area of LMH, a proposed buffer on one side of the drainage easement could include woody vegetation such as native shrubs and trees. The other side of the drainage easement would be mowed once or twice a year in order to deter woody vegetation and create a maintenance access if the need arises. Mowing should not happen during grassland bird nesting season.

Habitat connectivity would also offer an opportunity for another sort of connectivity--trails. With the approval of the Park at Lee Mill Heights, the neighborhood and region stand to benefit from this natural resource. Connections between the park and LMH could further enrich the livelihood of homeowners within the neighborhood. Figure 5.4 depicts a typical section view of proposed trails within the native drainage ways. Elevation will vary but the same concept will exist in this area.

Stormwater management is another element of the proposed LMH conceptual plan. Currently, there are two farm ponds on the northern half of the neighborhood. These ponds are located at junctions of multiple drainage ways. Standing water was one of the concerns brought up in the post-survey interviews. The concern is that standing water tends to attract mosquitos; therefore, redesigning these ponds to a rain garden meadow and infiltration basin (refer back to Figures 3.21 and 3.22) can help evaportranspire and infiltrate water to eliminate this problem.

In regards to the southern half of the neighborhood, there are no ponds in the area. The reason for no ponding is due to significant elevation change and steep drainage ways which runoff quickly from the site. Drawing upon the same rain garden meadow concepts to the north, multiple rain garden retention meadows are proposed in key areas of the southern half of LMH. These key areas should be located in junctions of existing and proposed conservation/drainage easements.

Figure 5.1 Lee Mill Heights-Aerial View of Ongoing Construction. By Author

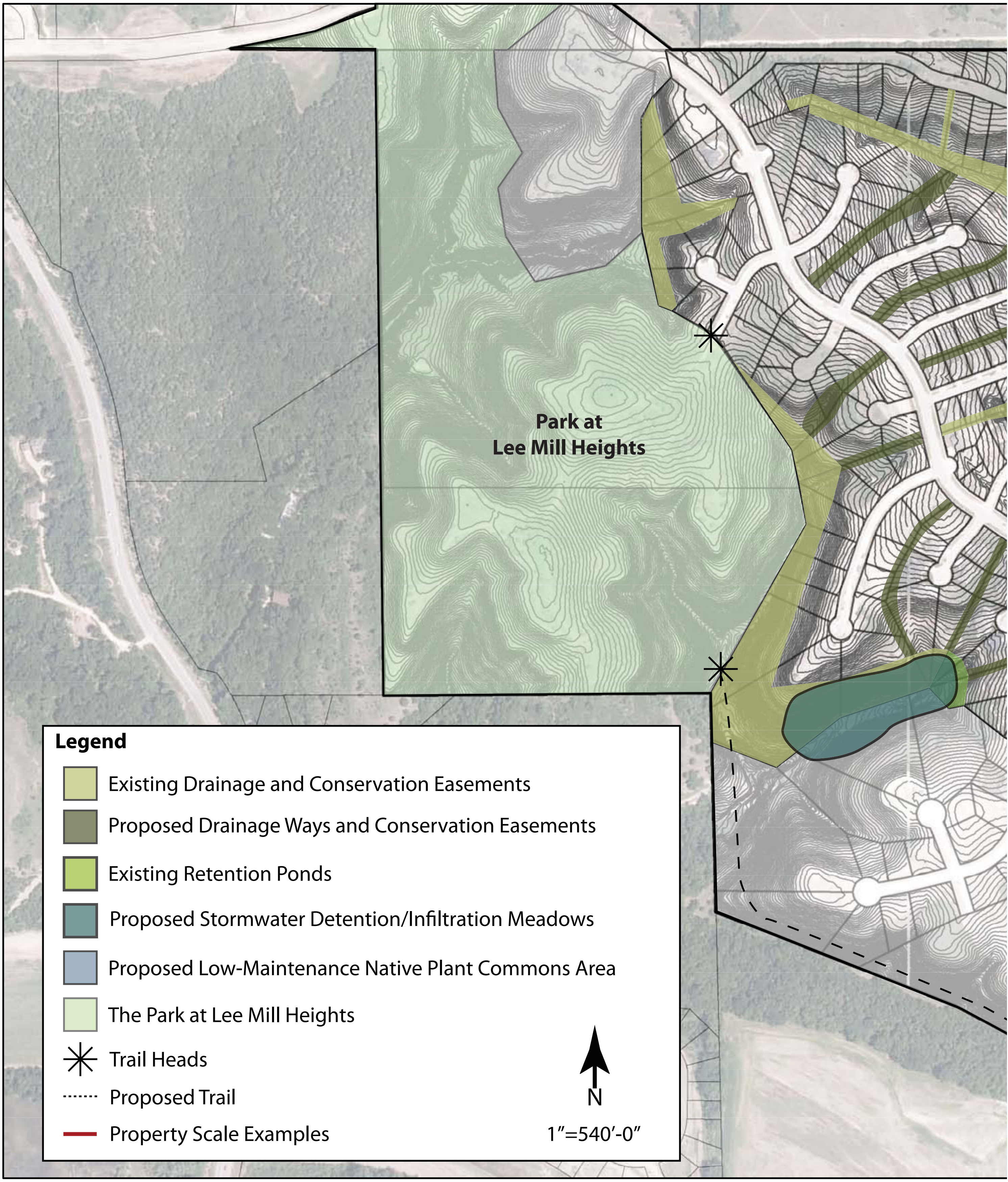


Figure 5.2 Lee Mill Heights-Proposed Conceptual Plan. By Author

A
A
B
B
0
270
540
1,080
1,620
2,160
Feet

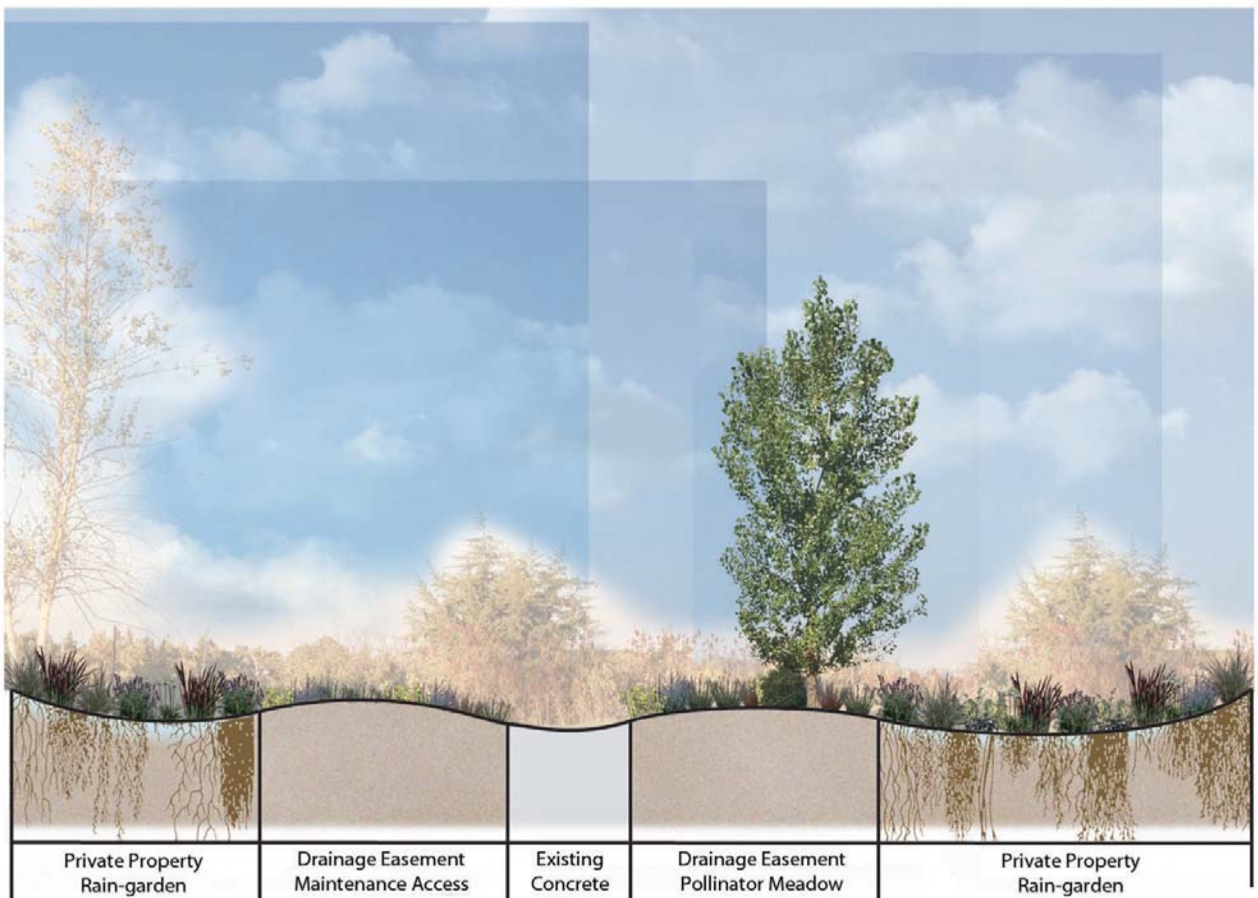


Figure 5.3 Section AA-Proposed Extensions of Conservation and Drainage Easements. By Author

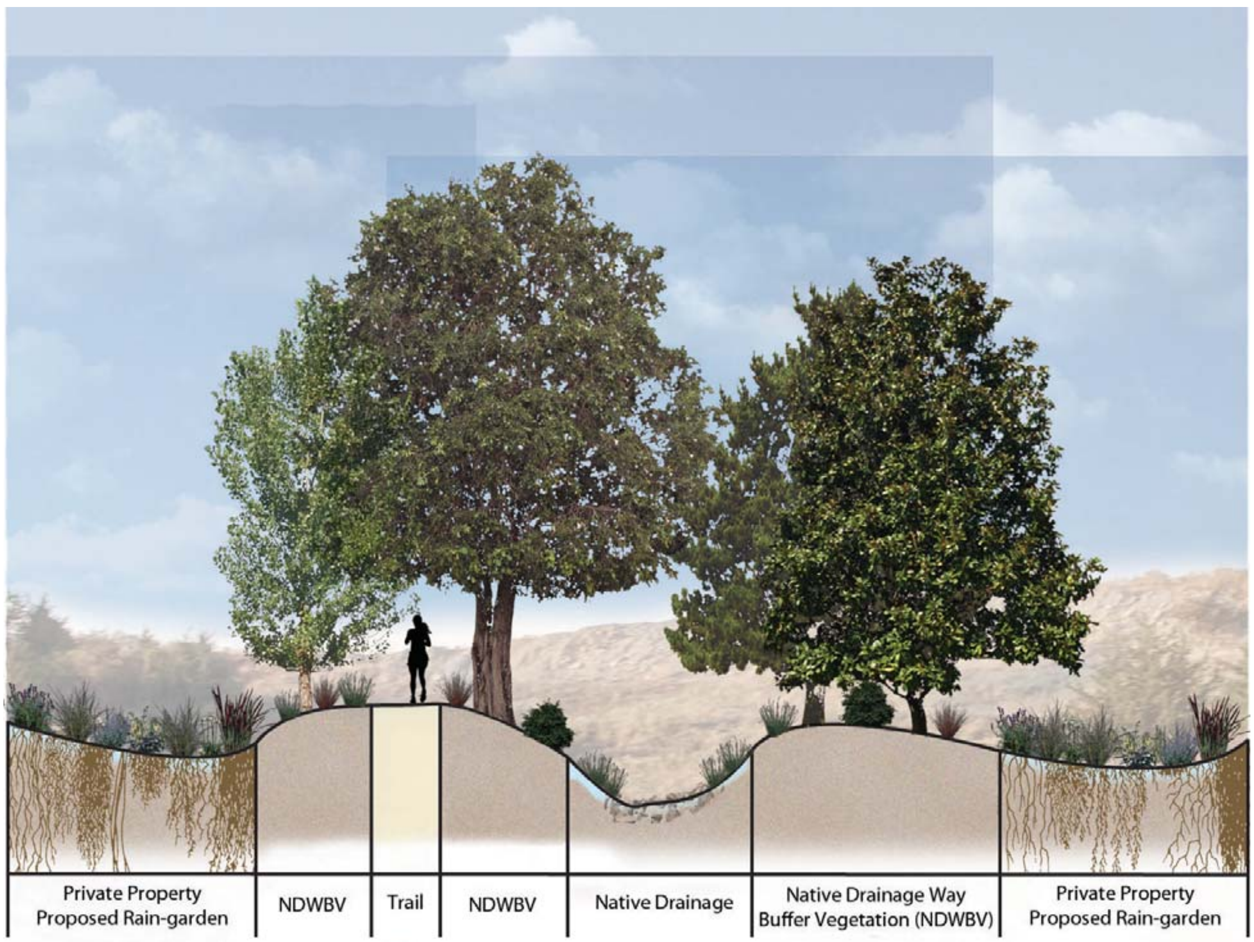


Figure 5.4 Section BB-Proposed Trails within Native Drainage Ways. By Author

Property Scale Designs
North Mill Point Circle Residence

The residence on North Mill Point is 0.46 acres and is located on the northern half of Lee Mill Heights, adjacent to Miller Parkway. The elevation change is moderate and slopes from the southwestern corner down towards the northeastern corner. One external factor affecting the property is the vehicular traffic along Miller Parkway. During the first meeting with the homeowner, the potential of creating a natural barrier between the lot and street arose. Currently, their backyard patio feels exposed to the traffic.

When designing for the residence on North Mill Point, working with existing contours and drainage flow was important in deciding placement of the rain garden. Another design element included was the pollinator meadow on the northern edge of the property. The neighbor has placed railroad ties on their property in an attempt to delineate the property line. The homeowners of the example on North Mill Point find the railroad ties visually distracting. Implementation of the pollinator meadow would help cover part of the neighbor's lot and better shape the space between the two properties.

In the post-survey interview held with the homeowner, they expressed great enthusiasm at the thought of a rain garden on their property. This came about when the researcher showed the homeowners a visual example of what a rain garden would like look. They further commented on the placement of the rain garden. Along with a few addition trees, the rain garden helps create a more personal space on their backyard patio. At the conclusion of the post-survey interview, no major concerns were brought up by the homeowners.

Figure 5.5 North Mill Point Circle Residence. By Author

Figure 5.6 North Mill Point Circle Backyard Facing West-View A. By Author

Figure 5.7 North Mill Point Circle Backyard Facing South-View B. By Author

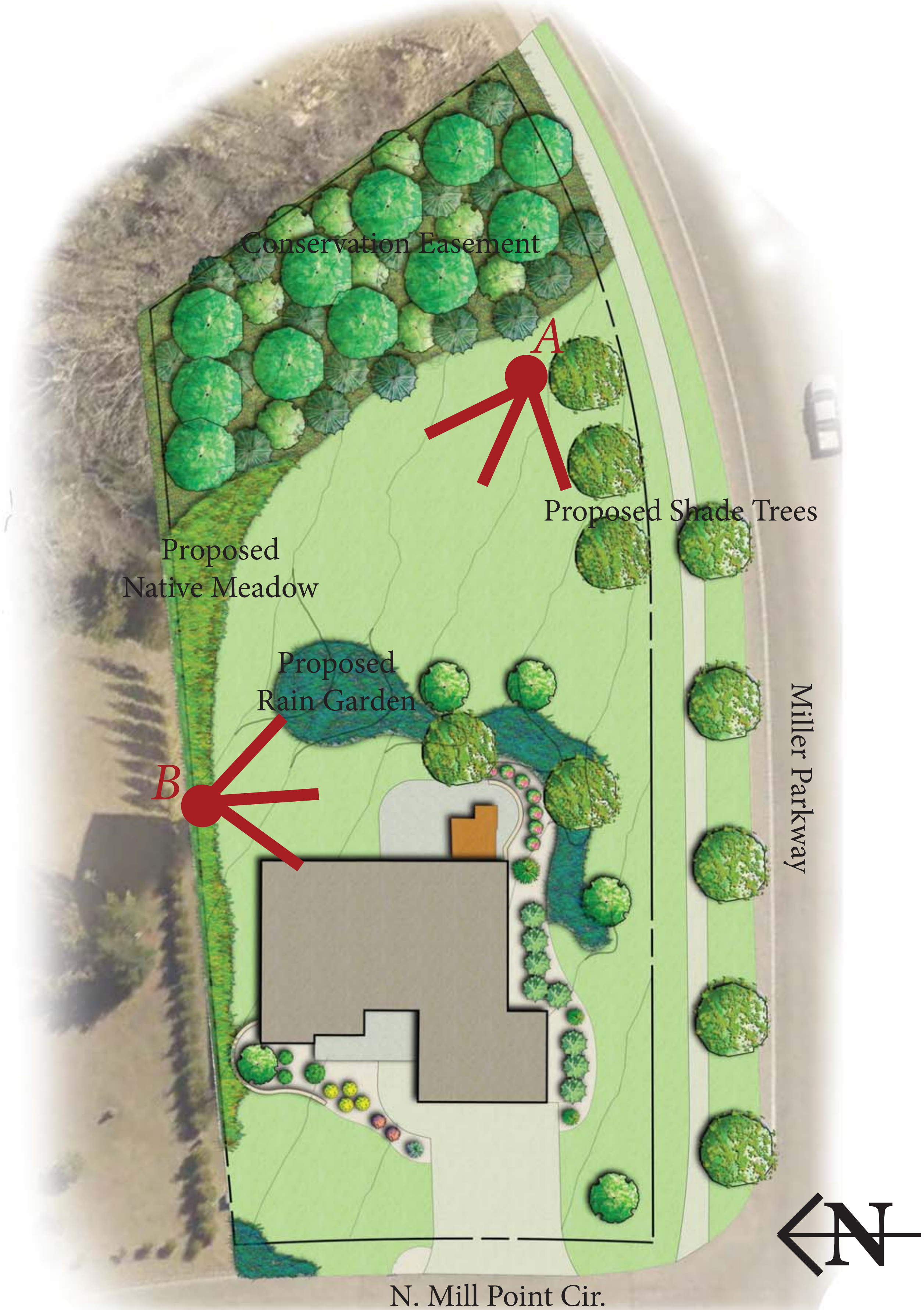


Figure 5.8 North Mill Point Circle-Proposed Design. By Author

East Park Grove Drive Residence

The East Park Grove property is a 0.4 acre corner lot on the southern half of Lee Mill Heights. The elevation change is gradual and slopes from the northwest down to the southwest corner. Much like the property on North Mill Point, this lot is also adjacent to Miller Parkway. When the researcher met with the homeowner, the following topics were discussed. The homeowner enjoys gardening and has a designated spot for a garden near the southwest exterior of the house. However, the rest of the property is simply lawn with no other landscape plantings and would provide a great opportunity to implement some of the design ideas found within this research project.

During the post-survey interview, the following topics were discussed. The homeowner wants to extended the backyard deck to create more space and is willing to implement ecologically-inspired landscape design retrofits but there was a major concern--snakes. The issue was not new to the researcher. Within the initial survey, multiple respondents brought up the concern of copperhead snakes being reported in the area.

Upon further research in understanding copperhead habitat and behavior, a few design guidelines were created to be used on the residence located at East Park Grove. First off, switching from well gravel planting beds to bark mulch would help deter copperhead snakes. The gravel bed absorbs the sun's heat and is prime sunbathing material for copperheads. Another design strategy is to avoid massing plants near walkways and entrances. Using these guidelines on this property would help ease the homeowners concerns about snakes on their property.

Figure 5.9 East Park Grove Drive Residence. By Author


Figure 5.10 East Park Grove Drive Frontyard Facing Southwest-View A. By Author


Figure 5.11 PEast Park Grove Drive Backyard Facing Northwest-View B. By Author

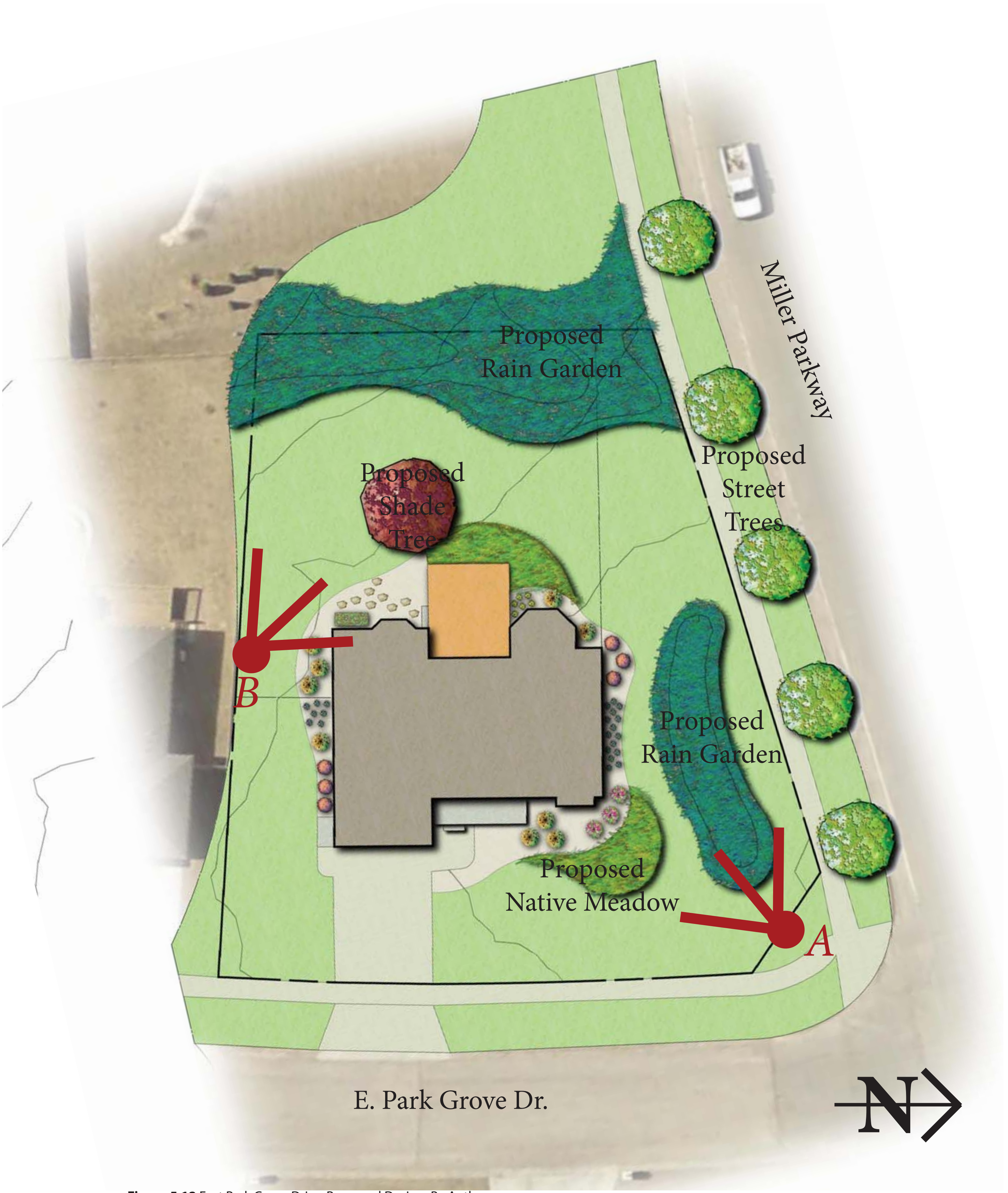


Figure 5.12 East Park Grove Drive-Proposed Design. By Author

West Park Grove Drive Residence

Unlike the North Mill Point and East Park Grove properties, the West Park Grove example is not adjacent to Miller Parkway. This property is 0.3 acres with moderate elevation change and slopes from the northeast down to the southwest corner. The house immediately south of the East Park Grove example was constructed at a later date. This construction altered drainage flow and created an issue of inadequate drainage on the example site. Pooling of stormwater on the southwest corner of the lot occurs often during rain events and is drowning the fescue lawn in the area.

The backyard is fenced-off with a steep slope in the southwest corner. The homeowner has stated a difficulty in maintaining this area mowed due to the steep slope. The proposed design calls for the implementation of a retaining wall in this area of the backyard. The retaining wall would help with maintenance and prevent any erosion from occurring in the future. A dry-laid retaining wall can be visually pleasing, cost effective, and act as a level-spreader (to slow and spread out runoff), reducing the chance for erosion and gully formation over time.

In response to the pooling of stormwater on the southwest corner of the property, a rain garden would be ideal in this location for infiltration purposes. This area is in proximity to the foundation of the house. For this reason, it would be best practice to install the rain garden ten or more feet away from the foundation with positive, gently sloping subgrades directing stormwater away from the house. This is done to prevent any problems that may occur between the presence of water and leaks into the basement.

The homeowner at West Park Grove brought up a concern that the others did not; resale value associated with landscaping vegetation. The homeowner did not want to plant trees to close to the house in the backyard. The reason discussed was that it may affect the property resale value if the future buyers were looking to install a pool. Therefore, the ecologically-inspired landscape design retrofits were kept close to the property lines with minimal interference on the backyard as a whole.

Figure 5.13 West Park Grove Drive Residence. By Author

Figure 5.14 West Park Grove Drive Frontyard Facing Northeast-View A. By Author

Figure 5.15 West Park Grove Drive Backyard Facing Northeast-View B. By Author

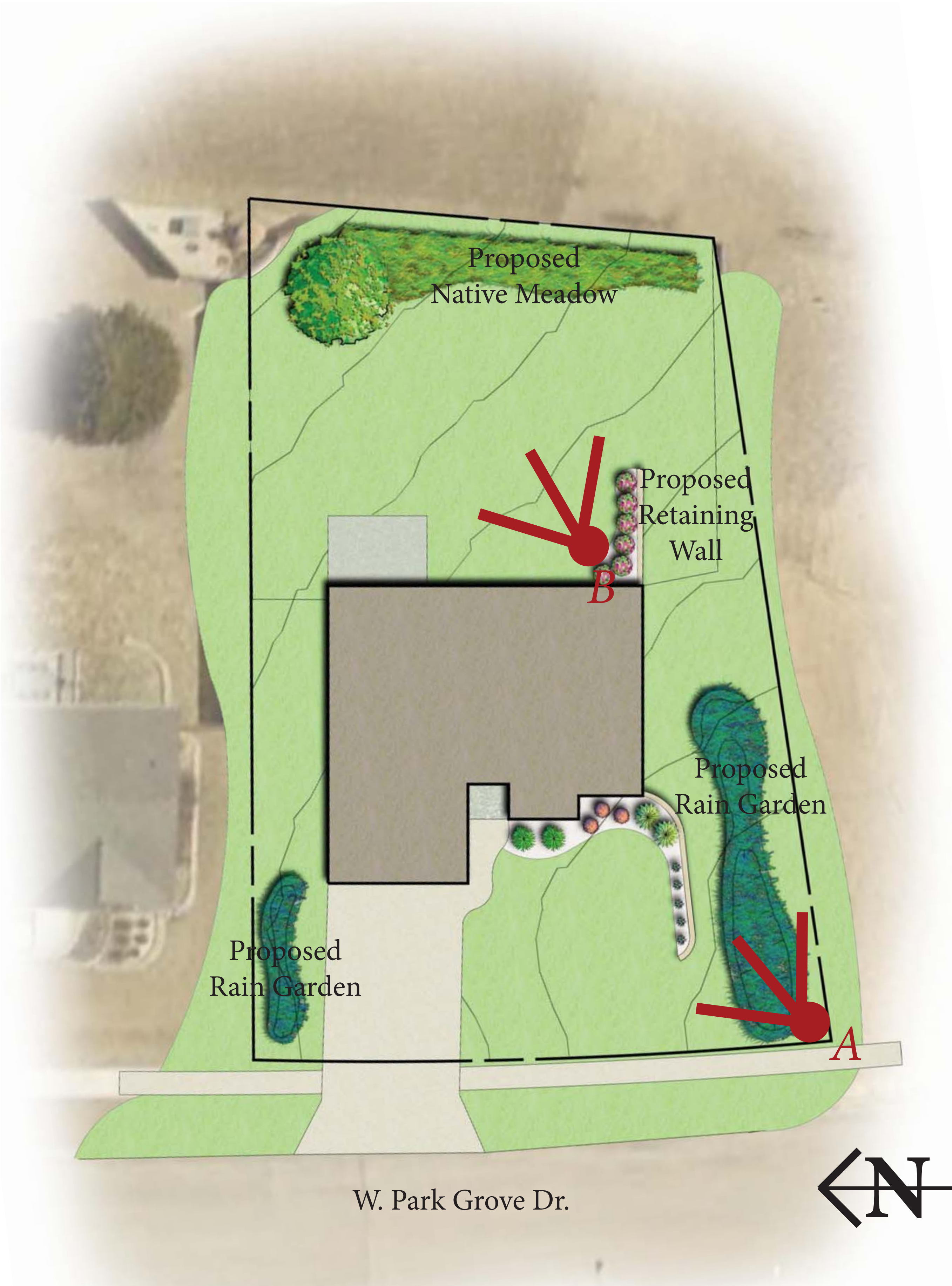


Figure 5.16 West Park Grove Drive-Proposed Design. By Author

Leone Ridge Drive Residence

The last property to be discussed is located on Leone Ridge Drive. The property is 0.8 acres and contains a conservation easement on the southeast corner of the lot. The elevation change is significant and slopes from the north/northeast down toward conservation easement. This property lies adjacent to Miller Parkway. The homeowner has taken advantage of the free street tree program provided by the City of Manhattan. On the northern edge of their property, within the city right of way, the homeowners have requested trees to be planted between the sidewalk and the street of Miller Parkway. The free street tree program can be utilized in the fruition of the concepts plans proposal to increase street trees along Miller Parkway.

Due to the property's abrupt change in elevation, one of the major concerns is bank erosion of the drainage way within the conservation easement. A large concrete drainage pipe daylights at the head of the conservation easement. This drainage pipe flows with enough force that it has begun to cut into the bank of the natural drainage way. With the implementation of rain gardens associated with step-pools, these erosion issues would be reduced and/or eliminated. It is for this reason that a large rain garden has been proposed to the east of the house. This location is ideal because it contains a large swale and would work well in deterring further bank erosion on the natural drainage way.

To the south of the house, the homeowners plan to construct a fire pit patio with native limestone boulders as retaining walls and seating. At the time of this research project, construction began on the retaining wall. Privacy was a concern for this area and plans to create a natural barrier can be accomplished by using berms, perennials, shrubs, and evergreen tree masses.

Figure 5.17 Leone Ridge Drive Residence. By Author

Figure 5.18 Leone Ridge Drive Backyard Facing Southwest-View A. By Author

Figure 5.19 Leone Ridge Drive Frontyard Facing South-View B. By Author

Figure 5.20 Leone Ridge Drive-Proposed Design. By Author

Quantifiable Ecological Significance

The four properties used in this research project are fairly representative of the typical lots found at Lee Mill Heights. In an attempt to quantify the ecological significance of the proposed landscape retrofits, an average area of the proposed rain gardens and native meadows were calculated between the four properties. The average area for proposed rain gardens was calculated to be around 2,490 square feet. The average native meadows were at 600 square feet. There are a total of 320 lots at LMH. Therefore, the total property scale rain garden area totals to be 871,500 square feet or 20 acres. Native meadows would calculate to be around 192,000 square feet or rounded up to about 5 acres. At the conceptual scale, there are a few additional proposed rain garden meadows totally approximately 4 acres in size, therefore increasing the total proposed rain garden vegetation to 24 acres.

The increase of rain gardens and native meadows would inversely affect the total area of the residential construction. The total stormwater runoff with the proposed retrofits would be around 105 cfs (Table 5.2). In comparison to the 116% increase of stormwater runoff between 1991 and 2014, there would be a 30% decrease of total stormwater runoff from the existing 116% (Table 5.1). The total percentage of stormwater runoff would continue to drop with the further implementation of rain gardens and native meadows.

This increase in native and rain garden vegetation would also increase habitat for songbirds, butterflies, and other pollinators found within the prairie grassland ecosystem.

Summary: Rational Method Equation for Stormwater Runoff-Lee Mill Heights	
1991 Total Runoff in cfs	56.78
2002 Total Runoff in cfs	57.32
2006 Total Runoff in cfs	77.04
2010 Total Runoff in cfs	107.03
2014 Total Runoff in cfs	122.47
Runoff Increase from 1991 to 2014	116%
Total Runoff in cfs with Proposed Native Vegetation and Rain Garden Retrofits	**105.81**
Runoff Decreased Over 20 year Implementation Period	**30%**

Table 5.1 Rational Method for Stormwater Runoff-Summary. By Author

Rational Method Equation for Stormwater Runoff Applied to Proposed Lee Mill Heights Retrofits

Rational Equation: Q=ciA		
Q=Peak Discharge, cfs		
c=Rational Method Runoff Coefficient		
i=Rainfall Intensity, inch/hour		
A=Drainage Area, acre		
Precipitation Frequency Curves for Manhattan, Kansas **(NOAA,2014)**		
i	One Year-60 Minute Rain Event in Inches	1.36
Rational Method Runoff Coefficients **(Singh, 1991; Corbitt, 1999)**		
c	Prairie Grassland	0.2
c	Woodland	0.25
c	Residential	0.6
c	Native Vegetation	0.2
c	Rain Garden Vegetation	0.1
Lee Mill Heights		
A	Prairie Grassland Area in Acres	28
A	Woodland Area in Acres	40
A	Residential Area in Acres	98
A	Proposed Native Vegetation	5
A	Proposed Rain Garden Vegetation	24
	Peak Discharge (cfs) for Prairie Grassland Area =	**7.62**
	Peak Discharge (cfs) for Woodland Area =	**13.60**
	Peak Discharge (cfs) for Residential Area =	**79.97**
	Peak Discharge (cfs) for Proposed Native Vegetation=	**1.36**
	Peak Discharge (cfs) for Proposed Rain Garden Vegetation=	**3.26**
	Total Runoff in cfs =	**105.81**

Table 5.2 Rational Method for Stormwater Runoff-Proposed Retrofits. By Author

Photograph by Jonathan E Knight

Chapter 6: Conclusions

Conclusions

Limitations

Although there was a 38% return on the 51 surveys handed out at the HOA meeting in February, a wider range of respondents would help to better gauge the neighborhood's perspective on ecological landscape design. It was also clear that not every resident within the HOA was present at the meeting. This limitation could have been addressed by mailing the surveys; however, time and project funding were an issue.

This research project could also have benefited from more meetings with the HOA and homeowners, therefore, creating a more iterative planning/design process and increasing opportunities for a discussion of ecological benefits and practical challenges to implementing and maintaining ecological designs in a development such as LMH. These meetings would be great opportunities to further educate homeowners on the value of sustainable design.

Further research could also take place in the field of human perceptions in regards to traditional and native planting designs and how traditional landscape design can be challenged in a manner that is not found to be aggressive by the homeowners.

Future Activities and Research

The next step in this research would be to work closely with the HOA's Executive Council, homeowners within Lee Mill Heights, and local landscape contractors in an effort to implement ecologically-inspired landscape design retrofits. In order for this to work effectively, more communication between homeowners and the lead activist (which in this case was the researcher) must continue.

The initial survey results showed that a majority of people still prefer the traditional, lawn-centric and more ornamental landscape aesthetic; however, this only indicates that a greater effort is necessary in challenging those perspectives by showing how conservation design strategies can save money, retain beauty, be safe, and help protect nearby prairie natural areas.

A way to get the homeowners involved would be to hold design workshops and community work days at the newly approved Park at Lee Mill Heights. This kind of engagement would help homeowners better understand the natural processes vital to the health of local prairie and woodland ecosystems and how important biodiversity and stormwater management are for the natural world around us. Taking this research further would also include opening a discussion with local landscape contractors about reasons for changing how residential developments are designed, implemented and maintained, and revealing how this can be done in ways that address homeowner interests in regards to aesthetics and ease of care.

The discussion with landscape contractors could be opened to those found locally and others who specialize in the implementation of sustainable landscapes. This could be accomplished in the form of a survey or interview. The survey/interview would inquire if the landscape contractors are seeing a demand for more environmentally-aware planting design, and if not, what steps they are taking to promote such designs.

As one approach, a researcher could survey landscape contractors before and after showing them one or more presentations on the importance of native landscapes by Dr. Doug Tallamay who speaks powerfully of the scientific evidence supporting the creation and conservation of native landscape systems. In addition, presentations about, and on-site tours of, local green infrastructure projects could be hosted so they could see and discuss the different ways that native plants have been incorporated into landscapes at KSU and Sunset Zoo projects.

Reflections-What I Learned from this Research Project

I learned that homeowners are willing to implement sustainable landscape design in Manhattan, Kansas. These types of designs are no longer only demanded on the east and west coasts of the U.S. I believe it takes several factors to implement ecologically-inspired landscape design retrofits within exurban and suburban neighborhoods:

1) *Community Engagement*. This engagement process comes in the form of raising ecological awareness. This research study made an effort to reach out to the homeowners of Lee Mill Heights by way of the neighborhoods Homeowners Association. A clear line of communication was essential for this project to be successful. I reached out to multiple sources to better understand both ecological systems and the neighborhood of Lee Mill Heights. Meeting with the homeowners at the annual HOA meeting was a major turning point in my research project. The interaction between the homeowners and myself started a process of communication that was both engaging and informative.

2) *Public Perception of Native Landscapes*. I find this topic to be the most interesting part of my research. I wish I only had more time to further explore this topic and challenge the homeowner's perception in regards to traditional landscape design. For now, I have at least planted the seed.

3) *Precedent Studies*. On my post-survey interview with homeowners, I showed them a few images of existing rain gardens and native planting designs. One of the homeowners reacted favorably toward the images I provided. I believe it is important for the homeowner to visually experience the proposed designs. This can be done by showing them existing designs through precedent studies and photographs of living landscapes in similar residential settings.

This process of design driven interaction with homeowners from Lee Mill Heights has been a pleasant experience. When I first entered the LARCP program at K-State, I never expected to be given the opportunity to develop such relationships with members of the community. Upon reflecting on my collegiate career, it is clear to me that I have developed confidence in my interaction with people through studios that involved stakeholders and Landscape Architect professionals. This exposure was further enhanced with my 4th year internship and by working with a local landscape contractor. These experiences prepared me for this extensive masters report project. I hope to carry these experiences on to my professional career as I begin a new chapter of my life in Denver with Norris Design.

Figure 6.1 Park at Lee Mill Heights. By Lee R Skabelund

Photograph by Jonathan E. Knight

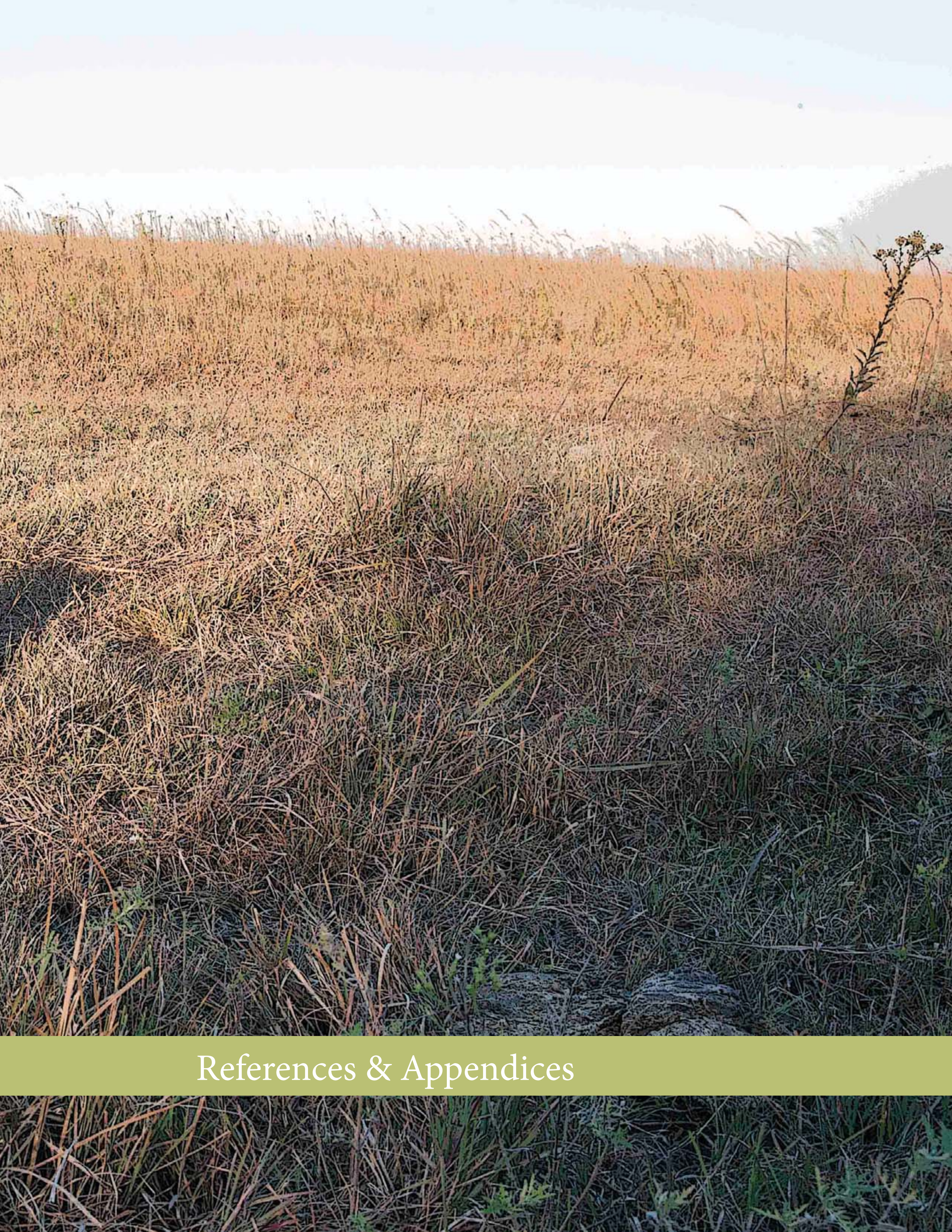


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Figure 2.2 Kansas Geological Survey (1997). Physiographic Map of Kansas. Map Modified by Leyva, A. From: http://www.kgs.ku.edu/Physio/physio.html
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Appendix A-IRB Approval & Modified

KANSAS STATE UNIVERSITY | University Research Compliance Office

TO: Lee Skabelund
LARCP
303I Seaton

Proposal Number: 8034

FROM: Rick Scheidt, Chair
Committee on Research Involving Human Subjects

DATE: 11/26/2015

RE: Proposal Entitled, "Restoration and Conservation of Ecological Systems in the Vicinity of Lee Hill Heights-Manhattan, Kansas"

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §46.101, paragraph b, category: 2, subsection: ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.

KANSAS STATE UNIVERSITY | University Research Compliance Office

TO: Lee Skabelund
LARCP
303I Seaton

FROM: Rick Scheidt, Chair
Committee on Research Involving Human Subjects

DATE: 03/04/2016

RE: Proposal #8034.1, entitled "Restoration and Conservation of Ecological Systems in the Vicinity of Lee Hill Heights-Manhattan, Kansas."

A MINOR MODIFICATION OF PREVIOUSLY APPROVED PROPOSAL #8034, ENTITLED, "Restoration and Conservation of Ecological Systems in the Vicinity of Lee Hill Heights-Manhattan, Kansas"

The Committee on Research Involving Human Subjects at Kansas State University has approved the proposal identified above as a minor modification of a previously approved proposal, and has determined that it is exempt from further review. This exemption applies only to the most recent proposal currently on file with the IRB. Any additional changes affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Unanticipated adverse events or problems involving risk to subjects or to others must be reported immediately to the IRB Chair, and / or the URCO.

It is important that your human subjects project is consistent with submissions to funding/contract entities. It is your responsibility to initiate notification procedures to any funding/contract entity of changes in your project that affects the use of human subjects.

Appendix B-Homeowner Survey

"Restoration and Conservation of Ecological Systems in the Vicinity of Lee Mill Heights—Manhattan, Kansas"

Graduate Student Surveyor: Alfonso Leyva, Kansas State University
(Phone: 620-655-1700; Email: leyva85@ksu.edu)

Faculty Advisor: Lee R. Skabelund, ASLA, Associate Professor of Landscape Architecture and Regional & Community Planning (Email: lskab@ksu.edu)

Purpose: The purpose of this survey is to inquire about current landscape maintenance practices at Lee Mill Heights, homeowner understanding of HOA restrictive covenants, and gauging homeowner's ecological awareness. In addition, I am interested in knowing how willing you and your neighbors are in implementing ecologically inspired landscape design retrofits. Because you are a homeowner at Lee Mill Heights, you are being invited to participate in this research survey.

Format and Time Requirements: The survey consists of 23 questions and will take approximately 10-15 minutes to complete. There is no compensation for responding, and potential risks are unlikely. A self-addressed stamped envelope has been enclosed with this survey for your convenience.

Survey Process and Information Disclosure: If you choose to participate in this survey, please answer all questions as honestly and accurately as possible. If you wish not to disclose some information, you may still continue with the survey and leave the question blank. Participation in this survey is voluntary and you may refuse to participate at any time. If you later decide that you would not like your responses compiled in the survey results prior to publication, you may request that your information be withheld by contacting Alfonso Leyva. If you require additional information or have questions, please contact Alfonso Leyva at the email or number listed above.

Survey Results and Dissemination: Survey results will be part of my Master's Report that will be publicly available on-line at the K-State Research Exchange (https://krex.k-state.edu) in approximately six months. If participants wish to receive a PDF copy directing from me, please feel free to email with your request. Results may also be published and/or presented in academic venues.

If you have any concerns or complaints, you may contact (anonymously if you so choose):
Kansas State University Research Compliance Office
203 Fairchild Hall
Manhattan, KS 66502
(785) 532-3224

Informed Consent Signature

1. I have read the informed consent shown on the first page of this survey. I voluntarily agree to participate in this study by signing my name in response.

Current Landscape Maintenance Practices

2. How often do you typically water your lawn between June 1st and September 30th?
   a. Once a week
   b. Twice a week
   c. Three times a week
   d. Four or more times a week
3. How often do you fertilize your lawn? Chose all that apply.
   a. Early Spring (March-April)
   b. Late Spring (May-June)
   c. Summer (July-September)
   d. Fall (October-November)
4. How often do you use an herbicide or pesticide on your yard/landscaping?
   a. Once a year
   b. Twice a year
   c. Three times a year
   d. Four or more times a year
5. How often do you typically mow your lawn between June 1st and September 30th?
   a. Once a month
   b. Twice a month
   c. Three times a month
   d. Four or more times a month
6. How high is your lawn typically mowed?
   a. 1 inch
   b. 2 inches
   c. 3 inches
   d. 4 or more inches
7. How often do you typically maintain (weed beds and prune) your shrubs/perennials?
   a. Once a year
   b. Twice a year
   c. Three times a year
   d. Four or more times a year
   e. Never

Awareness of Lee Mill Heights Homeowner Association (HOA) Restrictive Covenants

8. Are you familiar with your Homeowner Association (HOA) restrictive covenants?
   a. Yes
   b. No
   c. Somewhat
9. Does your property contain a conservation easement?
   a. Yes
   b. No
   c. I don't know
10. Are you aware that with 80% support of other homeowners within Lee Mill Heights HOA, amendments within the restrictive covenants can be changed?
    a. Yes
    b. No

Gauging Landscape Perceptions & Awareness

11. Numerically rank each landscape planting design that you find most favorable (#1, #2, #3 & #4) #1 being most favorable, and #4 being least favorable.

#___- Medium-sized irrigated and mowed lawn, with a predominantly native plant rain-garden to slow and infiltrate stormwater.

#___- Predominately native shrubs and wildflowers for native birds, butterflies, and other pollinators, with a small drought-tolerant lawn.

#___- Large, frequently irrigated and mowed lawn, with predominately non-native/ornamental plants.

#___- Predominately native grasses and wildflowers for native birds, butterflies, and other pollinators, with native non-irrigated turfgrass.

12. Why do you prefer the landscapes indicated as most favorable above?

13. Do you know what landscape ecology means?
    a. Yes
    b. No
14. If yes, please write a brief definition or description.

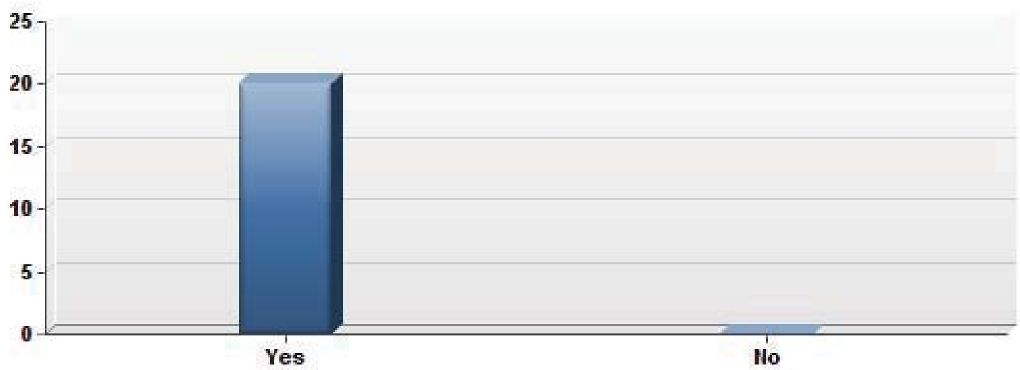
15. How familiar are you with how residential plantings influence broader ecological systems?
    a. Not at all familiar
    b. Slightly familiar
    c. Somewhat familiar
    d. Moderately familiar
    e. Extremely familiar
16. Did you know that well-designed native plantings typically cost less to maintain and irrigate than traditional landscapes composed of irrigated lawn and ornamental planting beds?
    a. Yes
    b. No

17. How likely is it that you or your family would install a predominately native landscape design to conserve resources and help protect nearby streams/water quality and prairie systems?
    a. Extremely unlikely
    b. Unlikely
    c. Neutral
    d. Likely
    e. Extremely Likely
18. How concerned would you be about your neighbor's opinion if you implemented a native planting design on your Lee Mill Heights property?
    a. Not at all concerned
    b. Slightly concerned
    c. Somewhat concerned
    d. Moderately concerned
    e. Extremely concerned
19. How concerned would you be if your neighbors implemented a native planting design?
    a. Not at all concerned
    b. Slightly concerned
    c. Somewhat concerned
    d. Moderately concerned
    e. Extremely concerned
20. Would you be willing to implement a native planting design on your Lee Mill Heights property if your neighbors were also willing to install a native planting design?
    a. Yes
    b. No
21. Would you be willing to install one or more rain gardens in your yard, using non-invasive native plant species to help reduce stormwater runoff, flooding, and water pollution in nearby drainageways and surface waters?
    a. Yes
    b. No
22. What are some concerns you may have about implementing native planting designs?
23. Please feel free to share any comments or questions you have about this survey.

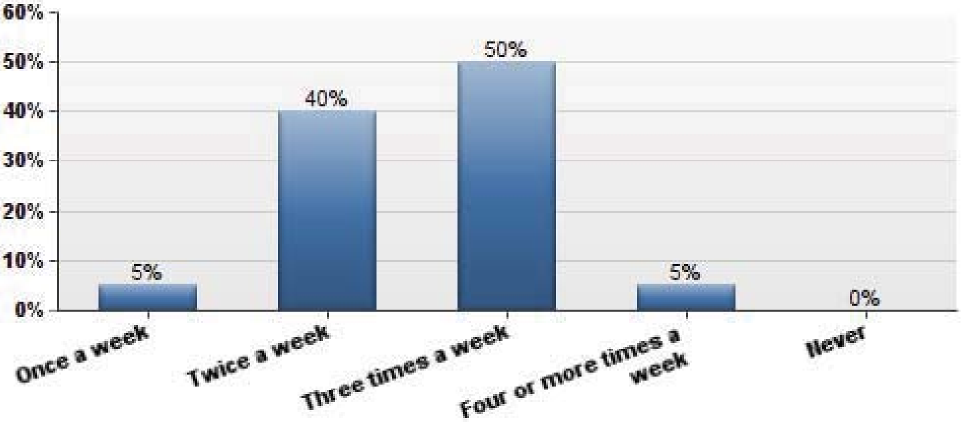
Appendix C-Homeowner Survey Data

"Implementing Ecologically-Inspired Landscape Design Retrofits within Exurban Neighborhoods" Survey Data

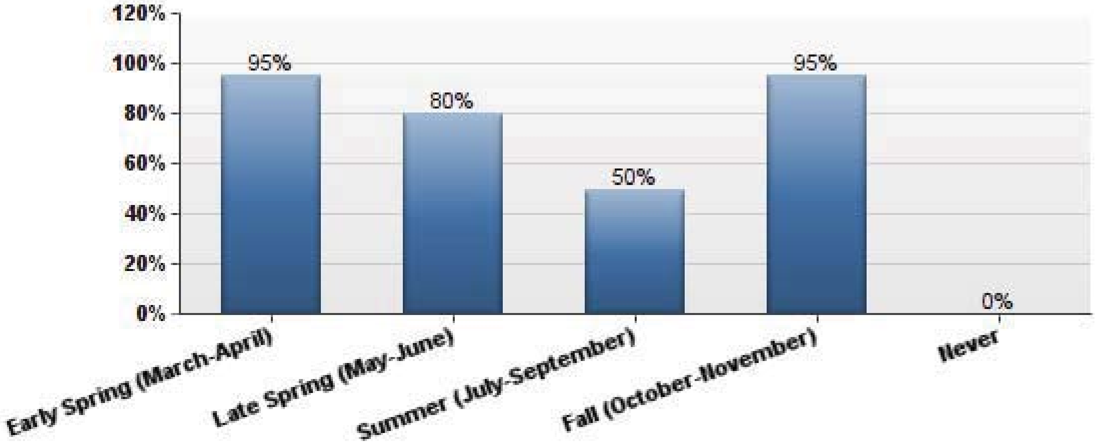
1. I have read the informed consent shown above. I voluntarily agree to participate in this survey by clicking 'Yes'



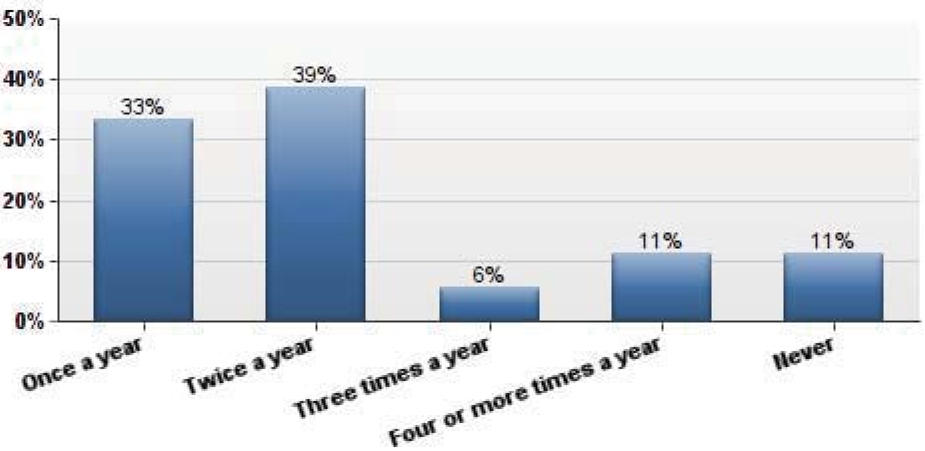
2. How often do you typically water your lawn between June 1st and September 30?



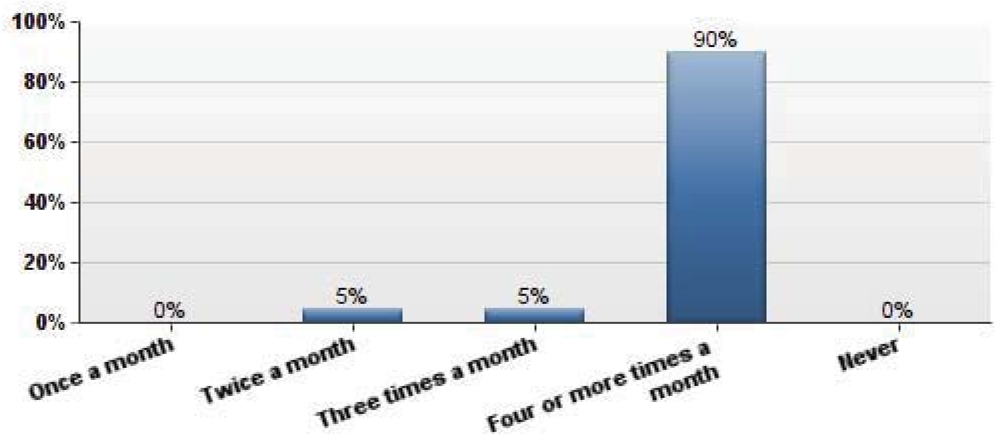
3. How often do you fertilize your lawn? Chose all that apply.



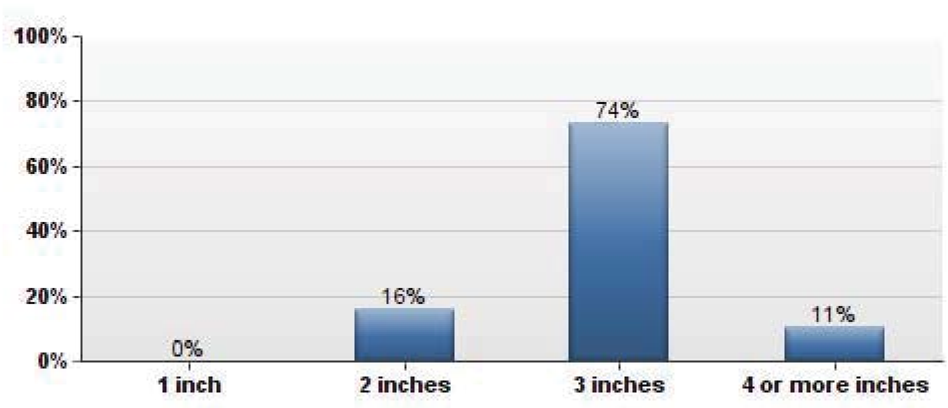
4. How often do you use an herbicide or pesticide on your yard/landscaping?



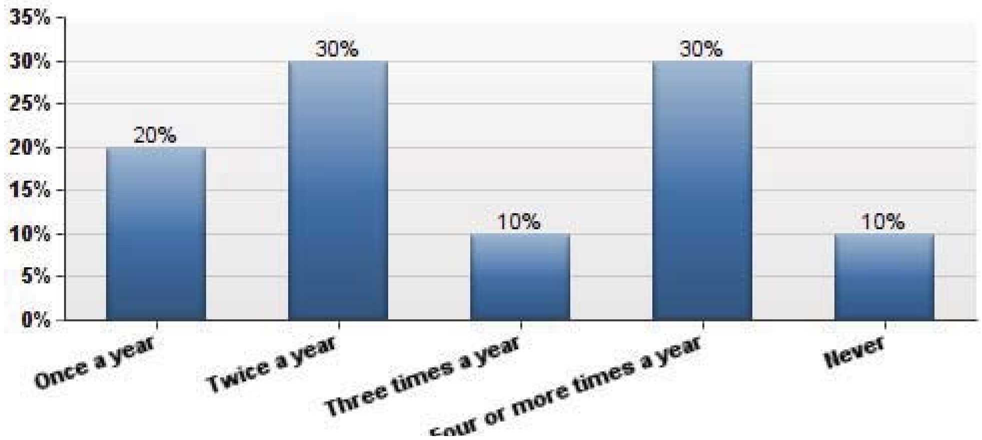
5. How often do you typically mow your lawn between June 1st and September 20th?



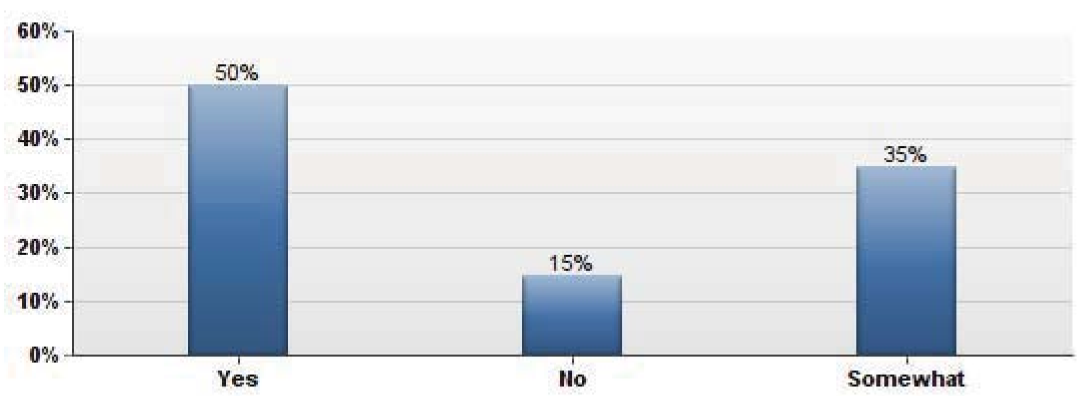
6. How high is your lawn typically mowed?



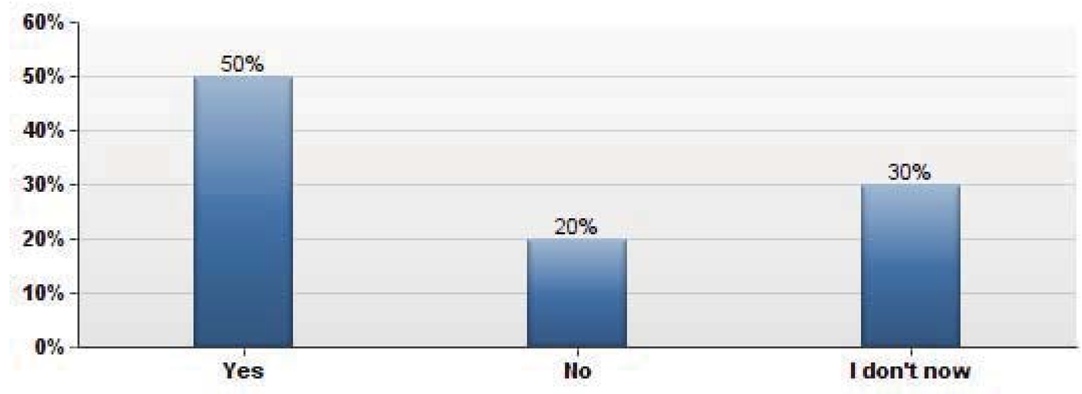
7. How often do you typically maintain (weed beds and prune) your shrubs/perennials?



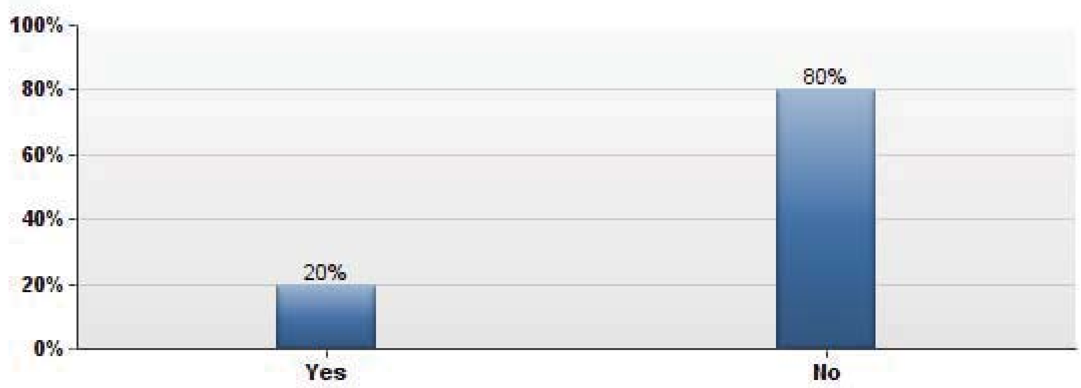
8. Are you familiar with your Homeowner Association (HOA) restrictive covenants?



9. Does your property contain a conservation easement?

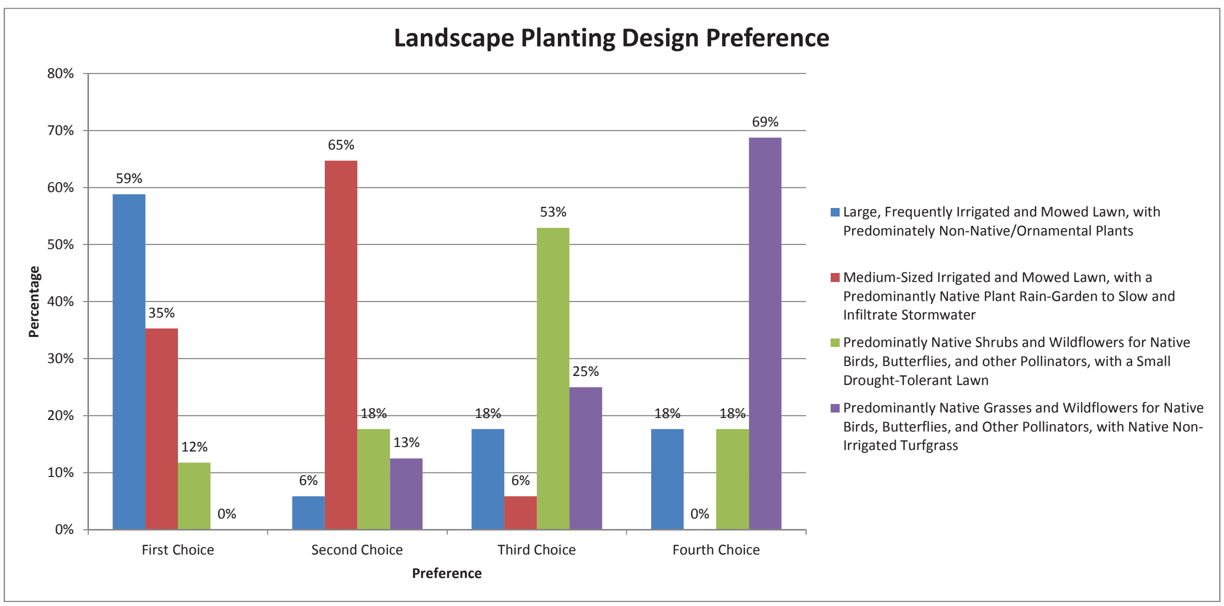


10. Are you aware that with 80% support of other homeowners within Lee Mill Heights HOA, amendments within the restrictive covenants can be changed?



11. Numerically rank each landscape planting design that you find most favorable (#1, #2, #3, #4) #1 being most favorable, and #4 being least favorable.

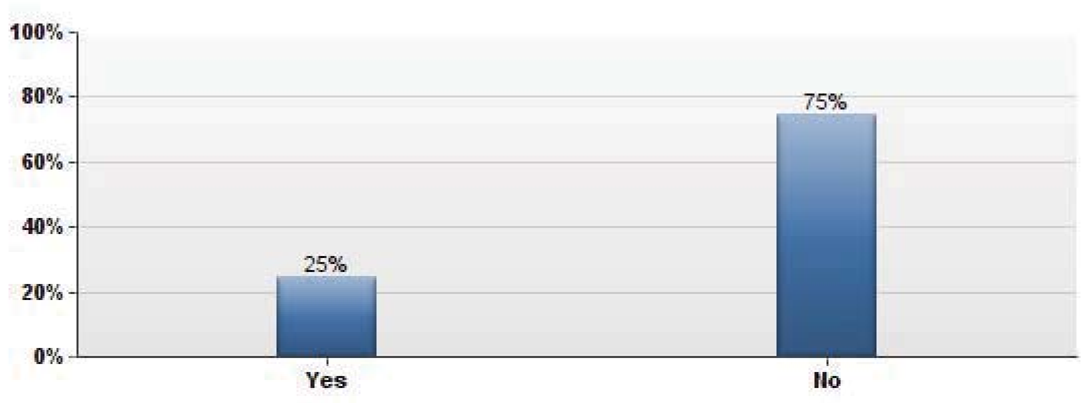
#	Answer					Total Responses
1		5	12	1	0	18
2		2	3	9	4	18
3		11	1	3	3	18
4		0	2	5	11	18
	Total	18	18	18	18	-



12. Why do you prefer the landscapes indicated as most favorable above?

Text Response
I like blooming plants in an orderly bed. I like nice weed free grass lawns.
Clean and neat
I like having some yard for kids to play, etc.
Native plants, butterflies
More natural
I do like a lawn for kids to play on, but also really enjoy wildflower. I do think watching water consumption is helpful.
none
I like the clean cut look. #4 is to "busy" looking
Cleaner look, less messy
Personal preference
Like the look
Every landscape design will differ depending on a variety of factors, including size, topographic layout & desire to maintain. All design above have their place and are all acceptable for various rationales.
I like clean looks & low maintenance; don't like too much flowers that attract bees.
Cleanest looking and elegant.
Very green, orderly, colorful!
Saving on irrigation and fertilization costs. Prefer hardiness of native plantings and want to attract birds & butterflies to property (to assist their survival & survival of native habitat).
It's open, clean, well kept easy to care for.

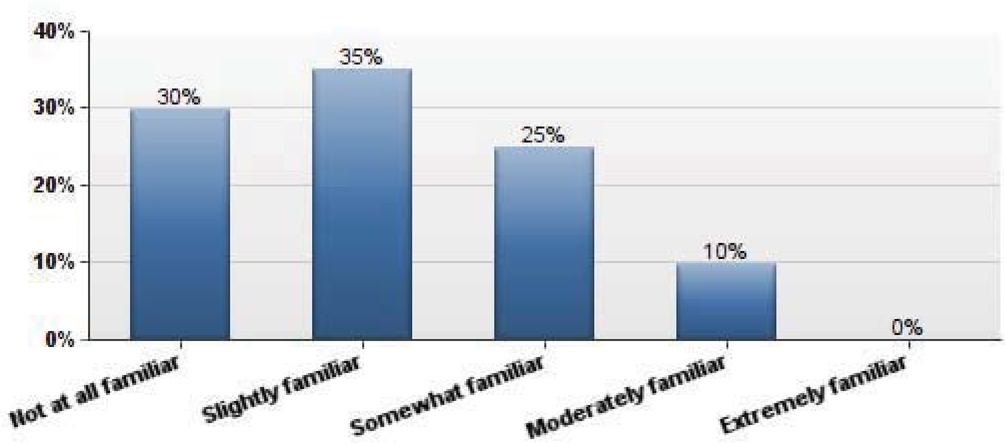
13. Do you know what landscape ecology means?



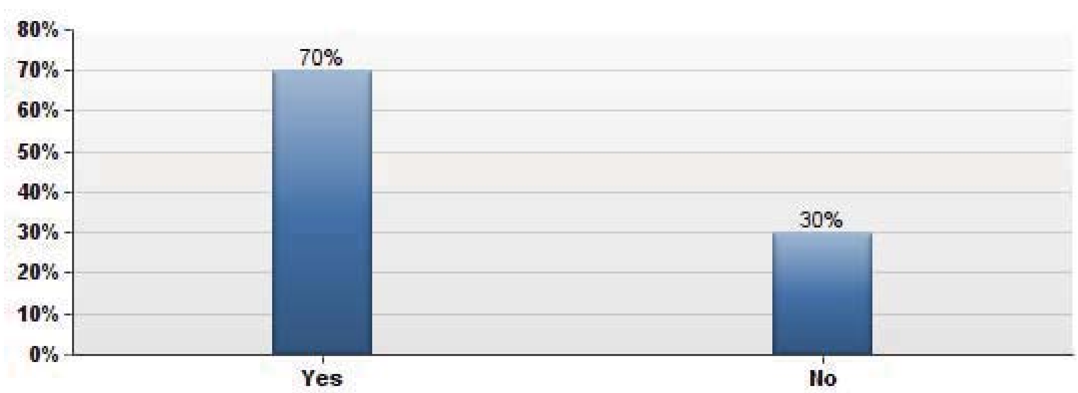
14. If yes, please write a brief definition or description.

Text Response
It is the study of landscape patterns, the interactions among the elements of this pattern, and how these patterns change over time.
Relationship between ecosystem & landscaping-how to landscape to coincide w/ecosystem.
none

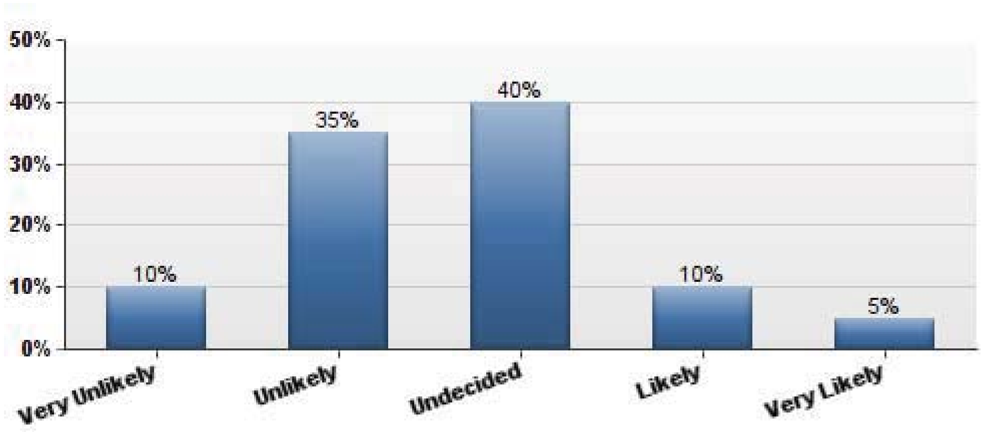
15. How familiar are you with how residential plantings influence broader ecological systems?



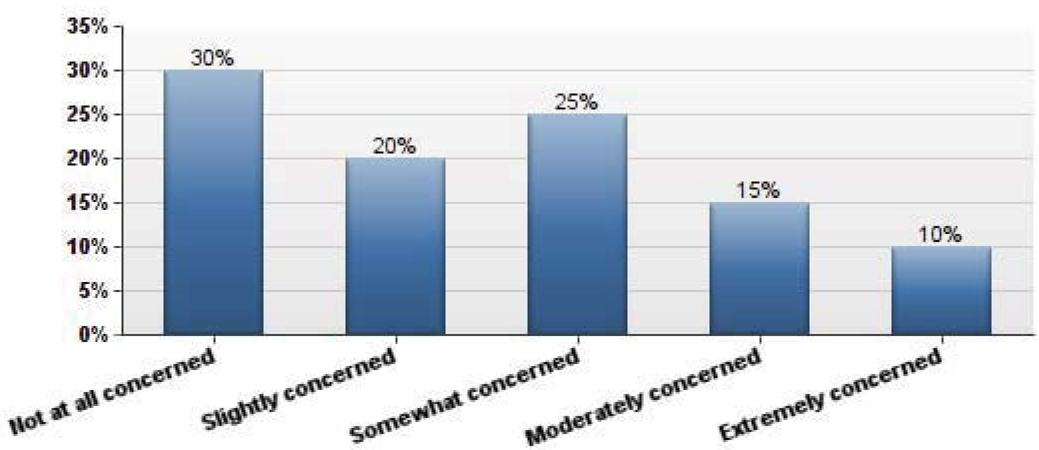
16. Did you know that well-designed native plantings typically cost less to maintain and irrigate than traditional landscapes composed of irrigated lawn and ornamental planting beds?



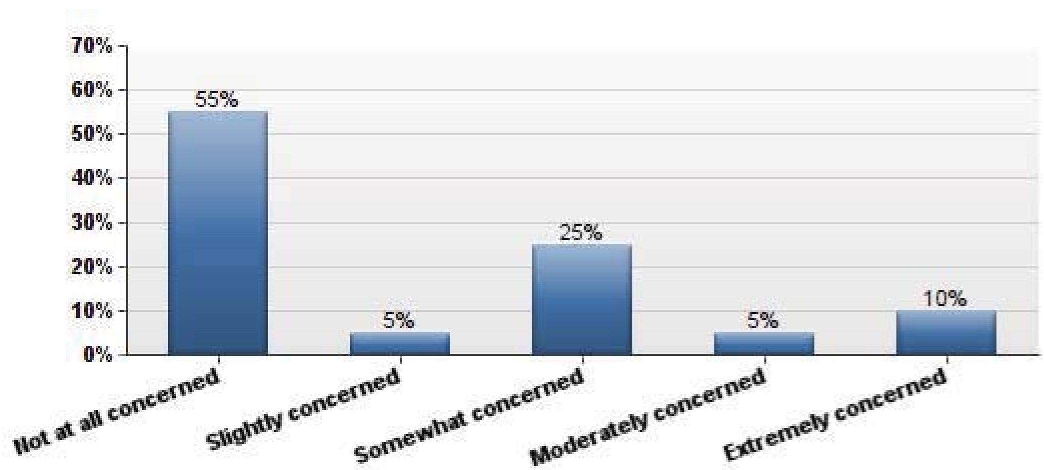
17. How likely is it that you or your family would install a predominately native landscape design to conserve resources and help protect nearby streams/water quality and prairie systems?



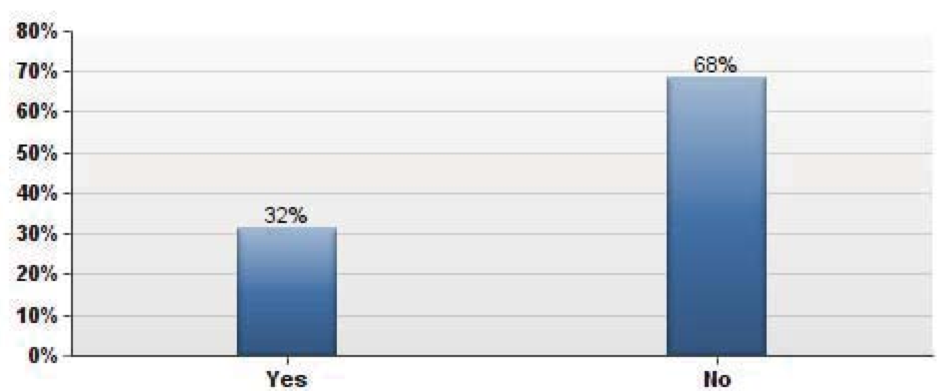
18. How concerned would you be about your neighbor's opinion if you implemented a native planting design on your Lee Mill Heights property?



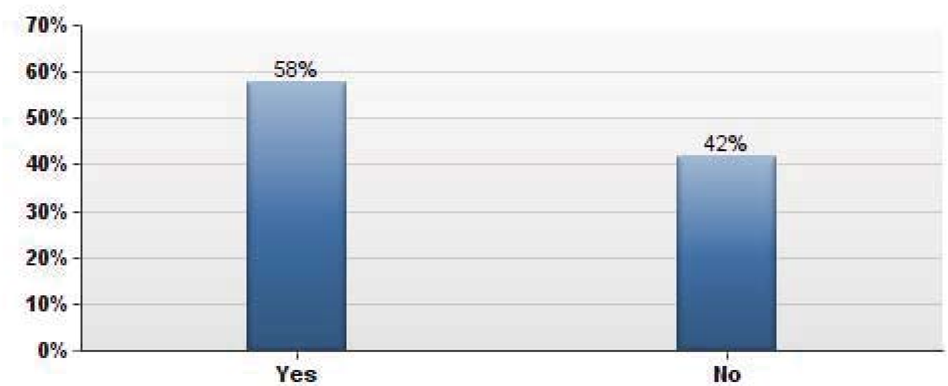
19. How concerned would you be if your neighbors implemented a native planting design?



20. Would you be willing to implement a native planting design on your Lee Mill Heights property if your neighbors were willing to install a native planting design?



21. Would you be willing to install one or more rain gardens in your yard, using non-invasive native plant species to help reduce stormwater runoff, flooding, and water pollution in nearby drainageways and surface waters?



22. What are some concerns you may have about implementing native planting designs?

Text Response
none
I don't have a green thumb and don't have a lot of time for maintenance.
Becoming overgrown and looking too wild
We should all do it as a group
When we bought our house, a lawn (sod) was already present. I do like grass, but am willing to consider adding native plants in the backyard as it is large. I would be interested in the cost.
Just the superfical concern of not wanting to spend any more $ for landscaping. otherwise no real problem.
The look of overgrown & messiness. I like the 'idea' of native planting & corrective use of plants for a region. We have crown vetch which we had planted. I hate it. I wish the landscape person gave us another choice. It's messy and hard to control.
The movement of plants & grasses. I wouldn't like that.
Needs to be done during construction and the likelihood that a relatively new housing area would implement changes so quickly after construction is limited. To promote such a concept, you should also include $ estimates of costs compared to traditional landscaping and promote with the top 3-4 landscape companies.
I'd prefer clean image & extremely low maint.
Look unkept. Trash collects in them. Weeds grow and hard to maintain so they look nice.
Not interested!
Maintaining the appearance of the design, amount of time to prune or weed, dead head, etc.
In our area there have been many sitings of copperhead snakes. Native planting design are conducive the habitat of copperheads. I would prefer NOT to enhance that. I want kids, grandkids to be safe with no worry about poisnous snakes hiding where they cannot be seen and killed.
I believe there is not enough space in my yard for an area described above since I have a lot of current landscaping. We are going to be selling our house soon and have been thinking about curb appeal. With the pictures that were shown, I do not believe the landscape would add value to our house right now. If we were staying here longer, I may

23. Please share any comments or questions you have about this survey. If you are interested in further discussion, please feel free in contacting me at leyva85@ksu.edu with your contact information.

Text Response
none
Have large community grassy area otherwise yards are a "suburban trap" that we have created ourselves gladly fed by landscaping companies.
I'd like to see what you're offering; I have a clean slate of a yard currently.
n/a
I think the perception of Lee Mill Heights is that homeowners take pride in their yards and maintain their homes. Many of the pictures shown show plants that look 'wild' or unkept so people would think your yard is not manicured. I'm sure if there was a way to have one of the landscape designs look more orderly with less plants that look rugged. Again, I would not mind this for my backyard because it is not seen from the street.

Appendix D-Homeowner Post-Survey & Data

"Implementing Ecologically-Inspired Landscape Design Retrofits within Exurban Neighborhoods"

Graduate Student Surveyor: Alfonso Leyva, Kansas State University
(Phone: 620-655-1700; Email: leyva85@ksu.edu)

Faculty Advisor: Lee R. Skabelund, ASLA, Associate Professor of Landscape Architecture and Regional & Community Planning (Email: lskab@ksu.edu)

Purpose: The purpose of this post-survey interview is to discuss the developed design and ask a few follow-up questions.

Format and Time Requirements: This interview will be in person and may take 15-20 minutes to complete.

Post-Survey Interview Process and Information Disclosure: If you choose to participate in this post-survey interview, please answer all questions as honestly and accurately as possible. Participation in this interview is voluntary and you may refuse to participate at any time. If you later decide that you would not like your responses compiled in the content analysis prior to publication, you may request that your information be withheld by contacting Alfonso Leyva. If you require additional information or have questions, please contact Alfonso Leyva at the email or number listed above.

Post-Survey Interview Results and Dissemination: Post-survey interview data will be part of my Master's Report that will be publicly available on-line at the K-State Research Exchange (https://krex.k-state.edu) in approximately three months. If participants wish to receive a PDF copy, please feel free to email with your request. Results may also be published and/or presented in academic venues.

If you have any concerns or complaints, you may contact (anonymously if you so choose):
Kansas State University Research Compliance Office
203 Fairchild Hall
Manhattan, KS 66502
(785) 532-3224

Informed Consent Signature

1. I have read the informed consent shown on the first page of this survey. I voluntarily agree to participate in this study by signing my name in response.

Post-Survey Homeowner Interview

2. Between completion of the survey and presentation of the potential design, has your opinion of ecologically-inspired landscape design retrofits changed?
3. Why or why not?
4. Would you like to receive more sources on the topic of native planting designs and their benefits?
5. What do you see as the major opportunities & barriers in implementing ecological design strategies?

Post-Survey Homeowner Interview Content Analysis

Homeowner	Between completion of the survey and presentation of the potential design, has your opinion of ecologcially-inspired landscape design retrofits changed?	Why or why not?	Would you like to receive more sources on the topic of native planting designs and their benefits?	What do you see as the major opportunities & barriers in implementing ecological design strategies?
Leone Ridge	Opinion has not changed. Still positive attitude toward sustainable design	Homeowner feels aware of the natural systems and benefits they provide for us.	Would like more information on the topic of native plantings.	Neighbor perception is still a concern with this homeowner. Maintenance is also a concern.
West Park Grove	Opinion has changed from skeptical to positive.	Likes rain garden concept for a section of her property. Concerned about maintenance.	Would like more information on the topic of native plantings. Enjoys learning about the topic.	Care, cost, and safety. Snakes brought up in this answer.
East Park Grove	Opinion has changed from skeptical to positive.	Design is 'gorgeous', thinks the idea behind sustainable design is 'lovely'. Homeowner brought up fear of snakes being an issue.	Would NOT like more information.	Anything ecologically friendly is enjoyed by homeowner. Brought up fear of snakes again.
North Mill Point	Opinion has changed from skeptical to positive.	Opened eyes to how the drainage on their property works. Changes made on their property has positive effect away from property.	Would like more information on topic of cost effective differences.	Barriers: startup cost, not status-quo Opportunities: cost effective over time yet visually attractive

Appendix D-Native and Rain Garden Plant List

Botanical Name	Common Name	Plant Type	Height	Spread
Eupatorium perfoliatum	Common Boneset	Native Wildflower	4-6'	3-4'
Juncus effusus	Soft Rush	Perennial	12-18"	12-18"
Carex vulpinoidea	Fox Sedge	Perennial	1-3'	0.5-2'
Asclepias incarnata	Swamp Milkweed / Red Milkweed	Perennial	2-6'	2-3'
Carex lupulina	Hop Sedge	Perennial	1-4'	
Lobelia cardinalis	Cardinal Flower	Native Wildflower	2-4'	1-2'
Carex hystericina	Bottle Brush Sedge	Perennial	1-3'	1-3'
Zizia aurea	Golden Alexanders/Zizia	Native Wildflower	18-36"	1-3'
Iris virginica-shrevei	Wild Blue Flag Iris	Native Wildflower	1-3'	1-3'
Physostegia virginiana	Obedient Plant	Native Wildflower	24-48"	24-48"
Calamagrostis canadensis	Blue Joint Grass			
Spartina pectinata	Prairie Cordgrass	Perennial	4-7'	4-7'
Panicum virgatum	Switchgrass	Native Grass	3-4'	3-4'
Cornus ammomum	Silky Dogwood			

Botanical Name	Common Name	Plant Type	Height	Spread
Asclepias				
Schizachyrium scoparium	Little Bluestem	Native Grass	2-4'	1-2'
Sporobolus heterolepis	Prairie Dropseed	Native Grass		
Solidago flexicaulis	Broad Leaf Goldenrod	Native Wildflower	1-3'	1-1.5'
Solidago speciosa	Showy Goldenrod	Native Wildflower	1-3'	1-1.5'
Ratibita columnifera	Prairie Coneflower	Native Wildflower	1-3'	1-1.5'
Verbena stricta	Hoary Vervain	Native Wildflower	1-4'	1-1.5'
Baptisia australis	Blue false indigo	Native Wildflower	3-4'	3-4'
Itea virginica	Virginia sweetspire	Shrub	3-4'	3-4'
Viburnum dentatum	Arrowwood viburnum	Shrub		
Dalea purpurea	Purple Prairie Clover	Native Wildflower	1-3'	1-1.5'
Ilex glabra	Inkberry	Shrub	3-4'	3-4'
Amelanchier arborea	Serviceberry	Tree	15-25'	15-25'

Botanical Name	Common Name	Plant Type	Height	Spread
Calamagrostis canadensis	Feather reedgrass 'Karl Foerster'	Ornamental Grass		
Bouteloua curtpindula	Sideoats grass / grama	Native Grass	1.5-2'	1.5-2'
Elymus canadensis	Canada wild rye	Native Grass	2-5'	2-5'
Sporobolus heterolepis	Prairie Dropseed	Native Grass	2-3'	2-3'
Sorghastrum nutans	Yellow Indiangrass	Native Grass	3-5'	1-2'
Asclepias	Milkweed			
Artemisia ludoviciana 'Silver King'	White Sage	Native Wildflower	2-3'	2-3'
Asclepias tuberosa	Butterfly Milkweed	Native Wildflower	1-2.5'	1-1.5'
Baptisia australis	Blue false indigo	Native Wildflower	3-4'	3-4'
Schizachyrium scoparium	Little Bluestem	Native Grass	2-4'	1.5-2'
Andropogon gerardii	Big Bluestem	Native Grass	4-6'	2-3'
Panicum virgatum	Switchgrass	Native Grass	3-4'	3-4'
Lespedeza capitata	Bush Clover	Native Wildflower		
Brickellia eupatorioides	False Boneset	Native Wildflower	3'	2'
Solidago rigida	Stiff goldenrod	Native Wildflower	2-5'	1.5-2.5'
Rosa setigera	Prairie Rosebush	Deciduous Shrub	6-12'	8-10'
Amorpha canescens	Lead Plant	Deciduous Shrub	2-3'	2-2.5'
Cornus asperifolia var. drummondii	Roughleaf Dogwood	Deciduous Shrub	6-15'	6-15'
Rhus aromatica	Fragrant Sumac	Deciduous Shrub		
Populus deltoides	Cottonwood	Tree	50-80'	35-60'

Bioswale / Rain Garden

Lower Slopes - Wet Zone

Sun	Soil	Bloom Color	Bloom Time	
Full Sun	Medium to Wet	White	July to September	
Full Sun to Full Shade	Wet	Yellow-ish Green	June to August	
Full to Partial Sun	Wet	Green	May to June	
Full to Partial Sun	Medium to Wet	White, Pink, Mauve	July to August	
Full to Partial Shade				
Full to Partial Shade	Medium to Wet	Red	Jul to September	
Full to Partial Sun	Wet to Moist Soils	Green	May to June	
Medum Sun to Shade	Medium	Yellow	May to June	
Full to Partial Sun	Medium to Wet	Violet-blue with yellow and white crested	June	
Full Sun	Medium	Pink, White	June to September	
Full sun to Part Shade	Medium to Wet	Yellow-Brown	July to August	larger areas
Full sun to part shade	*Reddish-pink*	July to February		larger areas

Upper Slopes - Mesic Zone

Sun	Soil	Bloom Color	Bloom Time	
Full Sun	Dry to Medium	Purplish bronze	August to February	
Full sun to part shade	Dry to Moist	Yellow	July to September	protected from heat & wind
Full sun to part shade	Dry to Medium	Yellow	July to September	protected from heat & wind
Full Sun		Yellow	May to August	
Full Sun to part shade	Dry to Medium	Indigo blue	May to June	larger areas
Full sun to part shade	Medium to wet	White	June to July	protected from heat & wind
				protected from heat & wind
Full Sun	Medium	Rose/Purple	June to August	
Full sun to part shade	Medium to Wet			protected from heat & wind
Full sun to part shade	Medium	White	March to April	protected from heat & wind

Re-establishment Mix

Sun	Flower Color / Fall Foliage	Bloom Time	
	Purplish	July to August	
Full Sun	Greenish	July to September	
Full Sun	Pink and brown-tinted	August to October	
Full Sun	Light brown with yellow	September to February	
	Cream/White		
Full Sun	Yellowish-grey	August to September	
Full Sun	Yellow/Orange	June to August	
Full Sun to part shade	Indigo blue	May to June	
Full Sun	Purplish bronze	August to February	
Full Sun	Purplish-red	September to February	
Full sun to part shade	Reddish-pink	July to February	
Full Sun to Part Shade	Cream	August to September	
Full Sun	Medium	Yellow	August to September
Full sun to part shade	Pink fading to whitish	June	
Full Sun	Purple, blue	July to September	
Full sun to part shade	Yellowish-White	May to June	
Full sun			will naturalize