THE CAMPUS CARBON CONVALESCENCE: CREATING A CARBON-FRIENDLY UNIVERSITY LANDSCAPE

by

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A THESIS

submitted in partial fulfillment of the requirements for the degree

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Abstract

Universities play a key role in the progression of society. With increased releases of carbon into the atmosphere and the effect of carbon dioxide and related pollutants on air quality and climate, it is critical that universities reduce their carbon footprints.

Alternative landscape architectural designs and management techniques, such as rain gardens, constructed wetlands, restored prairies, and woodlands can be implemented to mitigate carbon outputs. Infrastructural landscapes-called “green infrastructure” for their ability to meet essential human needs using natural processes - sequester carbon at high rates, improve stormwater runoff quality, and reduce runoff volumes.

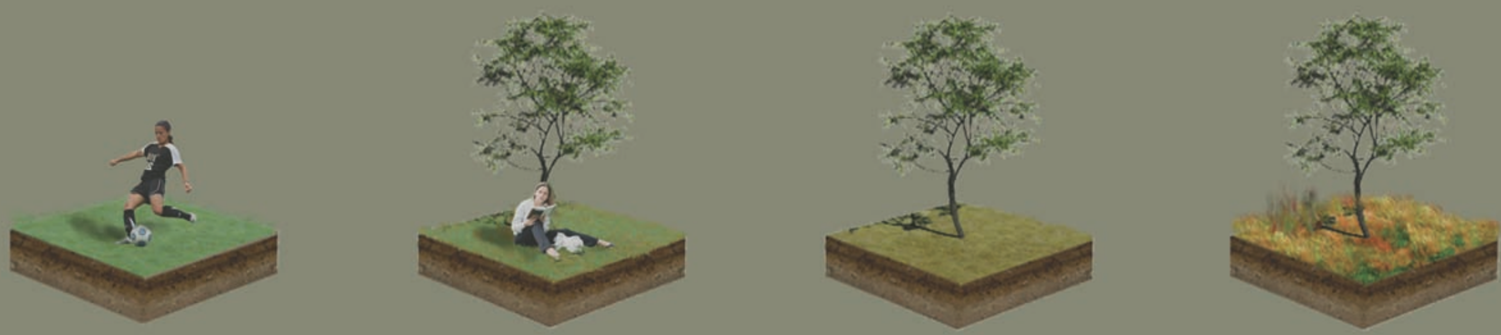
Establishment of native and other appropriate green space networks on university campuses can provide rich settings for education, research, and infrastructural services while also promoting carbon neutrality—achieving net zero carbon emissions by balancing carbon released to the atmosphere with an equivalent amount sequestered in vegetation or offset by investing in renewable energy sources.

The large experiential landscapes associated with university campuses can operate simultaneously as alternative stormwater and carbon mitigating landscapes. They likewise have the potential to restore critical ecological processes while reflecting many of the ecosystems associated with the eco-region where each university resides.

The educational aspect of universities will be enhanced through an interwoven landscape of green infrastructure networks and pedestrian corridors that engage and inform faculty, students, staff and visitors.

Development of green infrastructure on university campuses can significantly reduce human impacts on the local environment. They can also increase environmental awareness and showcase responsible stewardship of the land and recourses. These landscapes have great potential to restore native ecosystems and/or historic landscapes habitats. In the right locations they can provide stable environments for various regionally important plant and animal species. Green infrastructure can also reduce short- and long-term costs associated with creating, maintaining, and replacing traditional pipe-to-pond stormwater infrastructure. Increased carbon sequestered in infrastructural landscapes could likewise be a source of additional revenue for universities through the carbon trading market (assuming this market becomes active and remains productive in the U.S.), thus creating a return on investment in the overall green infrastructure system for a campus.

The Campus Carbon Convalescence:
Creating a Carbon-Friendly University Landscape



A Masters Project Report by Jesse Benedick

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The Campus Carbon Convalescence:
Creating a Carbon-Friendly University Landscape

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Dedication

This book is dedicated to Alec Waggoner (February 7, 1985 - October 26, 2008). The tragedy of his death has scarred many, but the glory of his life will affect all. He will live on through the influence he had on others. All who knew Alec strive to strive to keep life full experience and discovery. Without his influence, many things would not have been accomplished.

Abstract

Universities play a key role in the progression of society. With increased releases of carbon into the atmosphere and the effect of carbon dioxide and related pollutants on air quality and climate, it is critical that universities reduce their carbon footprints.

Alternative landscape architectural designs and management techniques, such as rain gardens, constructed wetlands, restored prairies, and woodlands can be implemented to mitigate carbon outputs. Infrastructural landscapes—called “green infrastructure” for their ability to meet essential human needs using natural processes—sequester carbon at high rates, improve stormwater runoff quality, and reduce runoff volumes.

Establishment of native and other appropriate green space networks on university campuses can provide rich settings for education, research, and infrastructural services while also promoting carbon neutrality—achieving net zero carbon emissions by balancing carbon released to the atmosphere with an equivalent amount of carbon sequestered in vegetation or offset by investing in renewable energy sources.

The large experiential landscapes associated with university campuses can operate simultaneously as alternative stormwater and carbon mitigating landscapes. They likewise have the potential to restore critical ecological processes while reflecting many of the ecosystems associated with the eco-region where each university resides.

The educational aspect of universities will be enhanced through an interwoven landscape of green infrastructure networks and pedestrian corridors that engage and inform faculty, students, staff and visitors.

At Kansas State University, spaces for experiential education, which are central to the teaching and outreach missions of the university and which can also contribute to scholarship, should be located at strategic points throughout the campus. This document describes promising locations for these experiential education spaces.

Development of green infrastructure on university campuses can significantly reduce human impacts on the local environment. They can also increase environmental awareness and showcase responsible stewardship of the land and resourses.

These landscapes have great potential to restore native ecosystems and/or historic landscapes habitats. In the right locations they can provide stable environments for various regionally important plant and animal species. Green infrastructure can also reduce short and long-term costs associated with creating, maintaining, and replacing traditional pipe-to-pond stormwater infrastructure. Increased carbon sequestered in infrastructural landscapes could likewise be a source of additional revenue for universities through the carbon trading market (assuming this market becomes active and remains productive in the U.S.), thus creating a return on investment in the overall green infrastructure system for a campus.

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Description and Intent

Dilemma

Universities have the potential to play a key role in the progression of society. Leading by example is one of the strongest ways to promote learning, and we have a great need to learn about creating and managing sustainable landscapes. Such landscapes must be well-functioning ecological systems that can be managed and enjoyed by those who visit or who work, study, and teach on campus. With increased releases of carbon into the atmosphere and the effect of carbon dioxide and related pollutants on air quality and climate change, it is critical for universities to address their carbon-and-pollution footprints in regards to buildings and landscape systems. Currently, the university campus landscape is typically a setting where carbon emissions are released from management of lawns and other softscape areas. Campus landscapes are also settings where vegetation pulls carbon from the atmosphere and sequesters it in biomass and soil.

A central question is: How can a university mediate air pollution impacts resulting from too much CO_2 emission within its campus landscape and do so in an aesthetic and manageable way?

Figure 01: Smoke Stacks

Thesis

Establishment of native and other appropriate green space networks on university campuses can provide settings for education, research, and infrastructural services leading to a more carbon-friendly campus landscape that educates by promoting carbon neutrality.

Large experiential outdoor spaces associated with universities can function as extensive carbon mitigating landscapes. They likewise have the potential to reduce negative environmental impacts from stormwater runoff, restore critical ecological processes, and engage and inform faculty, students, staff and visitors. These landscapes can also reflect many of the ecosystems associated with the eco-region where the university resides—thus connecting students, faculty, staff, and visitors to a landscape that has a more distinct sense of place. Changes in both landscape management and vegetative structure can play important roles in the process of moving towards carbon neutrality on campuses such as Kansas State University.

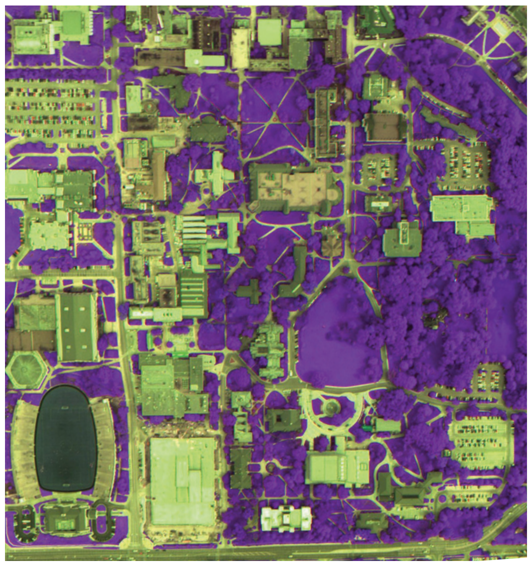


Figure 02: Kansas State University Softscape (In Purple)

Key Issues Relating to Landscape Architecture

Responsibility for the Environment and Society

Within the profession of landscape architecture soil carbon management is becoming an important part of site planning and design. Management of natural systems, such as stormwater have already taken a central position in the realm of sustainable design. Environmental impacts from traditional stormwater management techniques have led to the development of alternative on-site stormwater management techniques. The U.S. Green Building Council integrated stormwater management (as well as water use efficiency and innovative site planning/design) into LEED certification criteria. Sustainability issues and design certifications aside, on-site alternative stormwater management techniques provide additional cost savings to nearly any site or project.

Presently carbon management is not as widely acknowledged as stormwater management within the profession of landscape architecture. However, its importance to the future of the profession as a whole may be just as important as stormwater management in the years to come. The Sustainable Sites Initiative has identified carbon management as an important component of sustainable design (SSI 2009).

As climate change mitigation, soil conservation, and air quality issues increase, the need to responsibly manage carbon will become essential for all landscape architects who wish to create more sustainable sites and communities. In the minds of many soil scientists carbon management is already a critical issue—one that is not being addressed to its fullest extent (Kimble 2007).

The Landscape Architects Role in Carbon Management

Given that the role of landscape architecture is strongly associated with large-scale and over arching urban and human related challenges, it is critical that carbon management be included as an important factor in the planning and design process. Landscape Architects can provide valuable services as they help to address the challenges concerning the balance of social needs and environmental responsibility. The array of tools and skill sets available to Landscape Architects can be used to communicate relationships between emissions of carbon from landscape management and the sequestration of carbon from different types of vegetation. Careful analyses of these relationships will help universities and other institutions identify the overall balance of carbon being emitted into the atmosphere versus that which is sequestered in biomass and soils. This report argues that intelligent, innovative carbon-friendly landscape design and management can be realized and is a realm where Landscape Architects need to take more action.

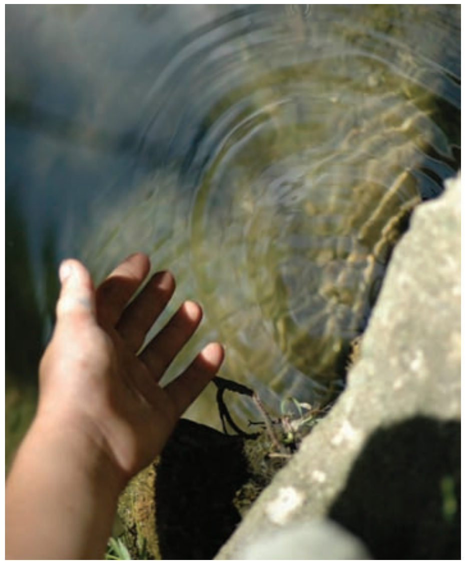


Figure 03: Water

Project Goals

1. Investigate Carbon-Friendly Landscape Design and Management

The primary goal of this project was to develop an analysis and planning frameworks that address carbon management in the urban landscape, using a rigorous and repeatable method. The frameworks are derived from a combination of key literature and individuals from Kansas State University Grounds and Facilities.

Soil carbon management and sequestration increases the amount of carbon (a greenhouse gas that is pulled from the atmosphere by vegetation) stored in soils. Carbon emissions are of increasing concern, not only on university campuses, but in many other urban and rural landscapes. This project focuses on the university setting because of the influence such institutions have as a result of their educational, research, and outreach responsibilities. Each of these factors (teaching, exploration, and service) can play a role in spreading environmental awareness and stewardship to individuals and society as a whole.

This project aims to discern a set of frameworks for campus landscape planning that reduces carbon impacts in the campus landscape. The frameworks direct the development of campus scale plans and renderings - with a focus on landscape structure, function and management. These frameworks also explore relevant issues that reflect how the campus is currently managed. From this, plans are developed that inform how the campus can be landscaped and managed in a way that reduces emissions and/or maintains or improves the landscapes' ability to sequester carbon. Because soil carbon sequestration is a proven method of carbon mitigation (Kimble 2007), ways to facilitate this natural process are emphasized.

Project Goals

2. Increase the Appreciation of A Carbon-Friendly Landscape Aesthetic

The types of landscapes that most effectively mitigate carbon emissions look and function different than manicured, frequently mowed, and irrigated landscapes—or they are similar in look and are simply mowed and watered much less frequently. In short, carbon-friendly landscapes, as opposed to highly manicured landscapes, contain dense vegetation that requires less carbon emitting management and sequester more amounts of carbon. This vegetation may appear to be “wild” or “natural,” and thus could be viewed as weedy or present an undesirable aesthetic given common sociocultural perceptions. Therefore, it is an objective of this project to effectively communicate the benefits of carbon-friendly landscapes to those with decision-making authority on campuses. It is assumed that university decision makers will be more comfortable implementing this new aesthetic into the campus if they more fully understand the financial benefits and appreciate a landscapes important role in mitigating carbon emissions.

At the same time, the beauty of more diverse landscape types needs to be recognized and appreciated. The value and deeper beauty of less-intensively managed landscapes can also be recognized and appreciated. In urban areas, framing more wild or natural vegetation can be a helpful way to show design interpretations of “carbon friendly.” Thus, the urban environment would increase a viewers appreciation for a carbon friendly aesthetic.

As has been eloquently argued by Aldo Leopold in *A Sand County Almanac* (as well as by botanist Gerald Wilhelm of the Conservation Design Forum), we come to love that which we understand, experience and/or perceive to be beautiful—and native ecosystems are truly elegant. One only needs to spend time at Konza Prairie during different seasons of the year to recognize the beauty and functional value of well-managed prairie and woodland ecosystems.

Figure 04: Prairie

Project Study Site and Context

For the purposes of this project a study site (Kansas State University, near the confluence of the Big Blue and Kansas rivers and within the Flint Hills Eco-region in north-central Kansas) was selected to explore the development of a carbon-friendly landscape planning and design process. Although the process will be developed focusing on this particular campus, it expected to be applicable to other universities.

Joe Myers of Kansas State University Grounds Department was the primary source for information concerning the campus landscape and its management.

Location and size of site
KSU Main Campus, Manhattan KS
597 acres (as outlined in Figure 05).

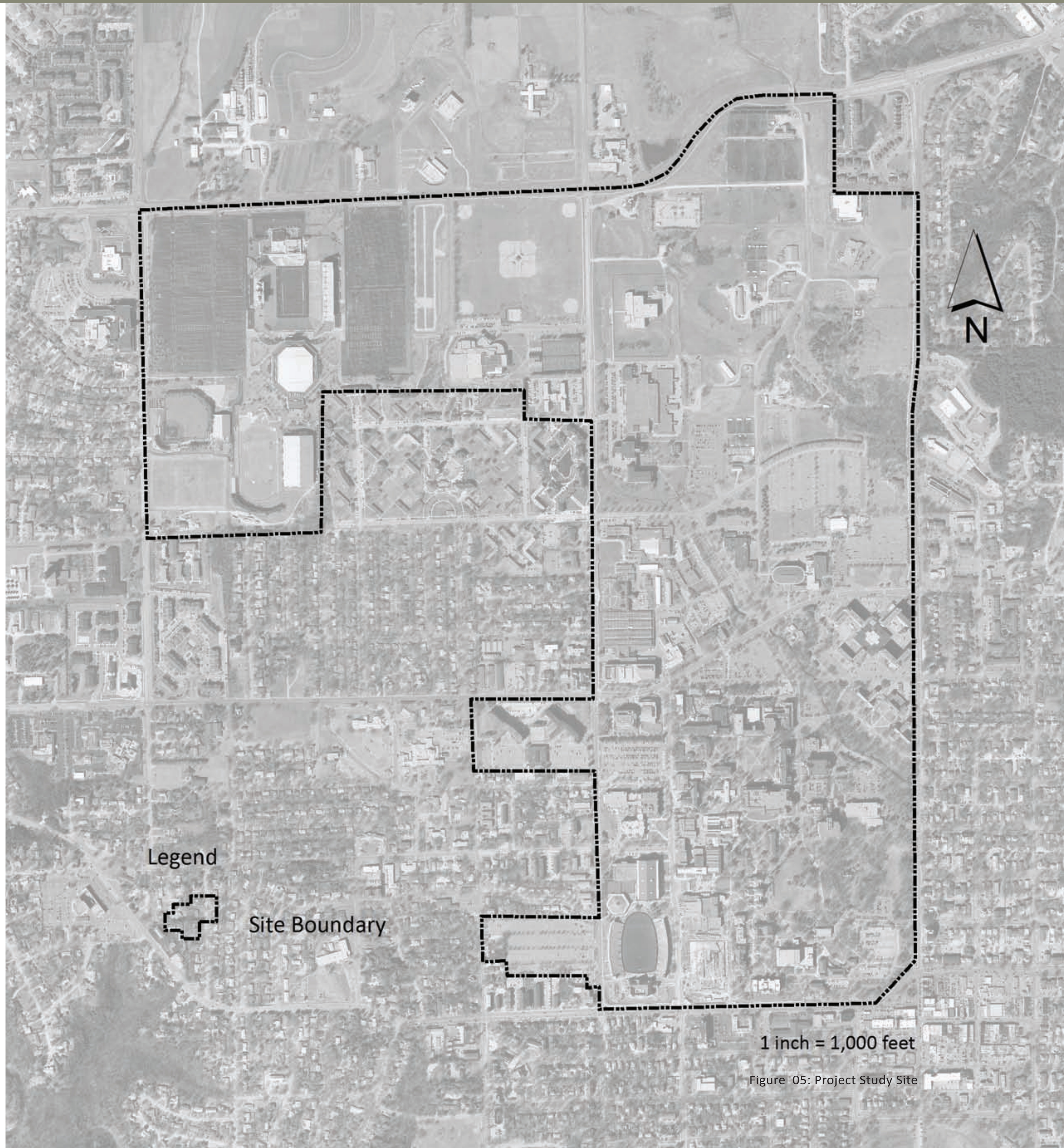


Figure 05: Project Study Site

Project Study
Site and Context

The current KSU Campus is managed in a way that releases significant amounts of carbon into the atmosphere. Mowed lawns, pavement, and exposed earth are types of land use or land cover that either release carbon or prevent it from being sequestered.

On the KSU campus many opportunities exist for addressing carbon within the landscape. These opportunities include changing vegetation (to that with greater above and below ground biomass production) and/or changing landscape management techniques (to that which emits less carbon dioxide). Various site conditions, such as the amount of human use, can dictate the type of vegetation and management need. For the KSU campus, a targeted and detailed site analysis has been conducted to determine the most suitable areas for changes to move the university toward a more carbon-friendly landscape. Not only can the implementation and management of carbon-friendly landscapes reduce net carbon, but these landscapes also can provide financial sustainability through cost effective design and the potential for additional revenues from the carbon credit trade market.

The figure to the right illustrates an abstract representation of the carbon flux on the Kansas State University campus. The upper portion of the figure shows the campus context. The height and color of the campus areas delineated in the lower portion of the diagram represent the carbon either emitted or sequestered in that area. Red colors represent the level of carbon emissions while green represents the level of sequestration.

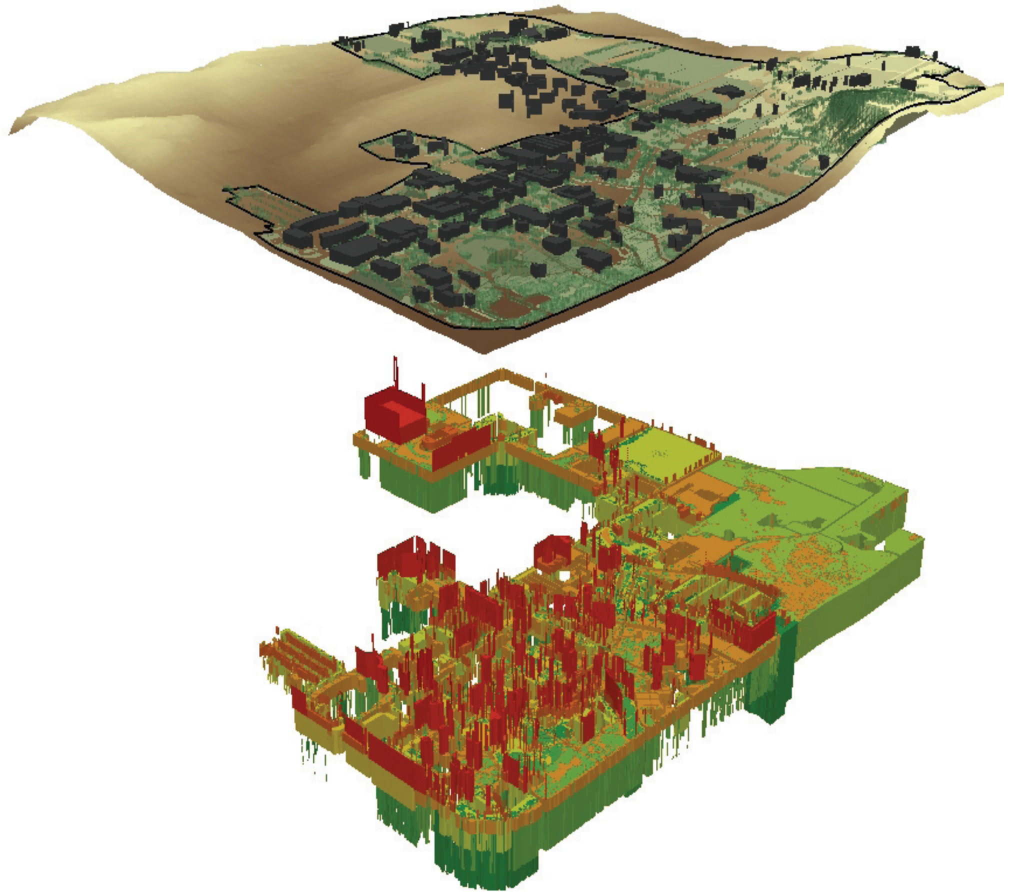


Figure 06: Project Context, Carbon Emissions, and Sequestration.

Landscape Architectural Design Philosophy

There is a sufficiency in the world for man’s need but not for man’s greed.
~Mohandas K. Gandhi

It is my belief that having a strong philosophy for design leads to, not only successfully designed projects, but also meaningful designs. My philosophy focuses on three general elements of the landscape. These elements include natural systems, built systems, and social systems.

Within every project these elements are present. During the design development phase of projects I rarely single out any of the three elements as more important than another. At times one element is given more attention than another, but all three are factored into final decisions and results. The reasoning for a balance of the three elements is because all of them exist as a whole. Social systems rely on natural and built systems, while natural systems are affected by social and built systems. The effects each element has on one another as they interact through time, or become dynamic, is the over arching dilemma associated with any landscape architecture project.

The most essential part of my design philosophy is trying to understand these dynamic interrelationships. I believe that understanding how each system interacts and changes through time will drive design decisions and will enable us to create places that are more sustainable and timeless.

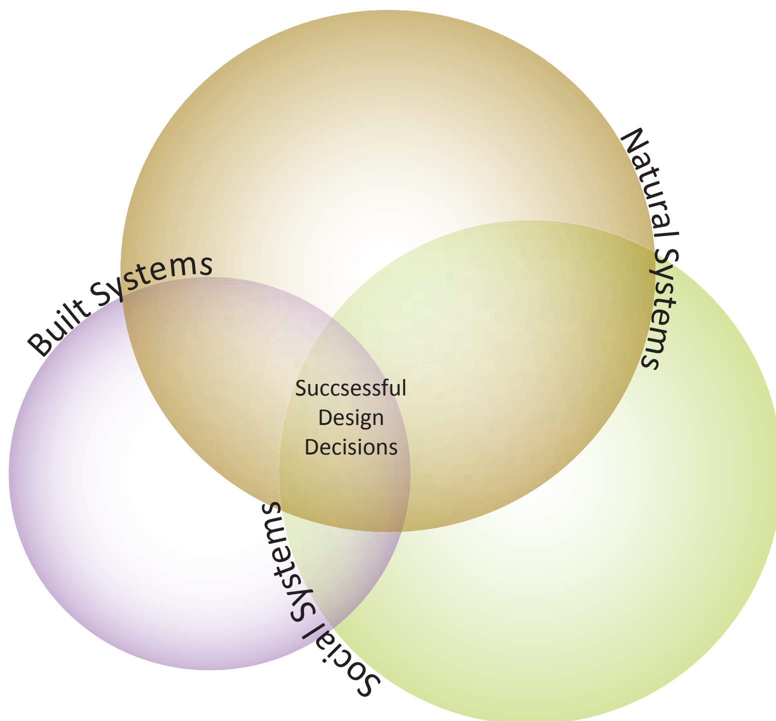


Figure 07: Design Philosophy

Tasks, Time, and Path

This diagram illustrates both the task and temporal aspects of the design process. Tasks are listed at the left and time is portrayed along the top. The bars of color represent the time allotted for each task and the actions involved. The course of action, or path, moves from the top left of the diagram to the bottom right. Initial tasks involved project ideation and proposal to committee members. As the project path began to manifest, concepts and structure became clear and directed. At the completion of all tasks and time the final product, this report, was brought to fruition.

	September	October	November	December	January	February	March	April	May
Description and Intent		*ideate*							
Dilemma and Thesis		*hypothesize*							
Goals	*aim*	*propose*							
Site Selection		*choose*							
Project Process		*orient*	*review*	*orient*	*review*	*orient*	*review*		
Research and Theory	*explore*	*seek*	*investigate*						
Base Data Collection		*inquire*	*download*	*interview*	*create*				
Project Precedents		*orient*	*adjust*	*familiarize*					
Project Programming			*arange*	*agenda*	*narrate*			*revise*	
Project Frameworks	*inform*	*conceptualize*	*order*	*structure*	*write*	*rewrite*		*revise*	
Design and Planning					*devise*	*visualize*	*prepare*	*revise*	
Inventory					*catalog*			*revise*	
Analysis and Synthesis					*examine*	*evaluate*	*amalgamate*	*revise*	
Campus Plan: Greenway Development							*settle*	*revise*	
Design Benefits							*assess*	*revise*	
Conclusion							*review*	*revise*	
Final Documentation						*design*	*assemble*	*revise*	
Final Product Development							*produce*	***Complete***	

Figure 08: Tasks, Time, and Path

Research and Theory

Literature Map

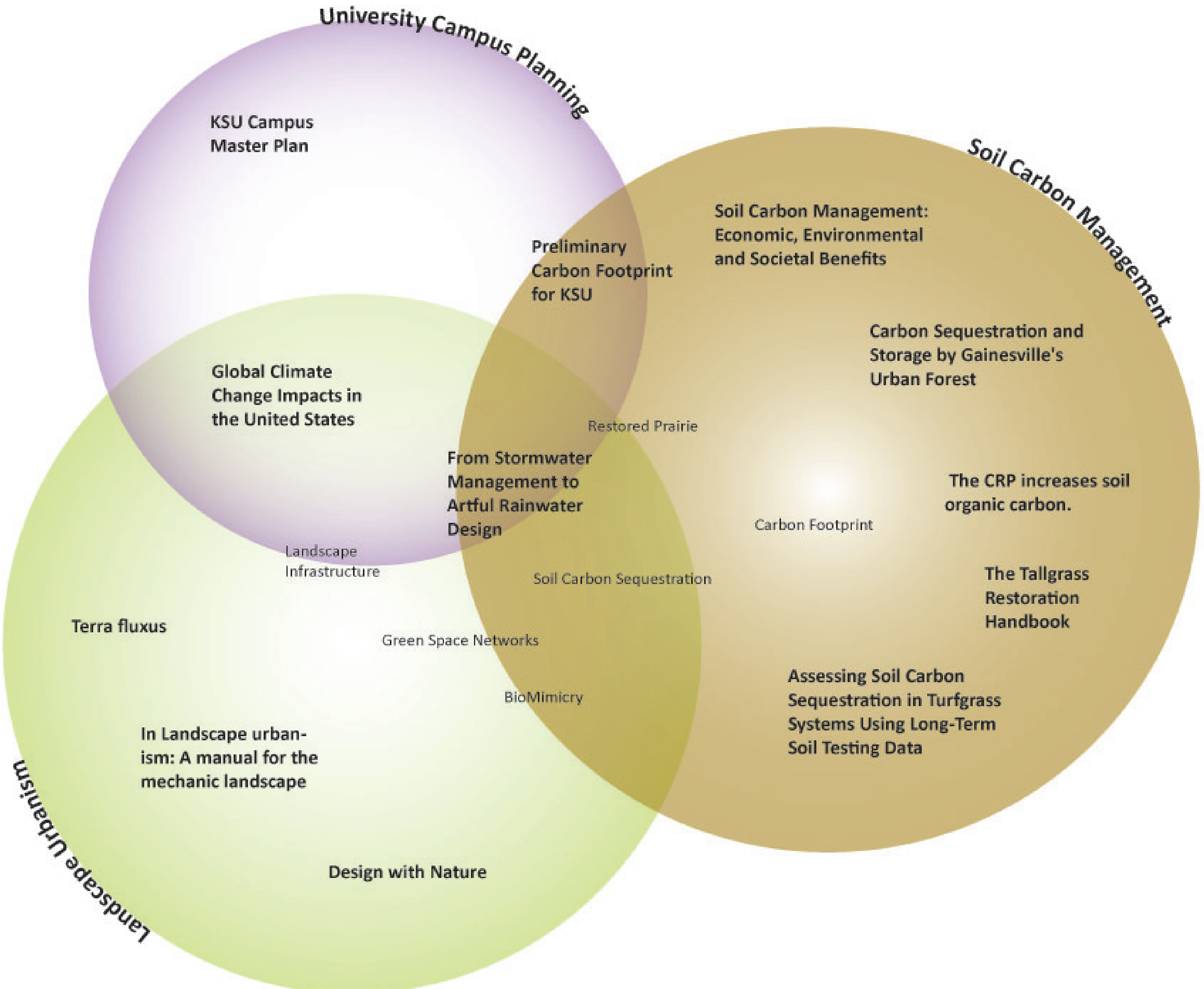


Figure 09: Literature Map

Literature Review

*Global Climate Change Impacts in the United States***,** available at www.globalchange.gov, gives insight on the relationship between carbon emissions and climate change. It is clear that impacts in the United States are already occurring and are projected to increase in the future, particularly if the concentration of heat-trapping greenhouse gases in the atmosphere continues to rise. So, choices about how we manage greenhouse gas emissions will have far-reaching consequences for climate change impacts.

The book *Soil Carbon Management: Economic, Environmental and Societal Benefits***,** is the primary source for carbon management associated with landscapes and soils. This multi-authored text covers many aspects of soil and atmospheric carbon. Chapter 13, by Steven I. Apfelbaum, covers urban soil carbon management. It directly relates to the Project Frameworks chapter of this report. Concepts discussed by Apfelbaum begin to suggest reducing carbon emissions and increasing sequestration via implementation of low maintenance vegetation. Apfelbaum also correlates alternative stormwater management techniques, such as stormwater best management practices, to soil carbon management, suggesting that both can be managed in the same landscape areas.

The three reports called *Carbon Sequestration and Storage by Gainesville's Urban Forest***,** *The CRP increases soil organic carbon*, and *Assessing Soil Carbon Sequestration in Turfgrass Systems Using Long-Term Soil Testing Data*, were used as sources for carbon sequestration rates. Rates taken from these sources were used in the analysis section of the project.

*An Ecological Method***,** by Ian McHarg covers overall concepts for design an ecological design process. The book focuses on nature as a guide for successful landscape architectural design and planning.

The books *Terra Fluxus* by Corner and *In Landscape Urbanism: A manual for the mechanic landscape* by Mostafavi, are conceptually based pieces of literature-concerning over arching concepts of urbanism and design (refer to page 15 for a discussion of infrastructural landscapes).

The KSU Campus Master Plan helped orient the project into the existing vision of the campus.

The Preliminary Carbon Footprint for KSU is a report that suggests and approximate carbon footprint for the university.

The article *From Stormwater Management to Artful Rainwater Design***,** by Stuart Echols and Eliza Pennypacker, suggests that a creative approach to stormwater management not only improves the process and makes financial sense, but also can inform people of the issues related to stormwater management.

The Tallgrass Restoration Handbook by Stephen Packard and Cornella F. Mutel is a helpful guide to prairie restoration. It covers an array of information, including types of prairie, recommended plant species for installation, and techniques for management.

It is the culmination of these key pieces of literature that has inspired the concept of carbon management in landscape architecture. The over arching concepts of landscape urbanism provide the theoretical framework at which carbon can be managed in the landscape.

Project Precedents

Many different types of precedents are identified in this section. These precedents identify projects that focus on topics ranging from local or native landscapes, environmental organizations, and universities that are managing carbon emissions. It should be noted that a number of universities are taking initiative to reduce their overall carbon footprint by minimizing emissions, as opposed to increasing carbon sequestration with vegetation. While many designs and projects focus on natural systems, few landscape architecture projects have put carbon mitigation at the forefront of design.

Kansas State University's Existing Carbon-Friendly Landscapes

Kansas State University already owns very large tracts of carbon-friendly landscape. The Konza Prairie is an example of an area that is maintained as a native tallgrass prairie. Marlatt Park, the location of the well-known "top of the world" northwest of Manhattan, Kansas, is another example of carbon-friendly land owned by Kansas State University. These places are prime examples of the types of low maintenance vegetation that this project suggests be implemented across the campus.

Although most prairie landscapes in the region are maintained by fire (fall or spring), burn management is more difficult to do in urban settings. Given residential development around Marlatt Park (another KSU-owned prairie landscape), fire management becomes more risky. In urban areas, mowing once or twice a year is a reasonable option for managing prairie-like systems. If fire management were to be pursued, building codes could be amended to better protect adjacent buildings from fire damage.

Figure 10: Konza Prairie

American College and University Presidents Climate Commitment

While no university that I am aware of has taken the initiative to implement soil carbon management landscapes on their campus, many universities have joined the American College and University Presidents Climate Commitment, an organization focused on the goal of climate neutrality (primarily carbon neutrality). This organization is also concerned with the collegiate level educational needs associated with climate and carbon related issues. When Kansas State University joins this group of carbon-conscious universities, the ideas embodied in this project are examples of initiatives that the university could undertake to help meet its commitments to reduce net carbon outputs.

Figure 11: PCC Logo

Southern New Hampshire University: A Carbon-Conscious University

Southern New Hampshire University has made significant progress as the first carbon-neutral university in the United States. They have achieved this by purchasing carbon offset credits in the carbon credit market. Universities able to achieve carbon emission levels below the minimum amount allowed will be able to act on the other end of the market that is able to sell the surplus carbon on the market in order to secure additional revenue.

Under President Obama, the White House has stated the following in relation to controlling carbon emissions: “We must take immediate action to reduce the carbon pollution that threatens our climate and sustains our dependence on fossil fuels.” (http://www.whitehouse.gov/issues/energy-and-environment)

Figure 12: Southern New Hampshire University

Project Precedents

The Floyds Fork Greenway (also referred to as “The Fork”)

An un-built park design project in Louisville, Kentucky, called The Floyds Fork Greenway, incorporates stormwater and carbon managing elements into its program. This project, designed by the firm Wallace Roberts & Todd, has been identified as a case study because of these elements. Although, the overall program of the Floyds Fork Greenway differs from this project. Prairies are a common ecosystem type found in the plans for The Fork. Plans include increased water quality through the filtration of stormwater runoff, increased carbon sequestration, increased wildlife habitat, and reduced maintenance (given that prairies require minimal mowing). At full implementation, the amount of prairie will be increased from 247 to 852 acres. The project also incorporates wetland bio-filtration that removes sediments and pollutants carried by storm water. Proposed vegetation and management changes are expected to increase the carbon sequestered annually by approximately 22,000 tons. This increase may offer an estimated $300,000 increase in carbon credit value, on top of the $1,600,000 value of carbon existing on the site.

Figure 13: Floyds Fork Greenway - Stream

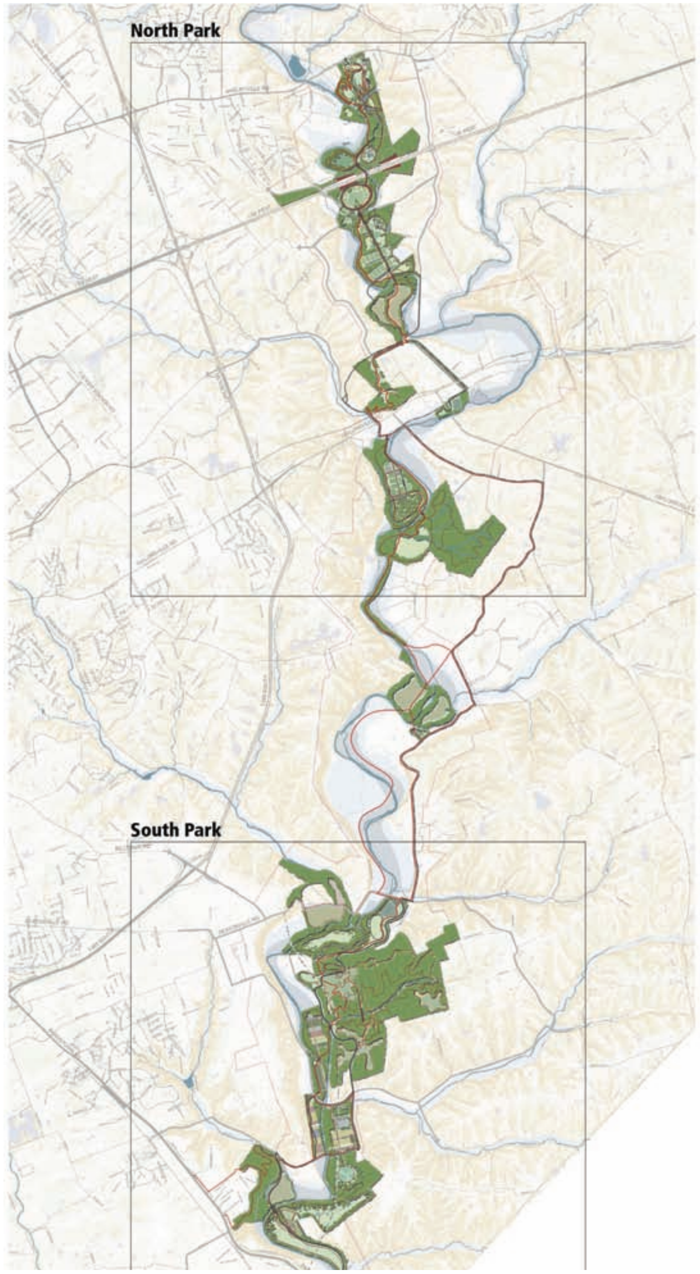


Figure 14: Floyds Fork Greenway - Plan

Sidwell Friends School

This built project by Andropogon Associates focuses on using natural landscapes to mitigate stormwater and waste water from this Washington D.C. school. The design collects stormwater from the site to be used for non-potable water uses. After the waste water is used, it is directed into a series of wetland cells where it is treated using natural infiltration and filtration from soils and vegetation. This project sets a precedent of using natural systems to mediate environmental concerns. The project, being an educational facility, also sets precedents associated with educational landscape spaces by creating a place for students to learn about natural systems in the landscape. In short, it creates an engaging outdoor teaching lab.

Figure 15: Sidwell Friends School

Kellogg-Creek and Dead River Watershed Plan

This built project, designed by Conservation Design Forum (CDF), set forth a plan to enhance the natural systems present in northeastern Lake County, Illinois. The design engaged local stakeholders to determine the goals and management recommendations for the plan. The completed project achieves water quality improvement, flood damage reduction, hydrologic restoration, green infrastructure, natural resource protection and enhancement, open space planning, and education. The large and complex framework used to develop this plan set an important precedent for the development this project.

Figure 16: Kellogg-Creek

Project Programming

Infrastructural Landscapes and Project Programming

Today's society is facing many challenges besides global warming. The availability of resources, energy, water, and other elements humans rely on are becoming more expensive and harder to get. In the pursuit of more fuel, fertilizers, pesticides, and other products habitat functions and values are greatly diminished. To mediate these concerns, our landscapes need to be managed in more environmentally friendly ways.

Architect, Mohsen Mostafavi states that the main problem in metro areas is "…the multi layered, multifunctional and in many respects conflicting organization of cities that had developed over many centuries" (Mostafavi 2003). This description of the urban structure points to the roots of many of the problems that cities are facing. Some professionals propose that if urban environments embrace natural processes, and strive to minimize human impact on these processes, quality of life and natural conditions will find a balance. Landscape architecture practitioner and professor, James Corner, discusses the importance of "infrastructural landscapes." He describes them as functioning "ecological vessels and pathways serving the community with hydrologic, atmospheric, and other dynamic environmental processes that are important to the health and welfare of the urban populations" (Corner 2006). People like Corner and Mostafavi work to make the cities we know today, better functioning and more sustainable communities, today and in the future.

Figure 17: Landscape Urbanism

It is obvious that typical, existing infrastructure is crucial for urban areas to exist as safe and sanitary. Electric lights provide comfort and accessibility at night. Urban sewer systems keep waste and unwanted substances out of our streets and alleys. As such, it is just as important to maintain healthy natural environments as it is to maintain healthy built elements in our towns and cities. James Corner wrote, "If we think of landscape as an infrastructure which underlies other urban systems, rather than equating it with nature or ecology we have a much more workable conceptual framework for designing urban systems" (Corner 2006, pg 176).

This being the case, an over arching goal for the program of this project is to identify ways to cause inspiration, discovery, and responsibility through experience of landscape infrastructure.

KSU Campus Landscape Program

MISSION STATEMENT FOR KANSAS STATE UNIVERSITY

“The mission of Kansas State University is to foster excellent teaching, research, and service that develop a highly skilled and educated citizenry necessary to advancing the well-being of Kansas, the nation, and the international community. The university embraces diversity, encourages engagement and is committed to the discovery of knowledge, the education of undergraduate and graduate students, and improvement in the quality of life and standard of living of those we serve.” (Approved by the Kansas Board of Regents on December 18, 2008)

Education, research, and service summarize the mission of Kansas State University. The ways in which the landscape is used and managed should support this three-fold mission.

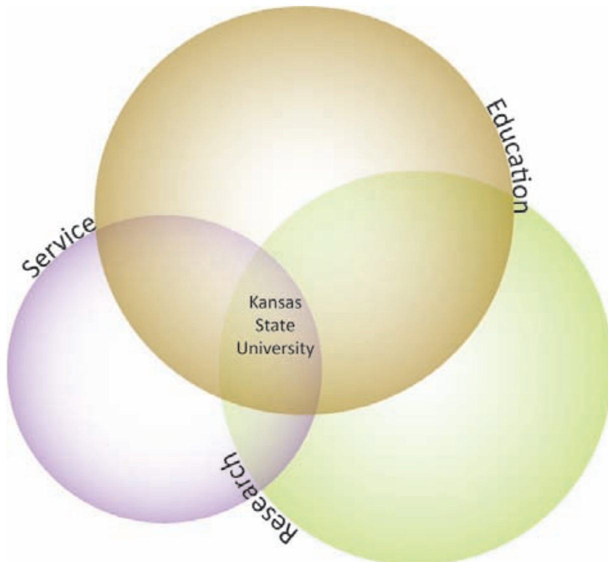


Figure 18: Kansas State University Program

KSU SEAL: “RULE BY OBEYING NATURE’S LAWS”

If the KSU seal was applied to the campus landscape, it would suggest that the landscape should be developed with respect to environmental vulnerability and suitability. The existing native vegetation of the Tallgrass Prairie makes up a rich habitat and eco-region that is a precedent for campus landscape design. This project envisions, prairie-like landscapes, gardens, and lawns strategically implemented onto the campus, providing the perfect setting for green infrastructure, human recreation and learning, and a network of carbon sequestering vegetation that requires very little management.

Figure 19: Kansas State University Seal

KSU Campus Landscape Program

The diverse campus of Kansas State University contains many opportunities for education, research, and service related to its campus landscape. As an institution for research and learning, KSU should more fully embrace these opportunities. The landscape that students, professors, and faculty walk through every day—from class, the office, and various social spaces—is an excellent setting for all to gain a better understanding of the natural world that humans are a part of.

Although the Kansas State University Seal of 1863 states, “Rule by Obeying Nature’s Laws” few members of the campus community have likely made the link between the motto and the structure and function of the landscape. KSU’s main campus was, at one time, a vast stretch of Tallgrass Prairie. When this natural landscape existed, the ecological, hydrological, and atmospheric systems were in a state of dynamic equilibrium. The health of the natural landscape was the foundation and framework that sustained a diverse set of plants, animals, and ecosystems. Currently on the KSU campus we get little- to no sense of the pre-existing natural environment, or of well-functioning ecosystems that provide essential ecosystem services.

As research and science suggests, natural systems are critical to nearly every aspect of human society and culture. Thus, it is the responsibility of all institutions to restore and safeguard natural systems wherever this is feasible and reasonable. To do so in the everyday environment helps bring the message home to those who live and visit these places. Introducing carbon friendly landscapes to the university campus will provide opportunities for experiential learning and research, as well as admiration for the services and beauty that well-functioning natural systems offer.

This is not to say that every lawn should be replaced by native prairie. Mowed and irrigated turfgrass has an important place on campus—but there are many places that need little or no mowing and/or watering.

Figure 20: Anderson Lawn

Project Programming and its Relationship to Project Frameworks

The relationships between urban and natural environments are complex. The process of analyzing conditions that affect where and how infrastructural landscapes should be restored is challenging. When these conditions and processes were initially studied by planners and designers, modern computer programs were not available.

Ian McHarg was one of the first to stress the importance of environmental stewardship. He also studied the relationships between urban and natural environments. McHarg was a professor of landscape architecture at University of Pennsylvania and is noted for writing the very influential book, *Design with Nature*. In this book he describes a type of landscape architectural design that embraces environmental processes as a primary guide for design decisions. This type of design he called the "ecological method" (McHarg 1967).

With today's computer-related technologies the ecological method is much easier to perform due to detailed mapping and computer applications. Geographic information systems (GIS) have provide tools and processes that help tremendously as we attempt to understand and visualize statistical and spatial data. Landscape architects, planners, engineers, scientists, and others are able to reveal connections between the cityscape and the landscape that were more difficult to visualize before. Turning the ideas of landscape urbanism from a conceptual theory into a reality is much more feasible. With contemporary maps, models and technology, infrastructural landscapes can be integrated into cities more thoroughly and swift. Implementation and management practices can also be more readily visualized and outcomes assessed.

Quad Spaces and Proposed Natural Areas are two very different types of landscape spaces on campus. They are managed differently, they contain different types and species of vegetation, and they are used differently by people.

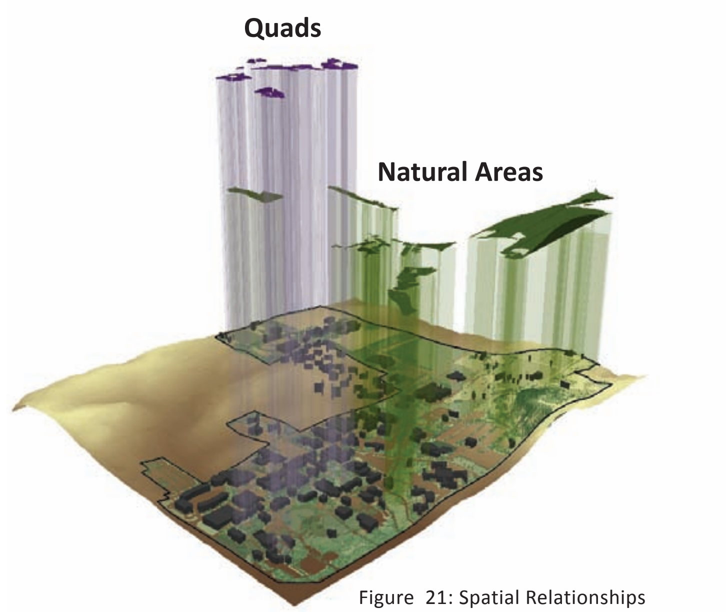


Figure 21: Spatial Relationships

Project Frameworks

Introduction to Project Frameworks

Project Frameworks guide the development and process of the Project Design and Planning Process. The Project Frameworks are the conditions that regulate the design process. Research regarding carbon emission and sequestration coupled with inquiry of existing campus softscape conditions suggests key relationships that delineate the framework for this project. Campus softscape areas are comprised of vegetation (as opposed to the hardscape, which is the pavement and buildings). Project frameworks aim to guide and inform the process of analyzing, designing, and planning of the campus softscape and its carbon output. To do this a series of landscape typologies have been developed. These typologies illustrate the degree of carbon sequestration by vegetation and carbon emission from campus landscape management. They also define factors of softscape suitability on campus.

Softscape Vegetation Typologies

Softscape Management Typologies

Softscape Suitability Typologies

Figure 22: Project Frameworks

Softscape Vegetation Typologies

Carbon Sequestration by Vegetation

Different campus vegetation types sequester varying amounts of carbon. It is assumed that sequestration rate data, although gathered from different locations in the United States, can be applied to this region. In other words, an oak tree in Florida may not sequester the same amount of carbon as one that is the same size in Kansas. But, for this project the rate of sequestration is used as the best source available.

Due to the limited availability of carbon sequestration data per vegetation type, the campus Softscape has been generalized to a few vegetation types (below). Vegetation is generalized as “grasses” and “trees” due to available carbon sequestration and emission data. Landscape vegetation such as shrubs, annual and perennial beds, foundation plantings, and ground covers, have not been inventoried. Isolated softscape areas comprised of these vegetation types have been omitted. Softscape areas comprised of both turf and an annual bed have been generalized as being only turf.

General Vegetation Types and Sequestration Rate Sources
- Managed Grass/Turf - Assessing Soil Carbon Sequestration in Turfgrass Systems using Long-Term Soil Testing Data
- Limited Management Grass - The CRP increases soil organic carbon
- Single Trees - Carbon Sequestration and Storage by Gainesville’s Urban Forest
- Canopy Area - Carbon storage and sequestration by urban trees in the USA

Figure 23: Softscape Vegetation Frameworks

Softscape Management Typologies

Carbon Emissions from Softscape Management

Dependence on combustion engine use in softscape management (primarily managed grass/turf) emits carbon into the atmosphere. The scope of carbon emissions only represents the amounts associated with management of campus softscape. This does not include the management of omitted softscapes, hardscape, or other impervious landscape surfaces. Management practices were determined from information provided by Joe Myers of Kansas State University Facilities Department. Emission rates are calculated using data from the United States Environmental Protection Agency.

Costs of Softscape Management

Higher degrees of softscape management require increased amounts of annual university funds. The scope of traditional landscape management increases costs associated with fuel use, fertilizer use, and irrigation use. Management costs associated with labor have not been taken into account, although they are a very important part of the overall equation.

Carbon Sequestration and Irrigation

Much of the campus is irrigated with either a traditional or smart irrigation system. Generally, sustainable landscape design and planning efforts strive to decrease irrigation use, as means to conserve the overall amount of water used on a site. For this project, it is a goal to decrease the amount of water used for irrigation on the Kansas State University campus. Although, it is important to note that current research shows that irrigating lawns actually increases the rate of carbon sequestration (Qian and Follett, 2002).

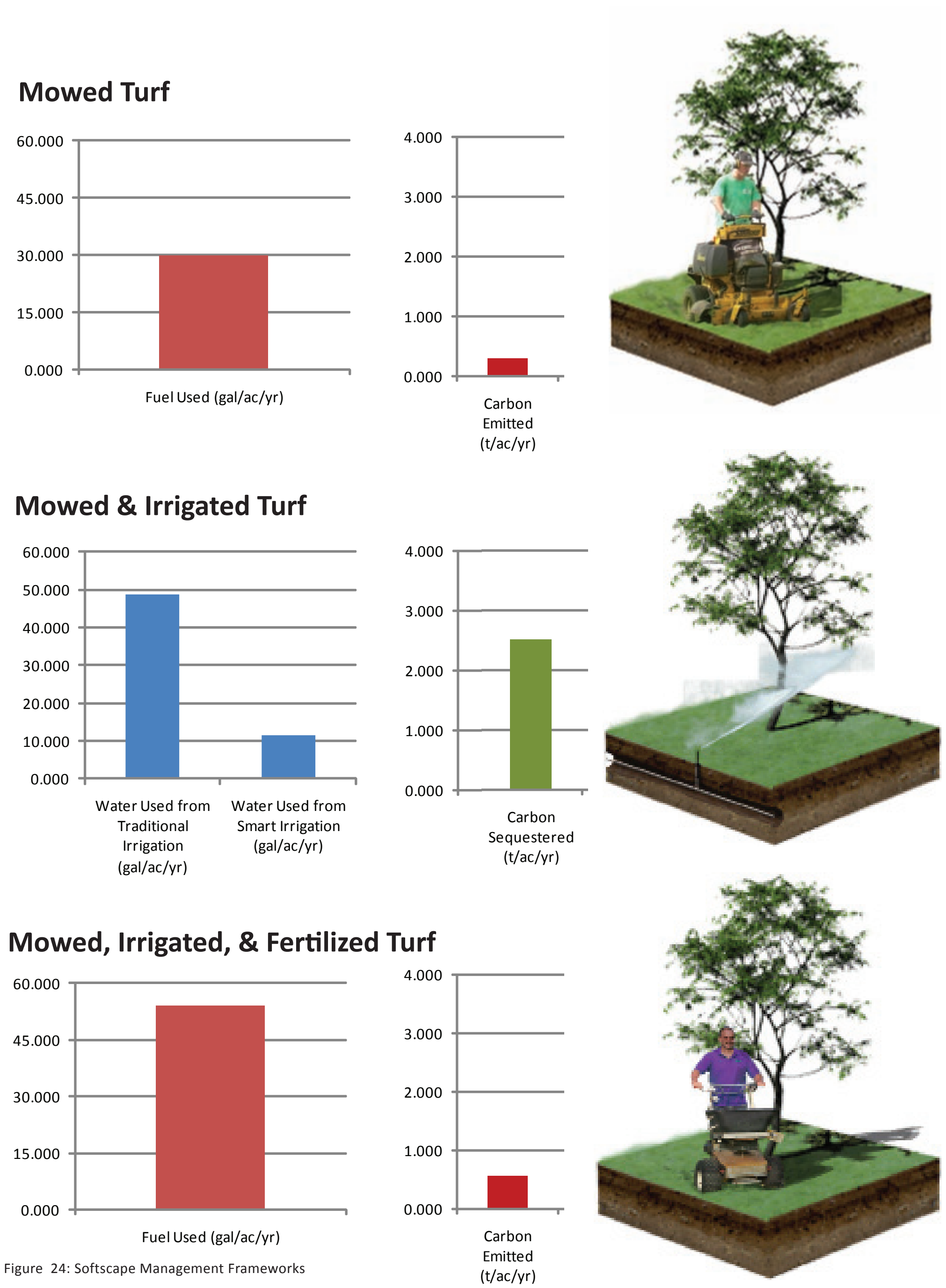


Figure 24: Softscape Management Frameworks

Social Value of Softscape

Campus softscape space is highly valued by people. Thus, social factors, including function and aesthetics, must be accounted for. The social function of campus softscape most directly relates to the implied suitability for changes to reduce management and implement low maintenance vegetation. Public perception of the visual appearance or aesthetic of reduced management landscapes (such as restored prairie, rain gardens, or less frequently mowed lawns) varies. By some, these reduced management landscapes are considered weedy or a nuisance.

Reduced Management and Low Maintenance Vegetation Suitability

Social function of softscape determines the type and intensity of management associated with campus landscape areas. For example, recreation fields and other highly programmed spaces require a higher degree of management because of their use. If a recreation field were left un-managed the functional qualities of the space would decline. On the other hand, spaces that are not used by people at all do not require as much, if any, management.

Spatial Suitability Framework used to Evaluate Campus Softscape Space

Softscape spaces with a higher degree of human use should be considered less suitable for significant changes in vegetation and management with the objective of reducing carbon emissions and increasing carbon sequestration. Spaces with little to no use should be considered more suitable for significant changes in vegetation and management, with the objective of reducing carbon emissions and increasing carbon sequestration. Areas identified as having little human use as well as producing a high overall carbon output (considering both emission and sequestration) should be considered most suitable for change in management and/or vegetative cover. Areas identified as having a higher degree of human use should be considered least suitable for changes in management and vegetative cover. On site investigation and consultation with other campus users helped determine the degree of use occurring in campus softscapes.

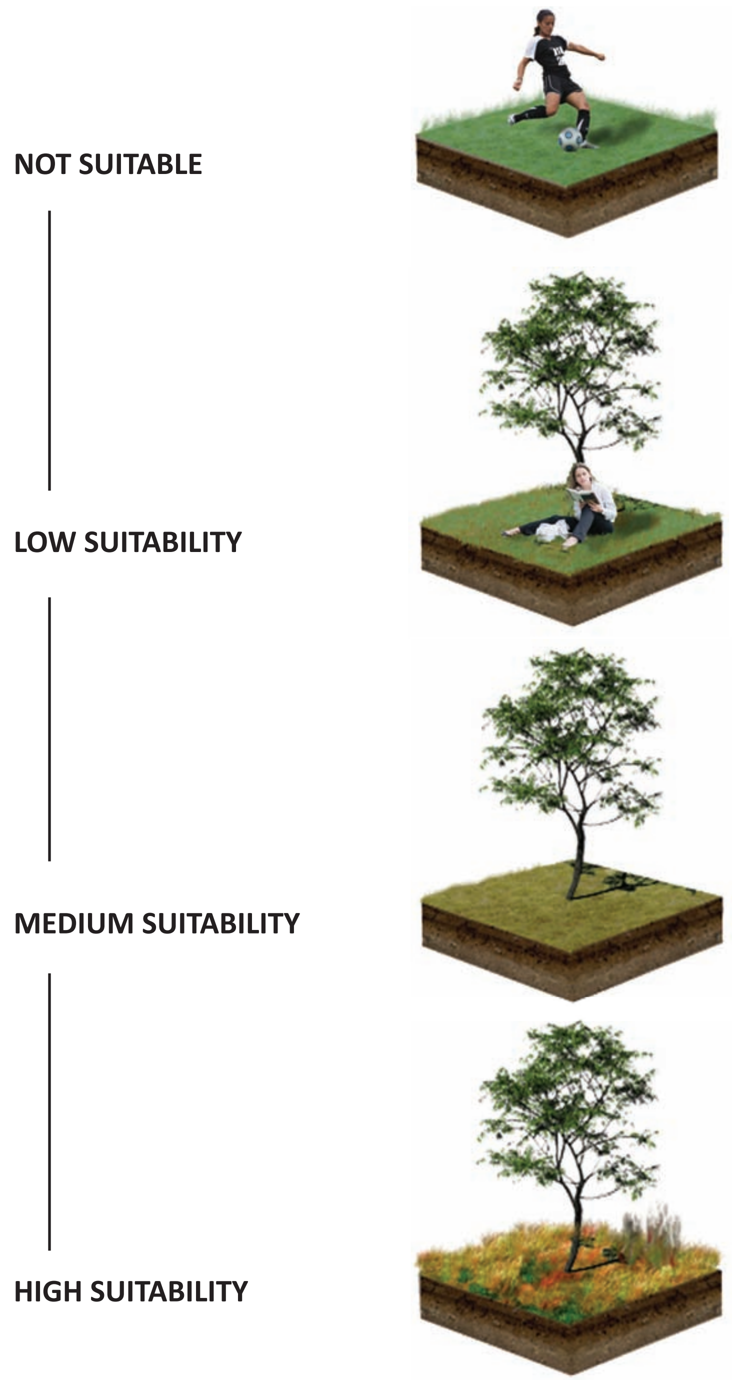


Figure 25: Softscape Suitability Frameworks

Planning and Design

Introduction to the Planning and Design Process

The Planning and Design process includes four main sections: Inventory, Analysis, Synthesis, and the Campus Plan.

Inventory is a process of recording attributes and characteristics of the landscape. For this project, the inventory includes softscape typologies as formulated in the “Project Frameworks” section.

Analysis is the evaluation of the attributes associated with the inventory. These attributes include carbon sequestration and emission rates, management practices, vegetation attributes, and social suitability.

Synthesis is a process that applies other significant design considerations in regards to planning and design of the campus landscape to the project. These design considerations include campus programming concepts, landscape urbanism concepts, and analysis results.

The Campus Plan section illustrates the initial design scheme that seeks to define the general scope and conceptual design of a carbon-friendly campus landscape. The results of the Design and Planning Process are campus plans that illustrate the opportunities for changes in vegetation and management, with the intent of reducing the overall amount of carbon or net carbon output of the campus softscape.

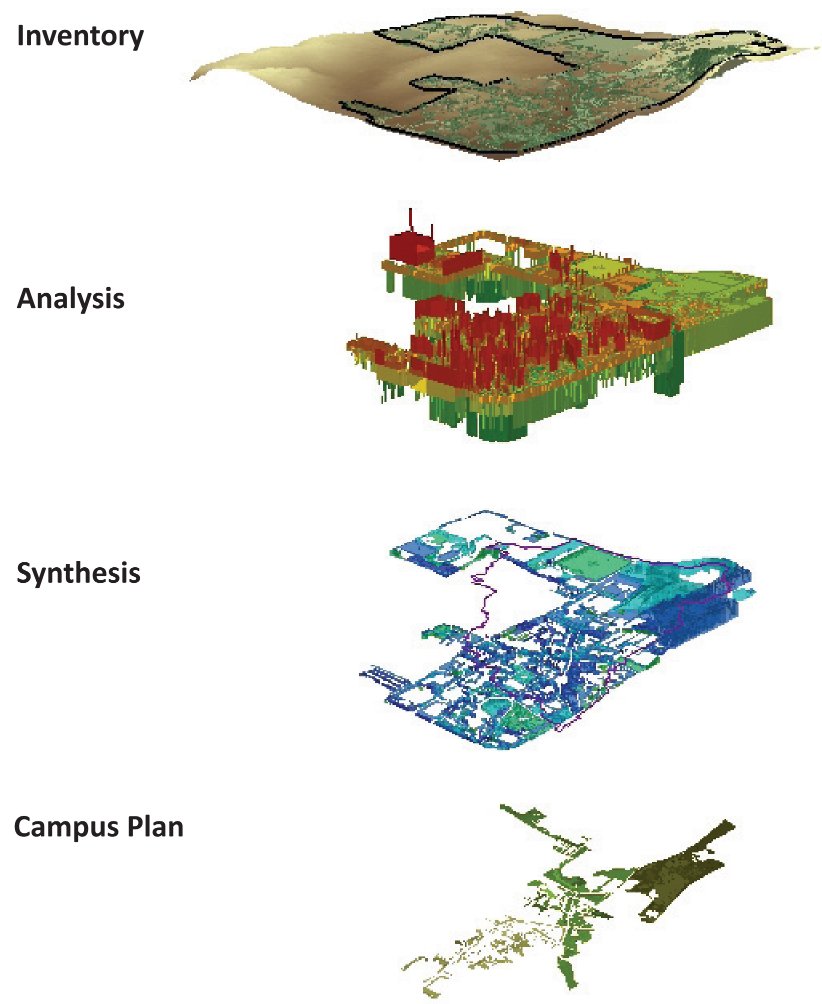


Figure 26: Design Process

Inventory

The Softscape Inventory includes three inventory subgroups. These inventory groups are derived from the Project Frameworks section. They include:

Softscape Vegetation Inventory

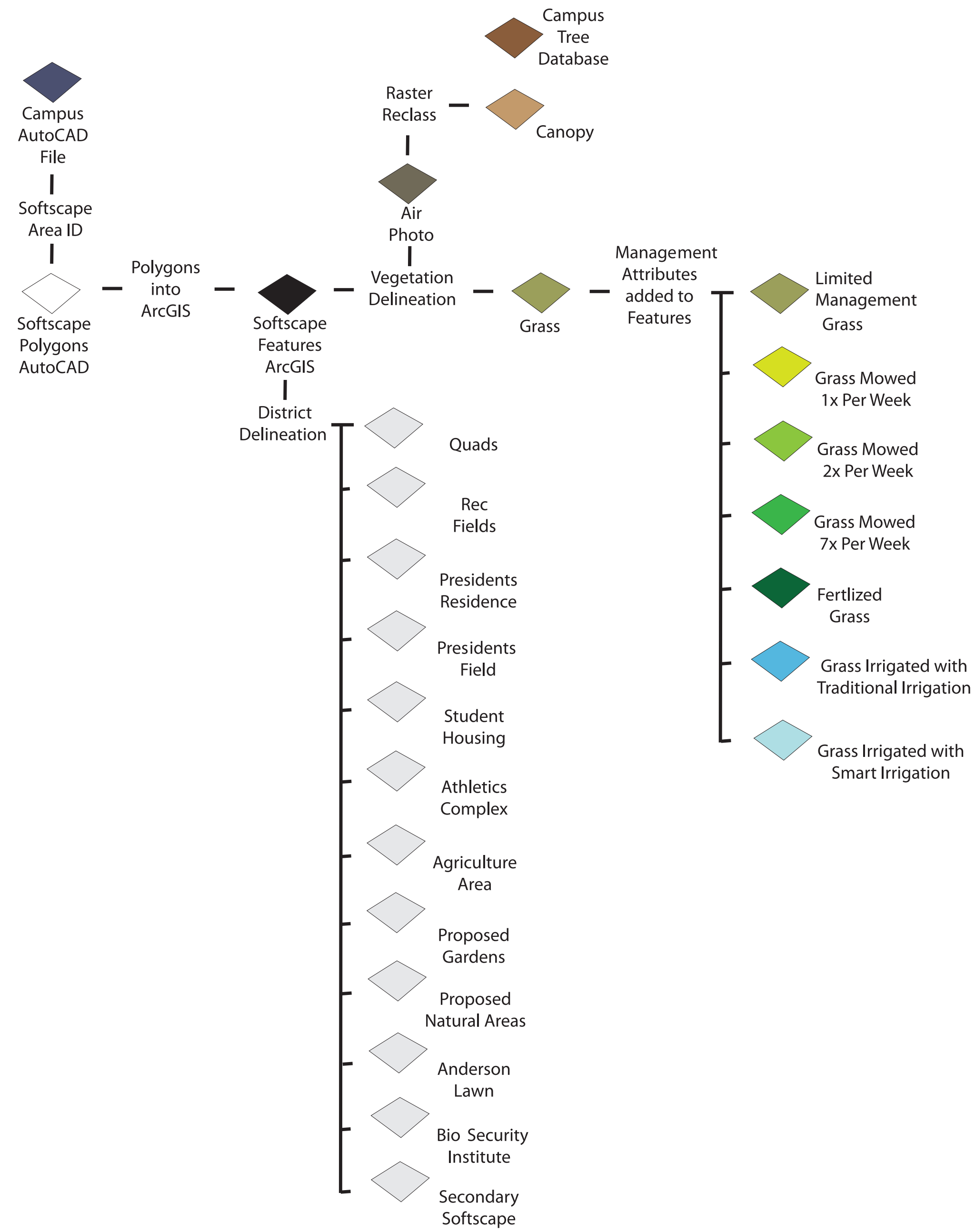
Four vegetation types on campus have been inventoried for this project. These vegetation types are managed grass, or turf, limited management grass, single trees, and tree canopy areas. Each vegetation type is managed differently. Each type may also sequester different amounts of carbon every year.

Softscape Management Inventory

Each vegetation type identified in the Softscape Vegetation Inventory is managed in a different way. The Softscape Management Inventory identifies different management practices that occur in turf areas. Landscape management occurring in trees could not be inventoried due to the a lack in management records associated with trees.

Softscape Suitability Inventory

Eleven campus districts were identified in the Softscape Suitability Inventory. These districts are all distinctly different areas—contrasted by planned use and functional, formal, and aesthetic characteristics. These differences dictate how suitable the districts are for reductions in management and implementation of low-maintenance vegetation.



Inventory:
Softscape Vegetation

Managed Grass – This vegetation is short grass that is mowed and/or irrigated. Turf, in some parts of campus, is fertilized.

These softscape areas were delineated using the Campus AutoCAD file provided by the Kansas State University Facilities Department. After these areas were identified in AutoCAD, they were imported into ArcGIS for analysis.

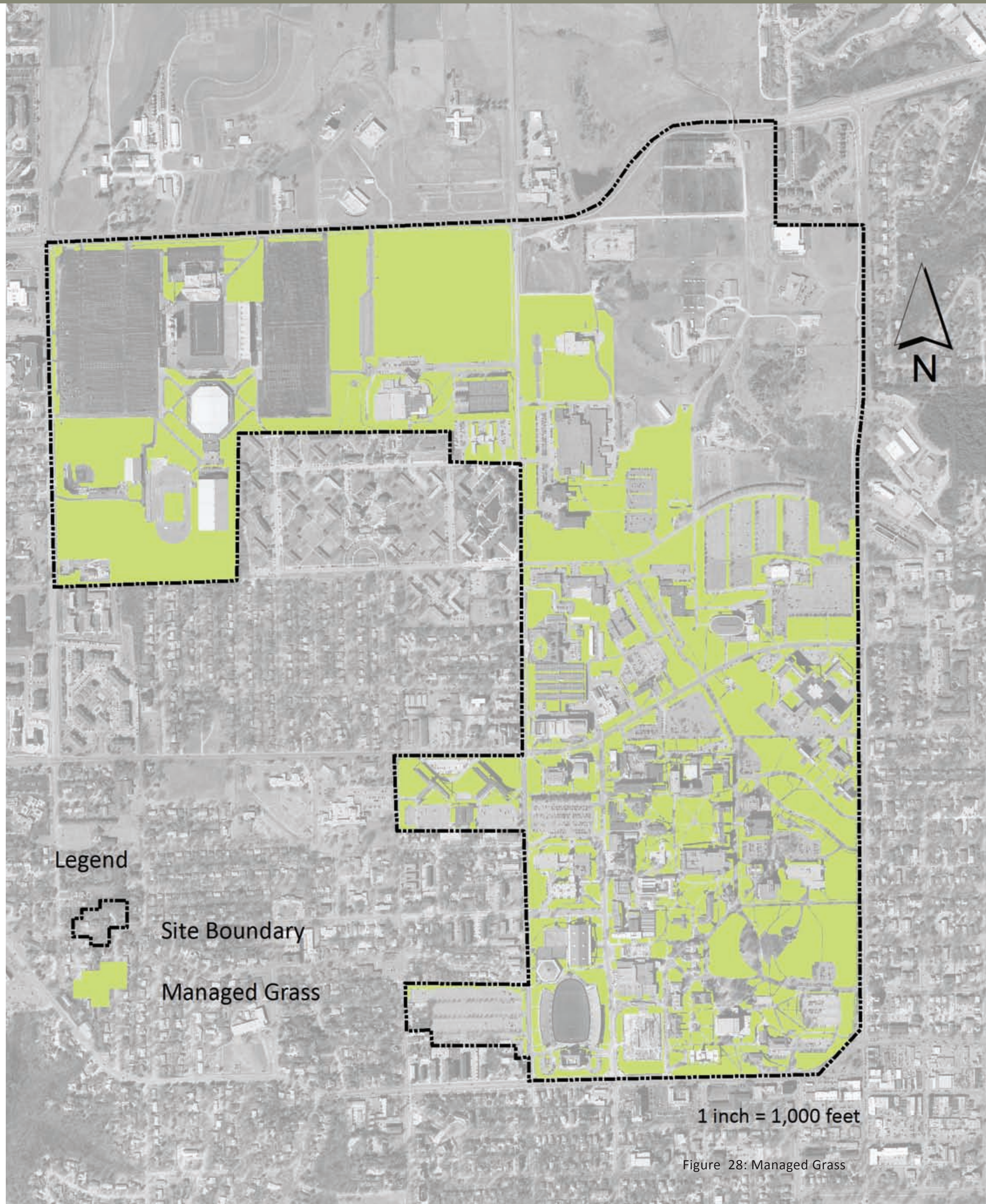


Figure 28: Managed Grass

Inventory:
Softscape Vegetation

Limited Management Grass – This includes tall, rarely managed grass or other unattended vegetation. It is primarily located in the agricultural campus district delineated in the Softscape Suitability Inventory. The management in this area is limited. Mowing rarely occurs in this area.

These softscape areas were delineated using the Campus AutoCAD file provided by the Kansas State University Facilities Department. After these areas were identified in AutoCAD, they were imported into ArcGIS for analysis.

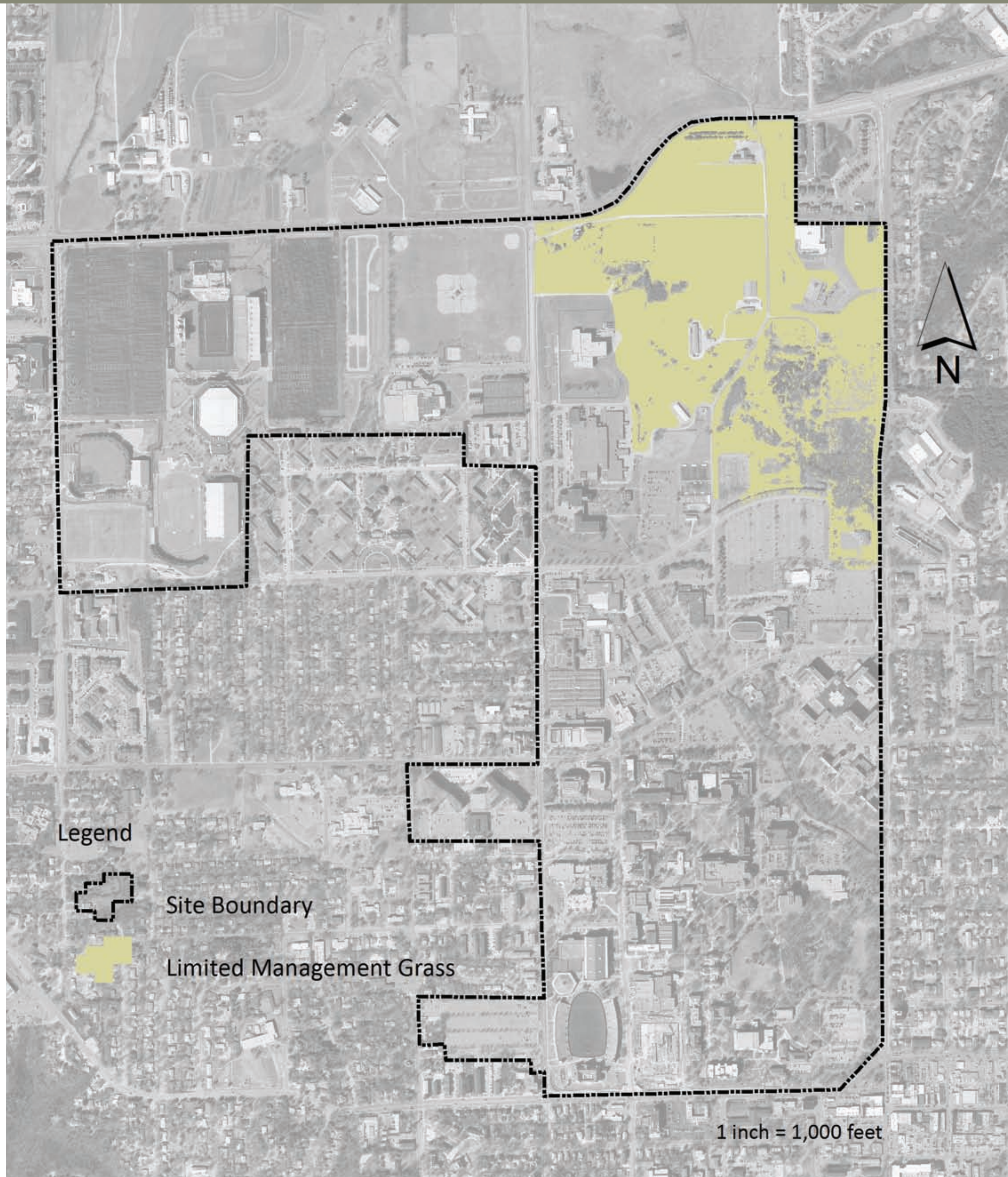


Figure 29: Limited Management Grass

Inventory:
Softscape Vegetation

Single Trees – This map shows individual trees across parts of campus. These tree points are independent of other trees. Together they make up a tree canopy area.

These points represent each tree on campus. The database contains specific information and attributes for each tree identified. The tree caliper, or width of the trunk, is included in this database and can be used to calculate the carbon sequestered by each tree. Note that tree points do not cover the entire site. This poses an issue when trying to calculate carbon sequestered by all of the trees on campus. This problem is further addressed in the conclusion of this report on page 66.

The database was provided by the Landscape Architecture Department at Kansas State University.

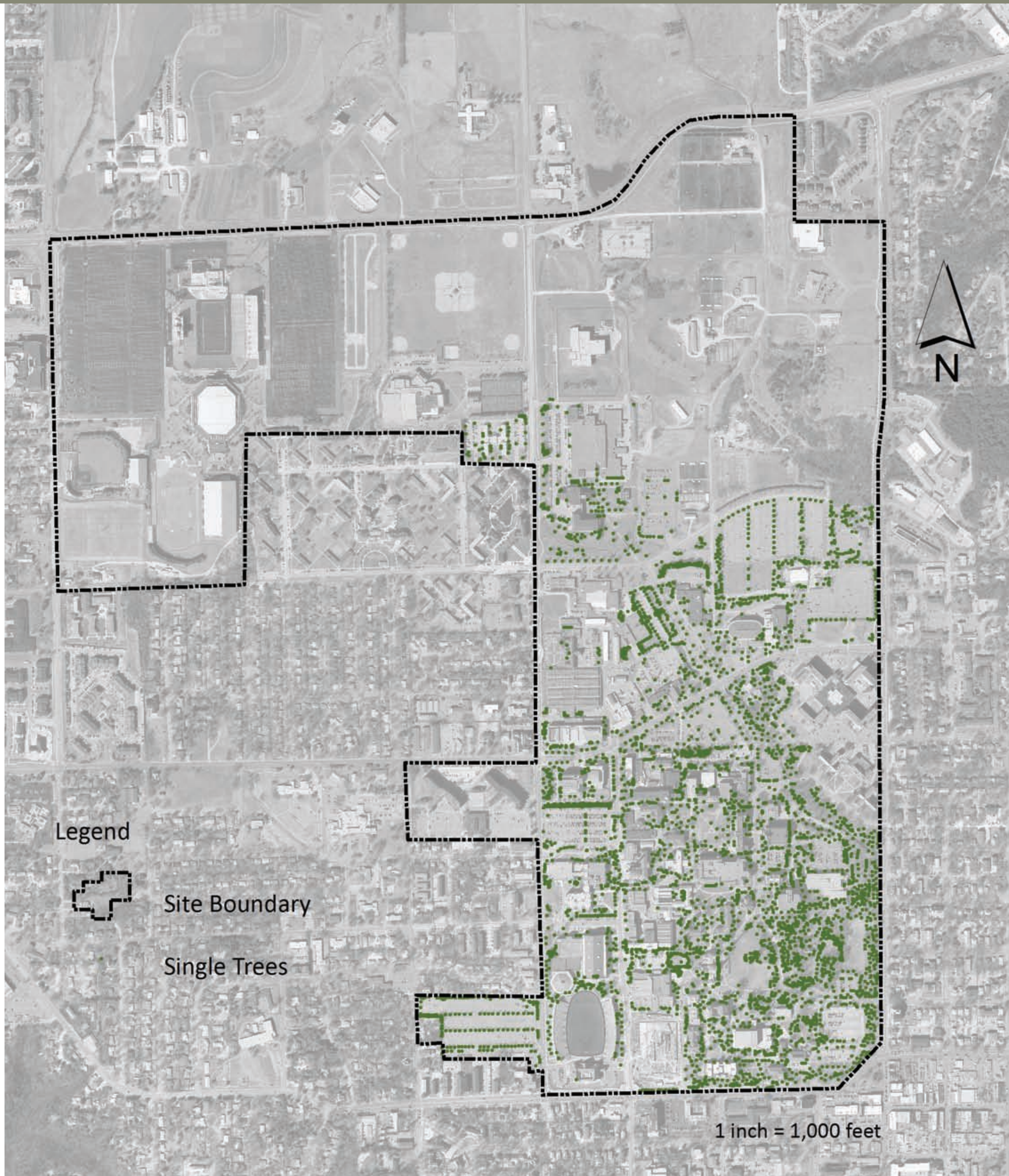


Figure 30: Single Trees

Inventory: Softscape Vegetation

Tree Canopy Areas – These are areas of tree canopy. Tree canopy is the area of ground covered by leafs and branches of multiple trees. Together they make up a canopy area.

This map was created using the raster reclassification tools in ArcGIS. The raster cells that represent trees in a color air photo of campus were identified and converted into these tree canopy areas. This data was checked and confirmed during on site observations of the campus.

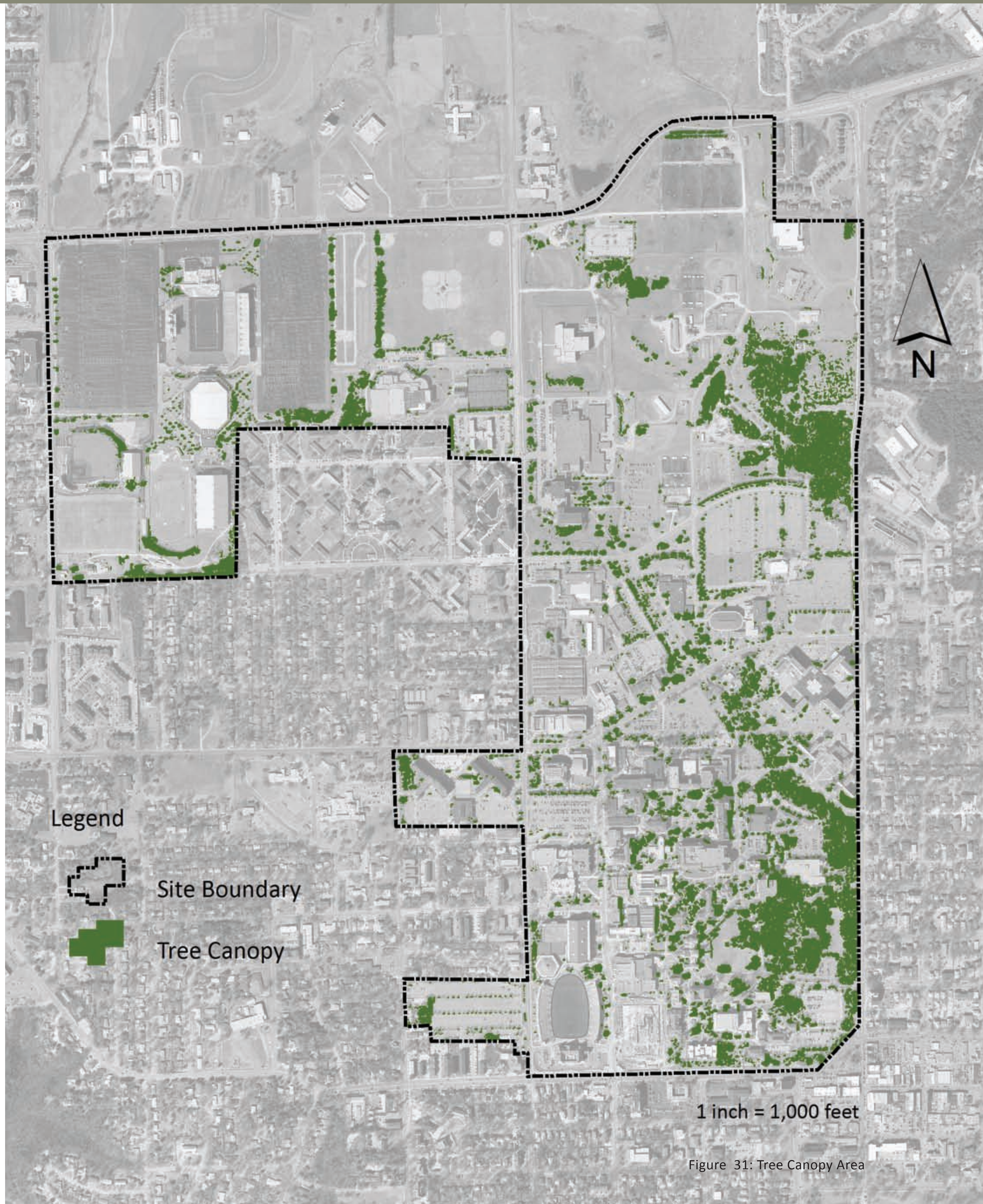


Figure 31: Tree Canopy Area

Inventory:
Softscape Management

Mowed Turf - These areas are turf grass areas that are generally mowed on a schedule: once per week, twice per week, or once a day.

These areas are mowed with four riding lawn mowers that have 72-inch mowing decks. Each individual mower maintains 30-40 acres. Two of the mowers run on diesel and the other two run on gasoline. All four mowers use between two and three gallons of fuel per hour of mowing. [Joe Myers, KSU Grounds Dept.]

From one season of mowing the Kansas State University campus, up to 75 tons of carbon can be released into the atmosphere.

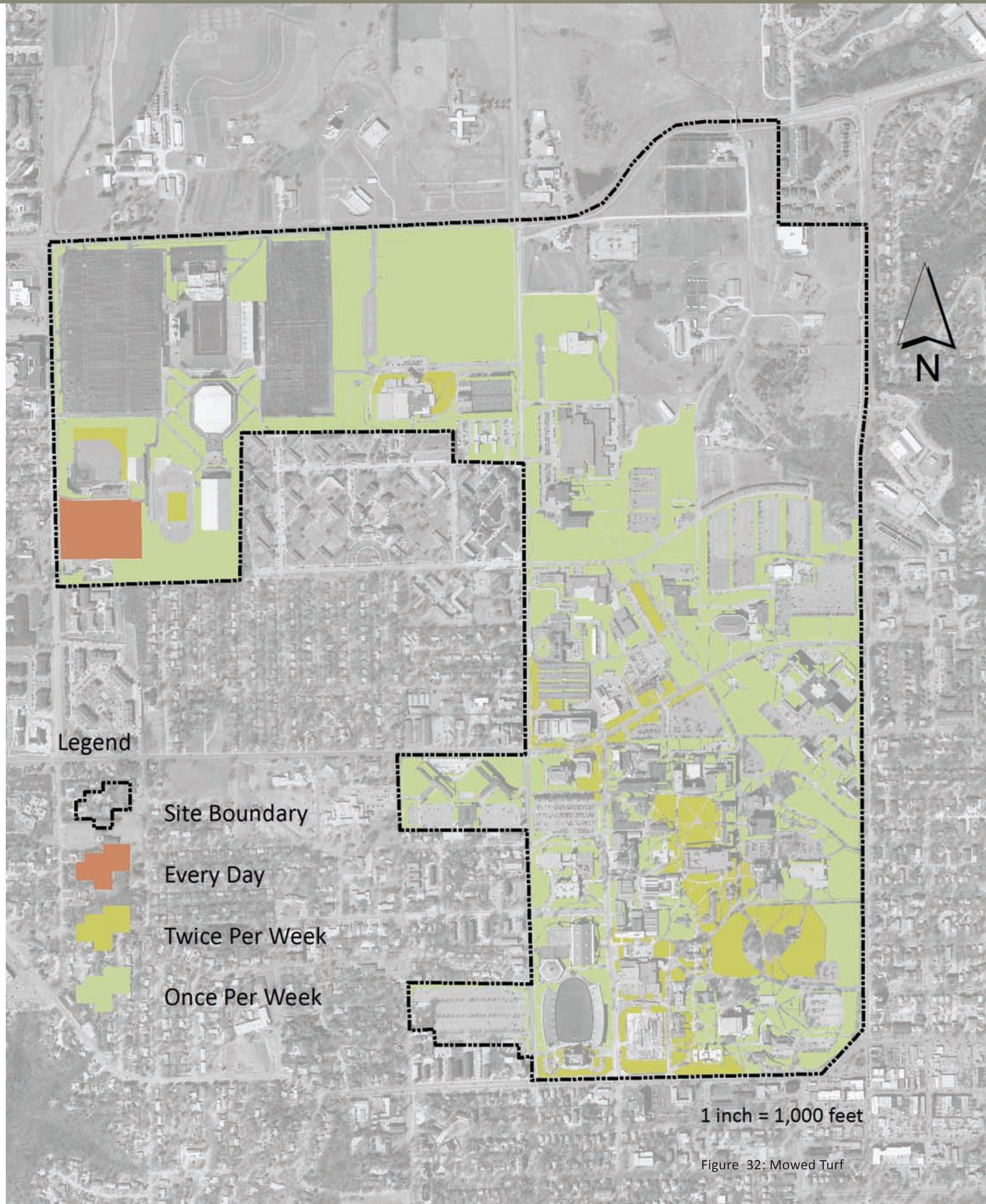


Figure 32: Mowed Turf

Inventory:
Softscape Management

Irrigated Turf - These areas are irrigated with either traditional irrigation or smart irrigation. Smart irrigation uses moisture sensors to trigger irrigation, as opposed to traditional irrigation, which is run by a timer.

Currently, Kansas State University uses 60 million gallons of water every year for irrigation. The areas irrigated most are the ones that have been updated to smart irrigation systems. [Joe Myers, KSU Grounds Dept.]

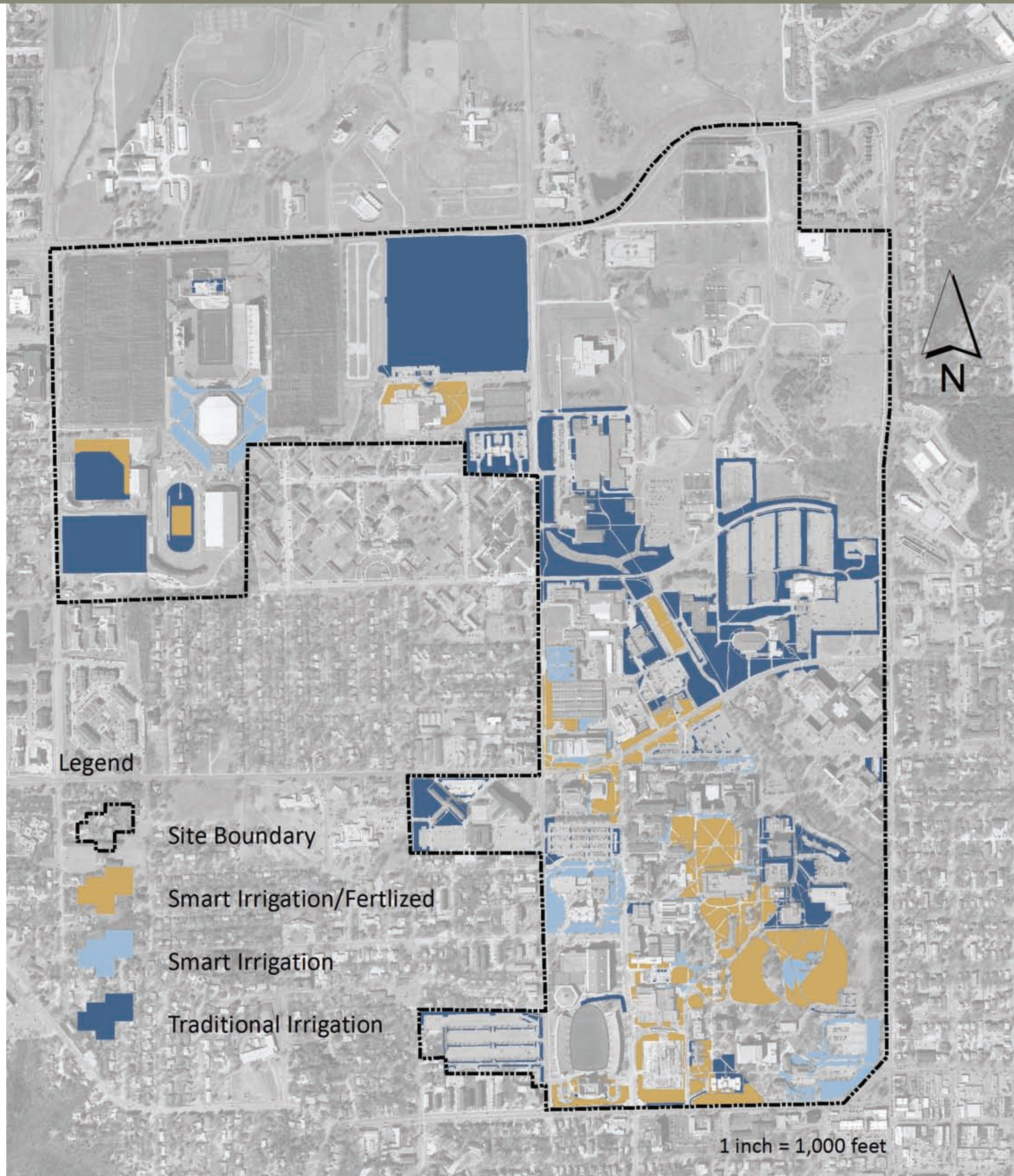


Figure 33: Irrigated Turf

Inventory: Softscape Suitability

An inventory of campus softscape districts was done in a effort to determine areas receiving different levels of human use. These districts were delineated from on site observation and consultation of other campus users.

Athletics Complex – The athletics complex area surrounds Bill Snyder Family Stadium and Bramlage Coliseum. This space acts as a stage for the facility.

President's Field – This large, flat surface makes this a very versatile space.

President's Residence - This is the landscaped area around the president's house. It includes a number of gardens with many trees and shrubs. This area does not include the president's field, located to the east of the house.

Agricultural Area - A setting for grazing, planting, and other agricultural uses, primarily relating to pasture in the project study area.

Quads - A setting for pedestrian circulation and gathering with proximity to multiple campus buildings that face all four sides of the space. These spaces are used for education, recreation, and relaxation.

Bio-Security Institute – Secure building frontage that is private in nature.

Recreation Areas – Large flat planar surfaces of lawn that are used for group sporting activity.

Student Housing Areas – The multi-use areas surrounding student dormitories and housing. Some parts of this space are more highly used than other parts, but this was not further researched for this project.

Proposed Natural Areas - This very large area, identified in the KSU Master Plan, is comprised of the Campus Creek Corridor running from the intersection of Manhattan Avenue and Bertrand Street to the intersection of Claflin and Campus Creek Drive. Another natural area is the sloped woodland area in the northeast part of campus. This natural area is to be developed with native species that embody remnants of the surrounding tallgrass prairie.

Existing/Proposed Gardens - The proposed gardens, identified in the KSU master plan, are located south of the Veterinary Medicine Building, surrounding the northern portion of campus creek. These gardens are to be comprised of landscape display areas, depicting native, low maintenance, and rain garden type flowering and specimen plant species.

Anderson Lawn - This "great lawn" is located east of Anderson Hall. The large open area acts as a stage for the hall giving it prominence on campus.

Secondary Softscape Space – These areas are composed of a combination of similar spaces that have little to no human use. These softscape spaces are found along road corridors, in parking islands, near building approaches and campus gateways, and along building frontage. All are less programmed and also less habitable than the softscape in other campus districts.

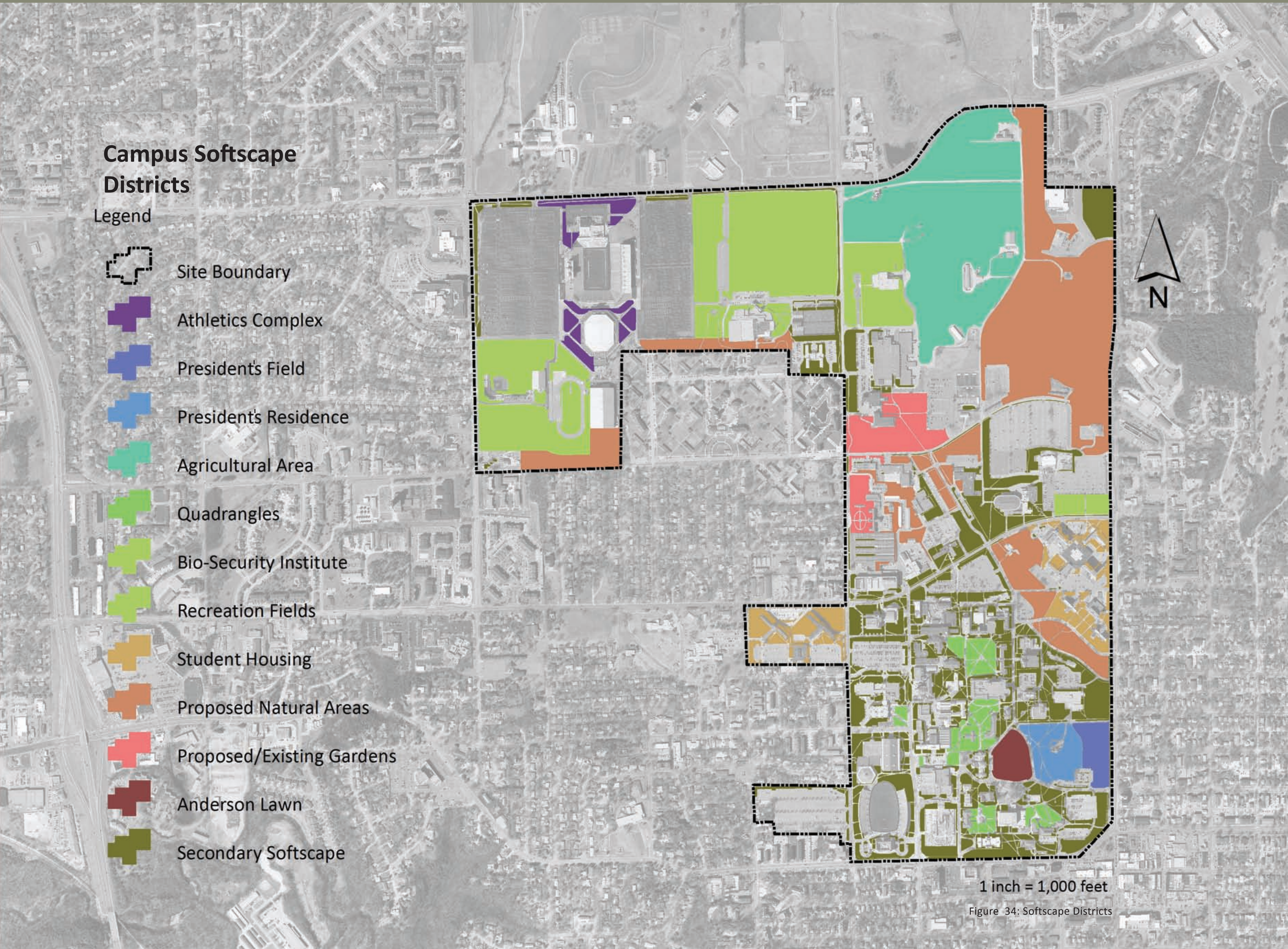
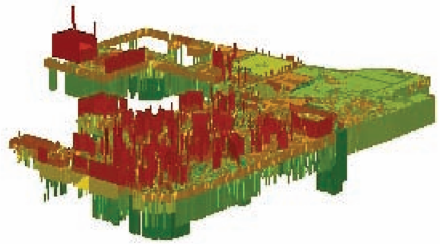


Figure 34: Softscape Districts



Analysis

As one can see by looking at the inventory map on page 32, there are a number of immediately recognized opportunities in regards to reducing mowing and increasing carbon sequestration potential. Such areas include secondary softscape spaces, proposed natural areas, and proposed gardens. These observations are tested through the process of analysis and synthesis.

The analysis of campus softscape is set up by the Project Frameworks and Inventory. All inventory groups noted on page 24 are analyzed using ArcGIS. The first three analysis groups are the same as the inventory groups, with the addition of Net Carbon Analysis and Key Site Identification. These additional analysis groups account for the vegetation, management, and suitability analysis results combined.

All analysis groups include:

- Softscape Vegetation Analysis (Carbon Sequestration Analysis)
- Softscape Management Analysis (Carbon Emission Analysis)
- Net Carbon Analysis
- Softscape Suitability Analysis
- Key Site Identification

Analysis: Process Diagram

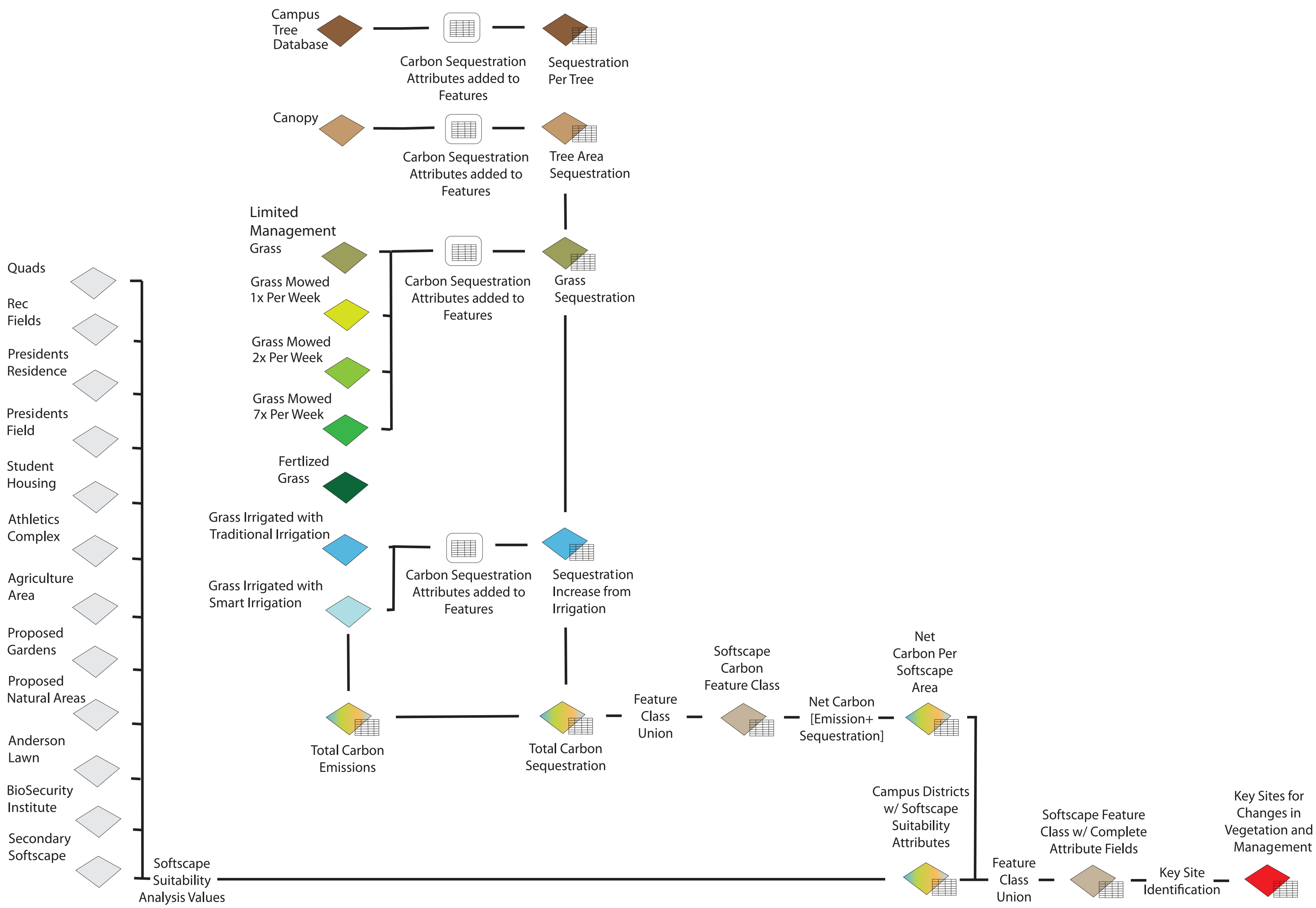


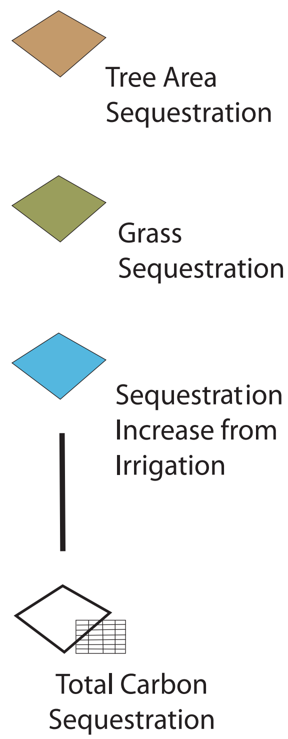
Figure 35: Analysis Process Diagram

Analysis:
Softscape Vegetation

For the purposes of this project the combination of vegetation types determines the total rate of carbon sequestration within a given softscape area (sequestration from canopy area + sequestration from grass area + sequestration from irrigation = total carbon sequestration). For a complete table of carbon sequestration rates per softscape typology refer to page 75 in the appendix. Tons of carbon sequestered per acre per year is the unit used to represent the rate of sequestration for grass and canopy areas.

Specific tree species are not taken into consideration, but could be in future studies.

Rates of carbon sequestration are taken from sources identified in the Project Frameworks.



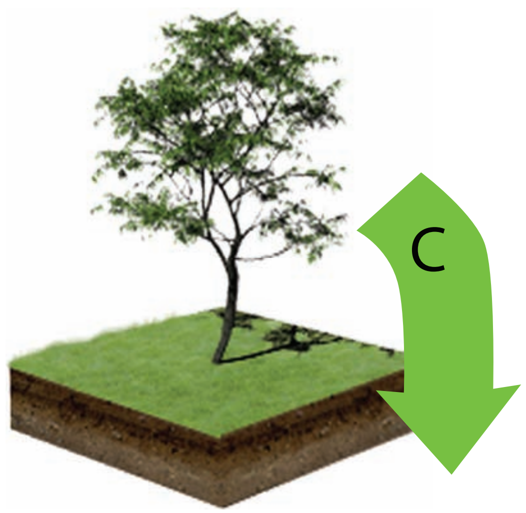


Figure 36: Carbon Sequestration

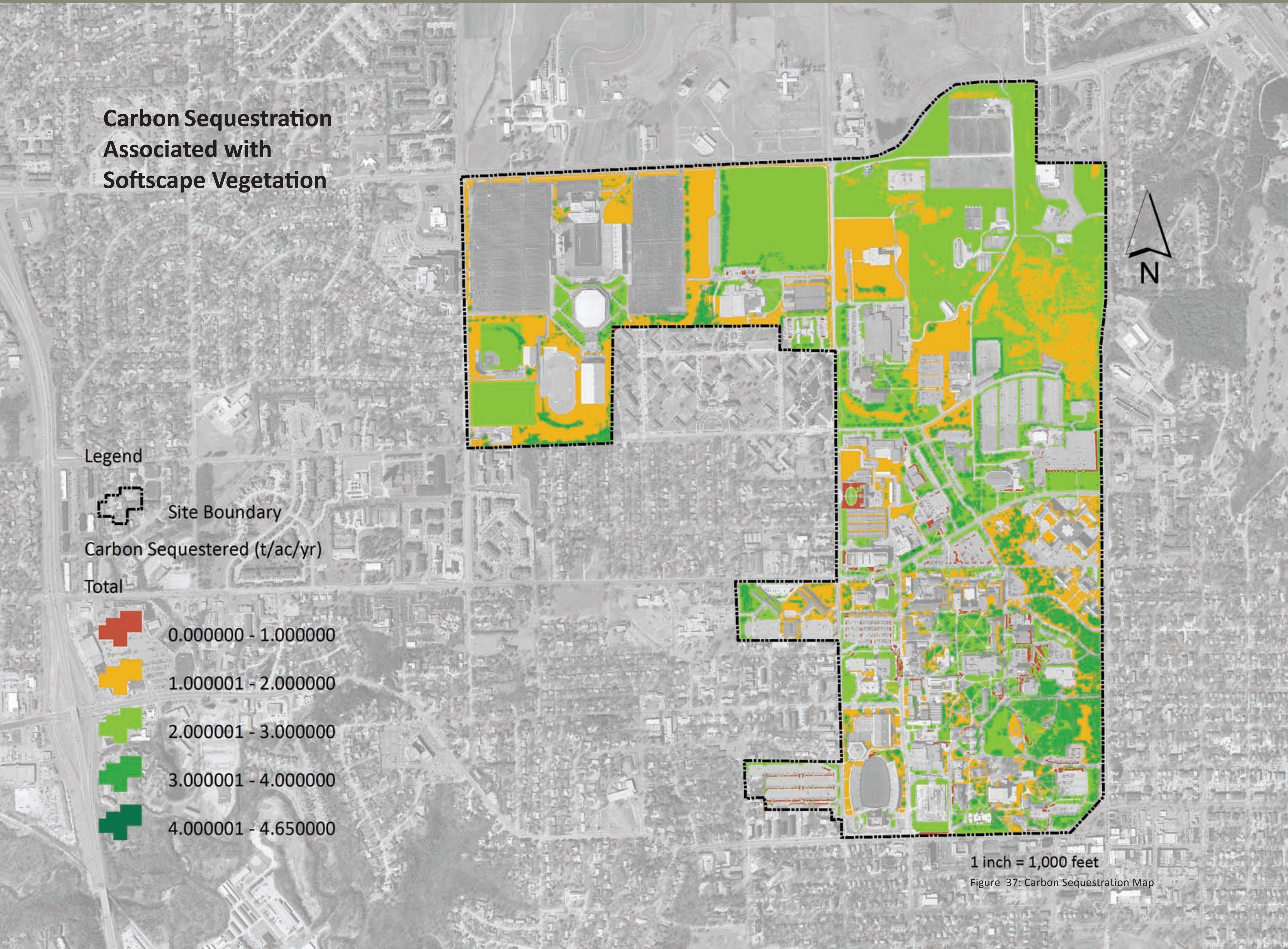


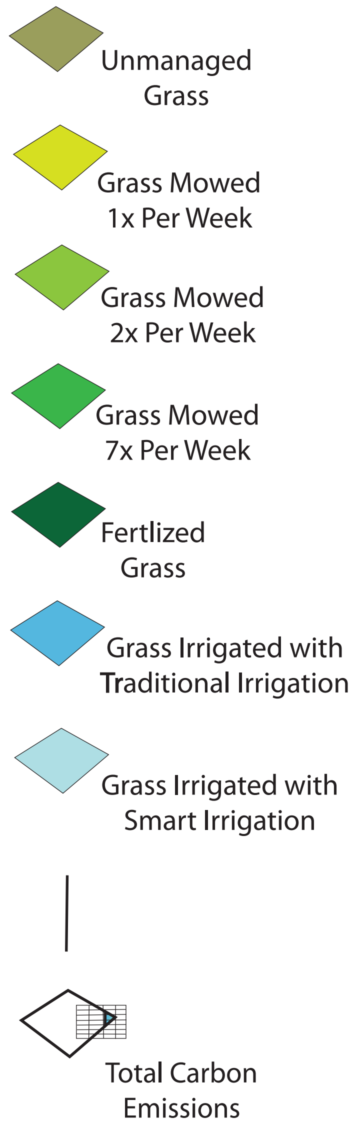
Figure 37: Carbon Sequestration Map

Analysis:
Softscape Management

Softscape Management Analysis and Maps

The total amount of carbon emissions from combustion engine use is calculated using the total hours of mowing, gallons of fuel per hour, pounds of carbon emitted per gallon of fuel, frequency of areas mowed, and total area mowed. Campus management information and base data was provided by Joe Myers of the Kansas State University Grounds Department. Carbon Emission values were calculated by the author using the information provided by facilities and carbon emission research done by the United States Environmental Protection Agency. Gasoline engines emit around 19.4 pounds per gallon used, while diesel engines emit about 22.2 pounds per gallon (U.S. Environmental Protection Agency, 2005 For a complete table of emissions per landscape typology refer to page 75 in the appendix.

Figure 38: Carbon Emission



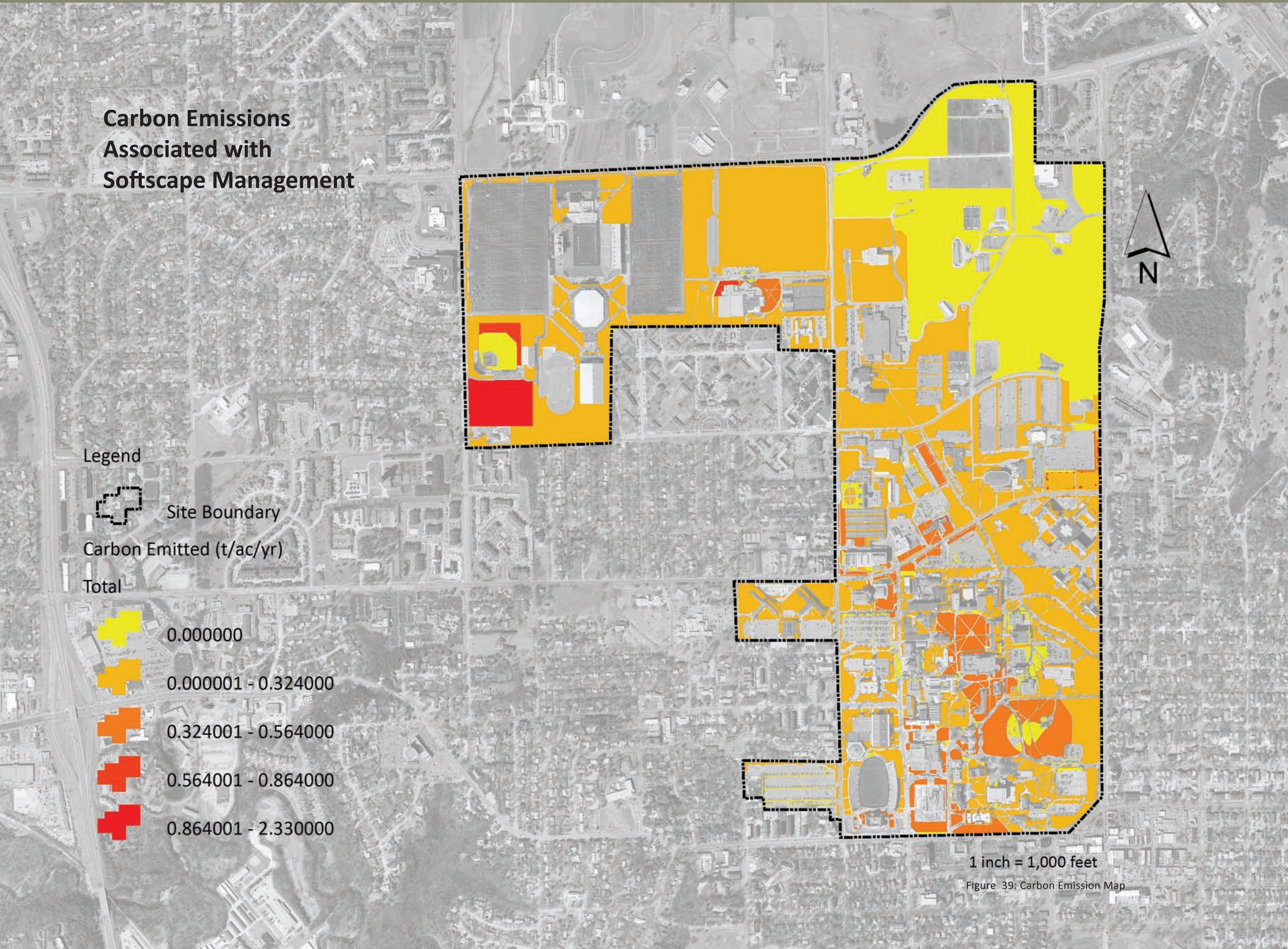


Figure 39: Carbon Emission Map

Analysis:
Net Carbon

Once the level of carbon sequestration and carbon emission were found, net carbon was figured. This is the balance of carbon sequestered and carbon emitted. In other words net carbon is the carbon emitted minus carbon sequestered for each softscape area (C Emitted - C Sequestered = Net Carbon).

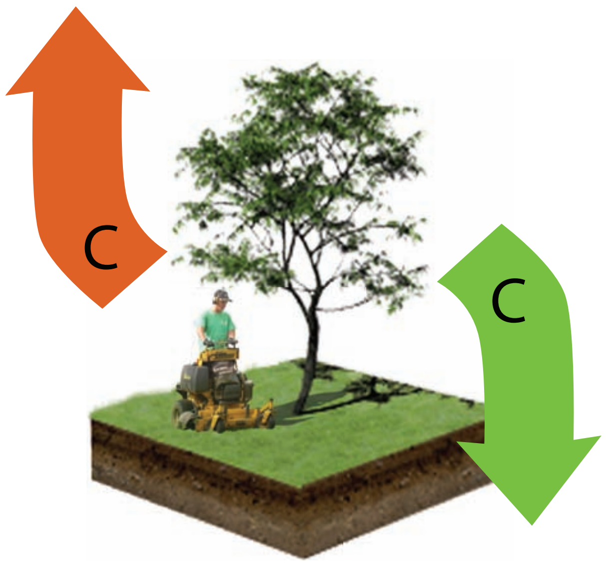
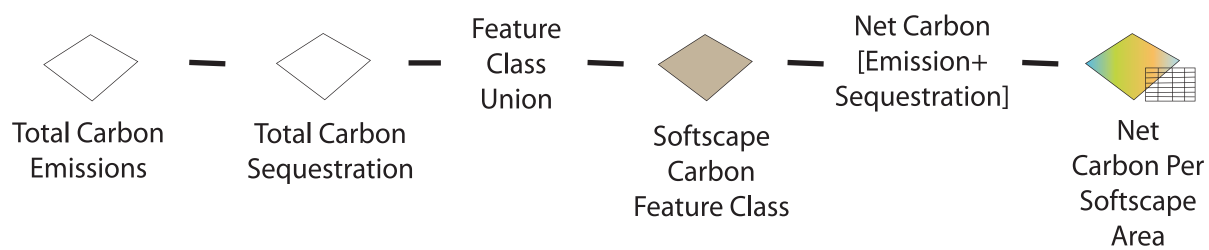


Figure 40: Net Carbon



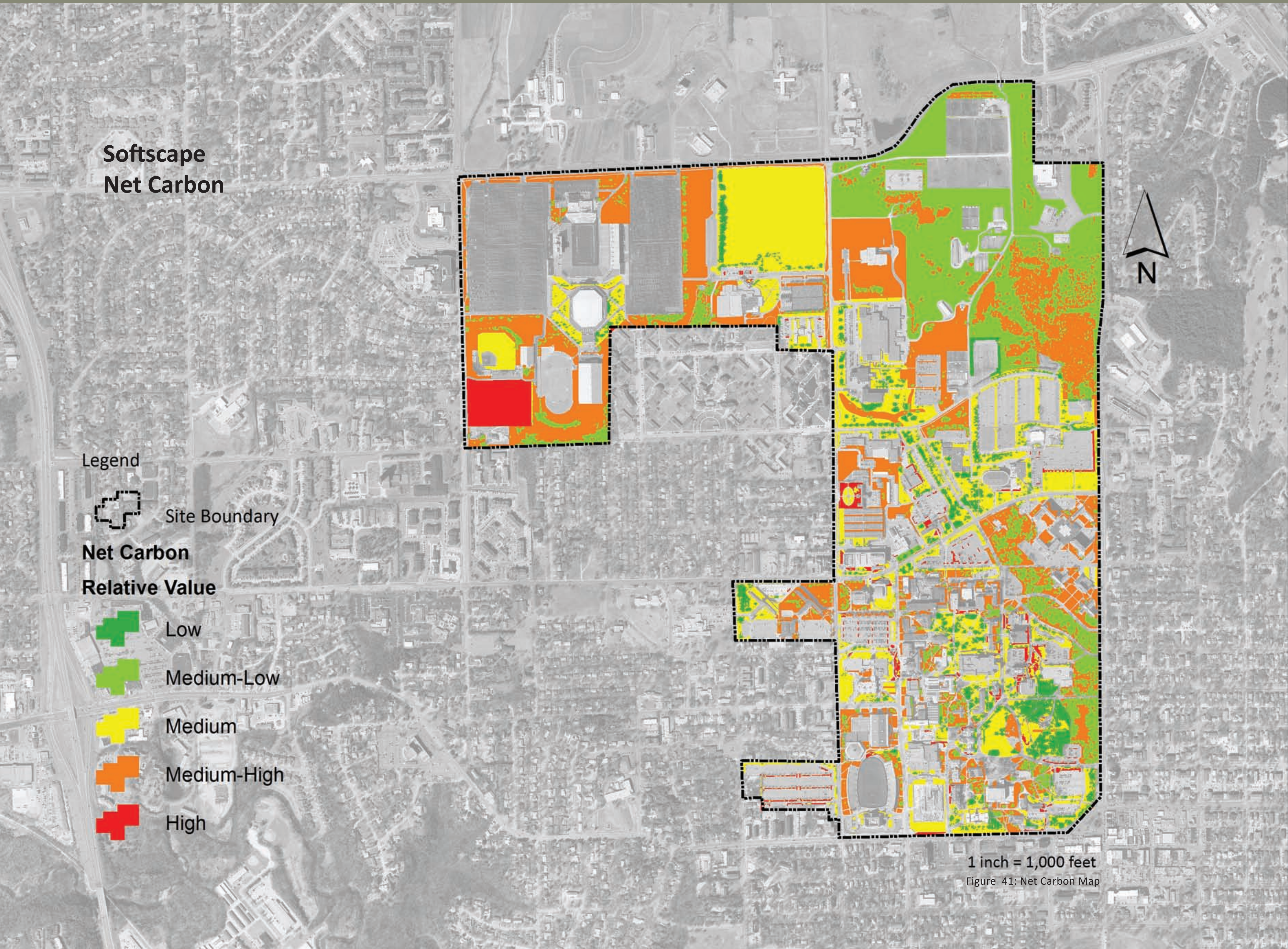


Figure 41: Net Carbon Map

Analysis:
Softscape Suitability

The Softscape Suitability Analysis is an evaluation of the social value of campus softscape space. This analysis places special emphasis on the anticipated effects on human use of softscape if existing vegetation is replaced with lower maintenance vegetation and/or reduced management for the purposes of reducing carbon emissions and increasing sequestration. In other words, the following question was explored. How do changes in vegetation and management effect spaces with a higher degree of spatial program, function, and use?

It is argued that softscape with a high use (and thus high social value) should be considered less suitable for significant changes in vegetation and management. On the other hand, softscape with low use (and thus low social value) should be considered more suitable for significant changes in vegetation and management.

The table below shows the analysis process for determining softscape suitability. Four districts, each having a different suitability value, are shown in this table. For the complete table, that includes all districts, refer to page 72 in the appendix.

Campus Softscape District	Softscape Suitability for Low Maintenance Vegetation **Low Maintenance Vegetation Changes May Include:** Changing turf to tall grass, Planting a denser coverage of trees, Planting native or low maintenance woody and herbacious plant materials, Installing raingarden/storm water bmp vegetation.	Prairie Vegetation Suitability Value: This value represents the softscape suitability for low maintenance vegetation.	Softscape Suitability for Reductions in Existing Management **Changes in Management may include:** Reduced Mowing, Reduced Fertilization, Reduced Irrigation, No Mowing, No Fertilization, No Irrigation.	Reduced Management Suitability Value: This value represents the suitability of the softscape space for reduced management.	Combined Suitability Value: This value represents the overall suitability of the space for both reduced management and low maintenance vegetation.
	High: No constraints for change in vegetation or management. **Medium:** Minor constraints influencing suitability to change vegetation or management. **Low:** Significant constraints for change in vegetation and management.	**High**=3 **Medium**=2 **Low**=1	**High:** No constraints for change in vegetation or management. **Medium:** Minor constraints influencing suitability to change vegetation or management. **Low:** Significant constraints for change in vegetation and management.	**High**=3 **Medium**=2 **Low**=1	This value is the sum of the Prairie Vegetation Suitability Value and the Reduced Management Value.
Rec Fields	**Low:** Required vegetation types for functional use of the space. (Astro turf is an exception for intensively managed recreation fields, i.e. Old Stadium Field).	1	**Medium:** Reduced management could take place as not to significantly change overall functional quality.	2	3
Quads	**Medium:** Open lawn areas used as gathering space should not see significant change.	2	**Medium:** Reduced management could take place as not to significantly change overall aesthetic appearance and function.	2	4
Proposed Gardens	**High:** Opportunity for display areas showing the potential beauty of carbon-friendly, low maintenance vegetation.	3	**High:** Irrigation reductions possible when converting turf to low maintenance vegetation.	2	5
Natural Areas	**High:** Opportunity for display areas showing the potential beauty of carbon-friendly, low maintenance vegetation.	3	**High:** Reduced management practices in designated natural areas is a significant opportunity.	3	6

Figure 42: Example Softscape Suitability Analysis Table

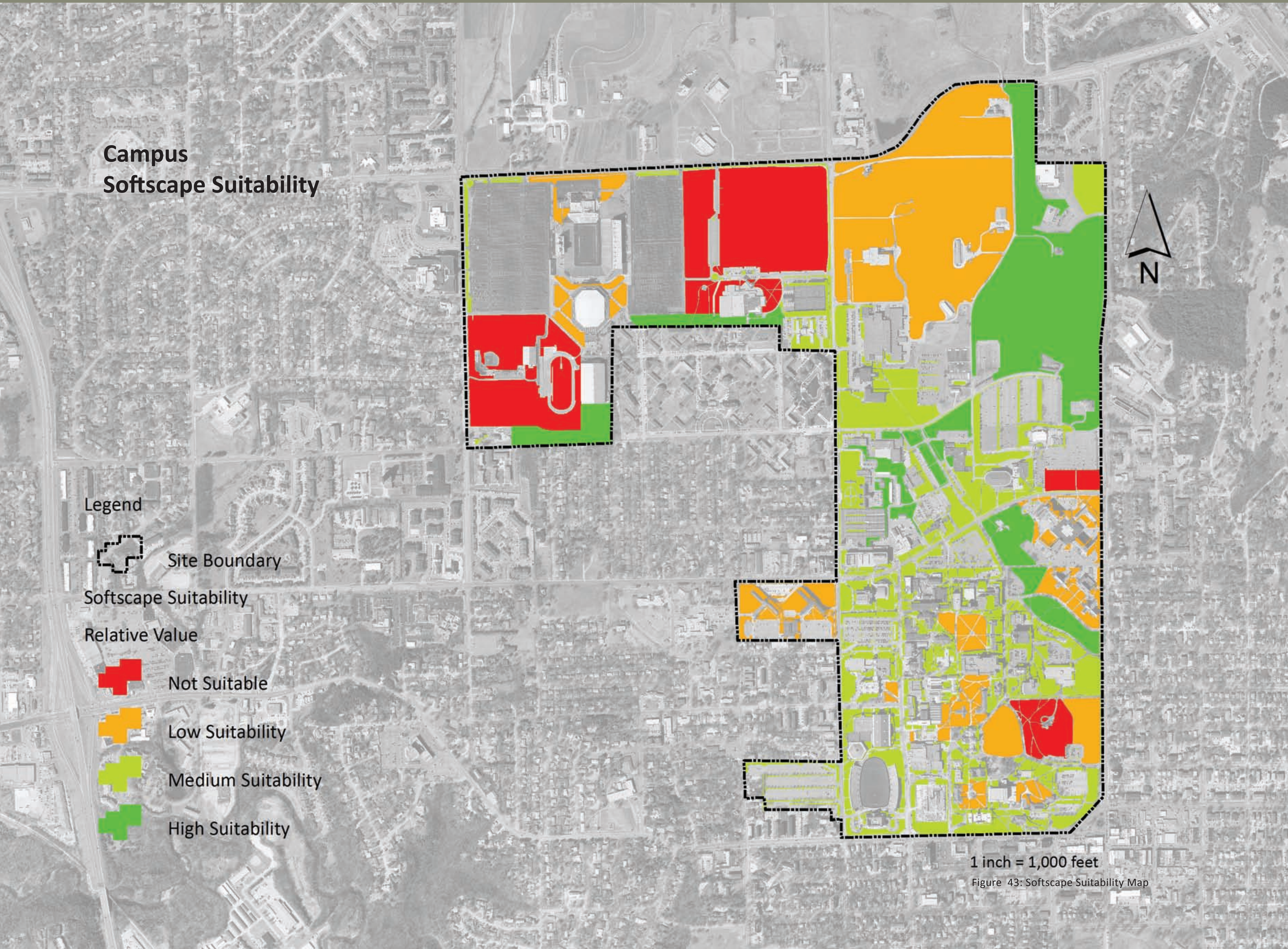


Figure 43: Softscape Suitability Map

Analysis:
Key Sites

Areas identified as having a low degree of use and function, while also identified as producing a high overall carbon output (considering both emission and sequestration) are considered most opportune spaces for implementation of a carbon-friendly landscape. These areas are designated as "key sites" on the associated map (Figure 44).

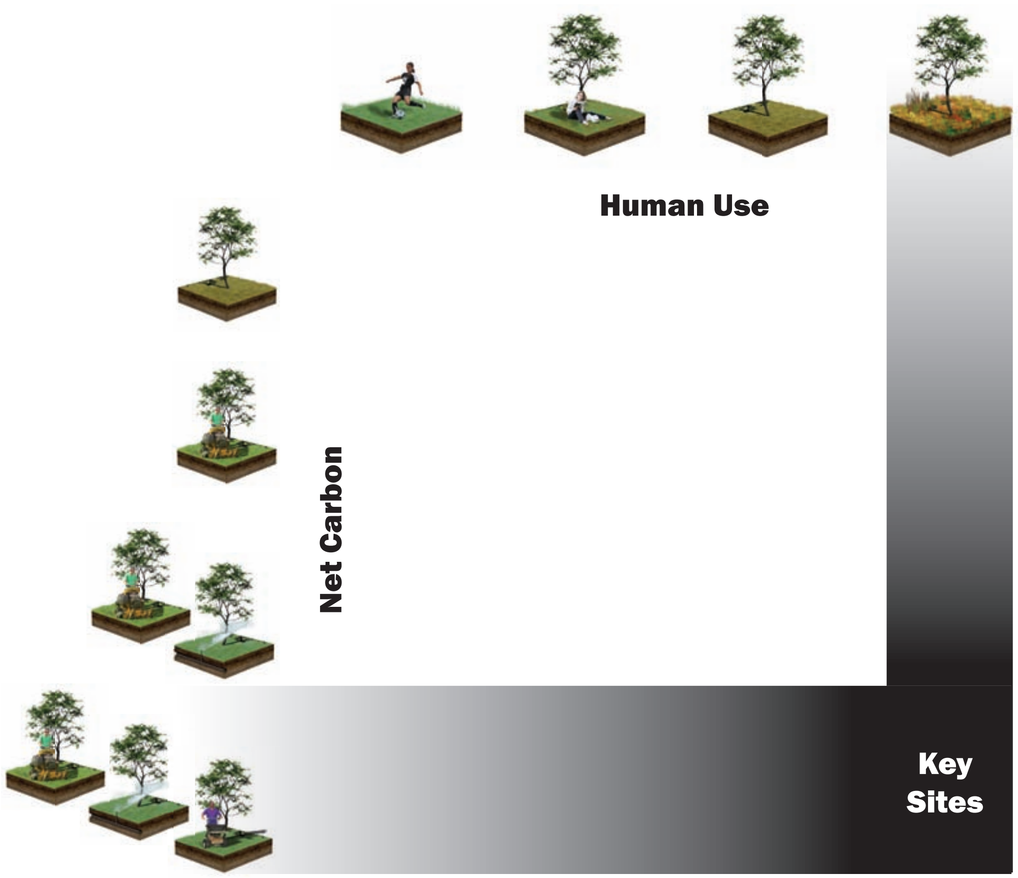
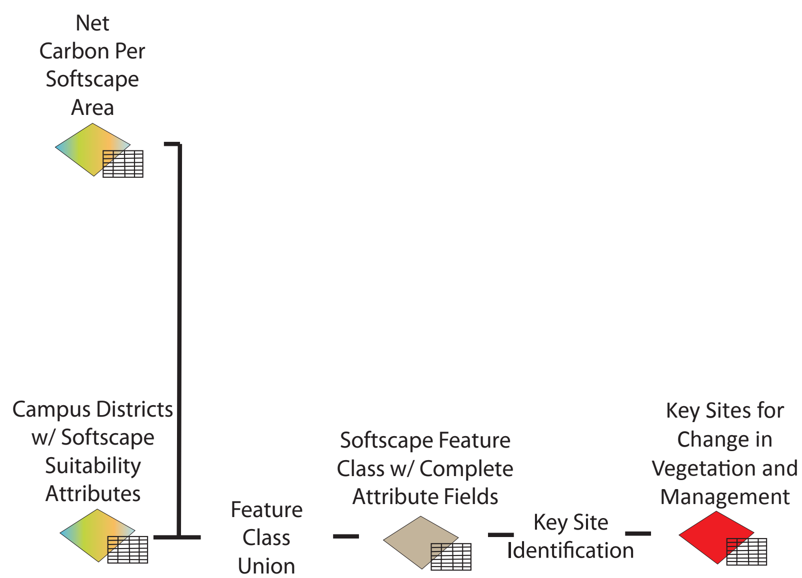


Figure 44: Key Site Analysis Diagram



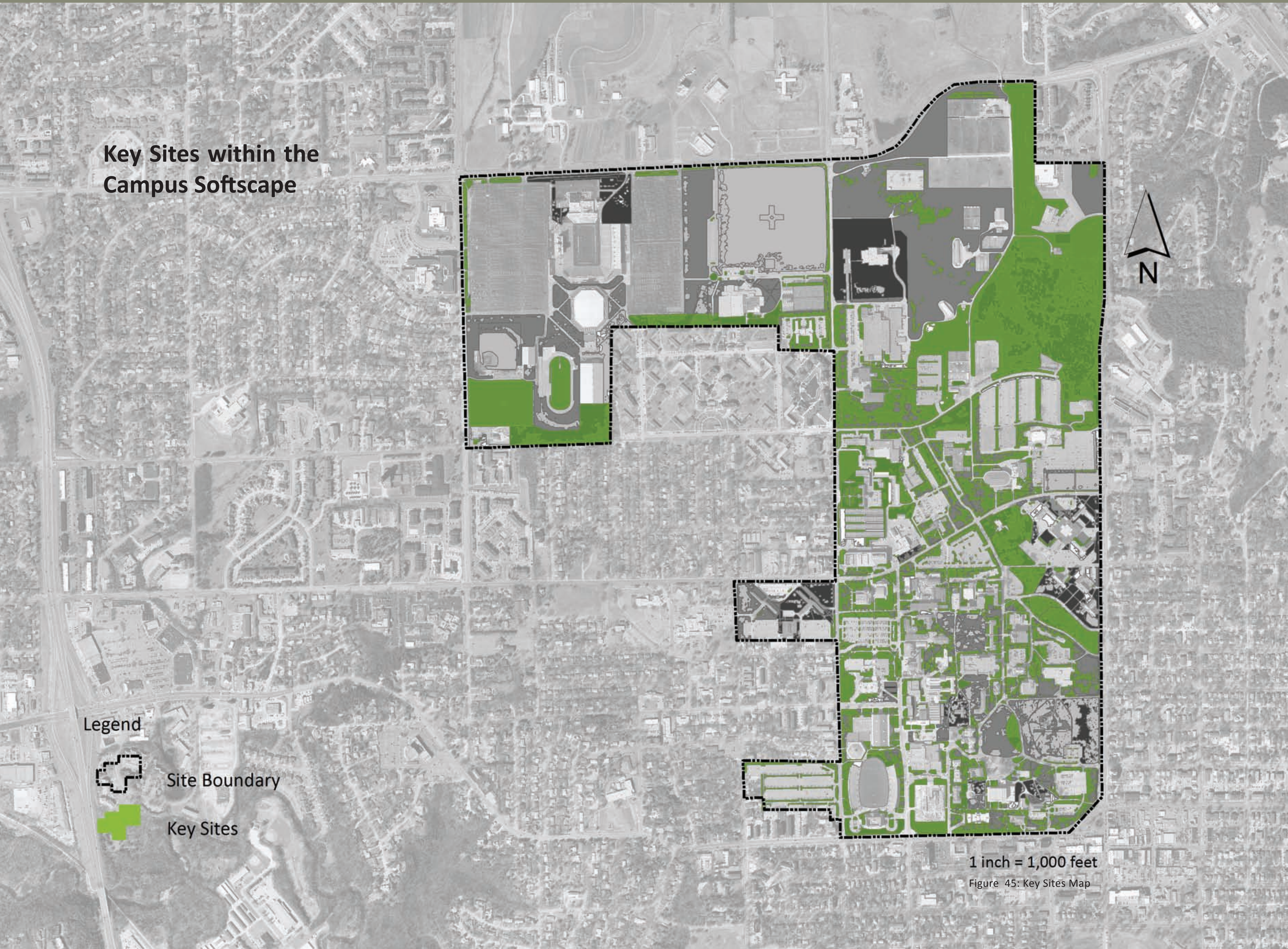
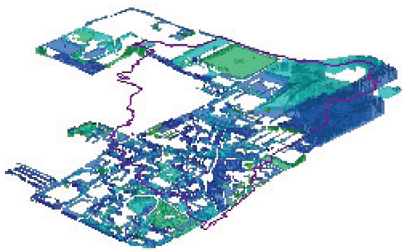


Figure 45: Key Sites Map



Synthesis

Synthesis is a process used to incorporate other significant design considerations relating to the planning and design of the campus landscape. These opportunities further delineate appropriate schematic design concepts and planning principles associated with successful campus planning and sustainable landscape architecture. This process combines the overall objectives of the analysis process, landscape urbanism/infrastructure, and the campus program and use. These objectives are addressed in two sections of this project: Project Programming and Planning and Design.

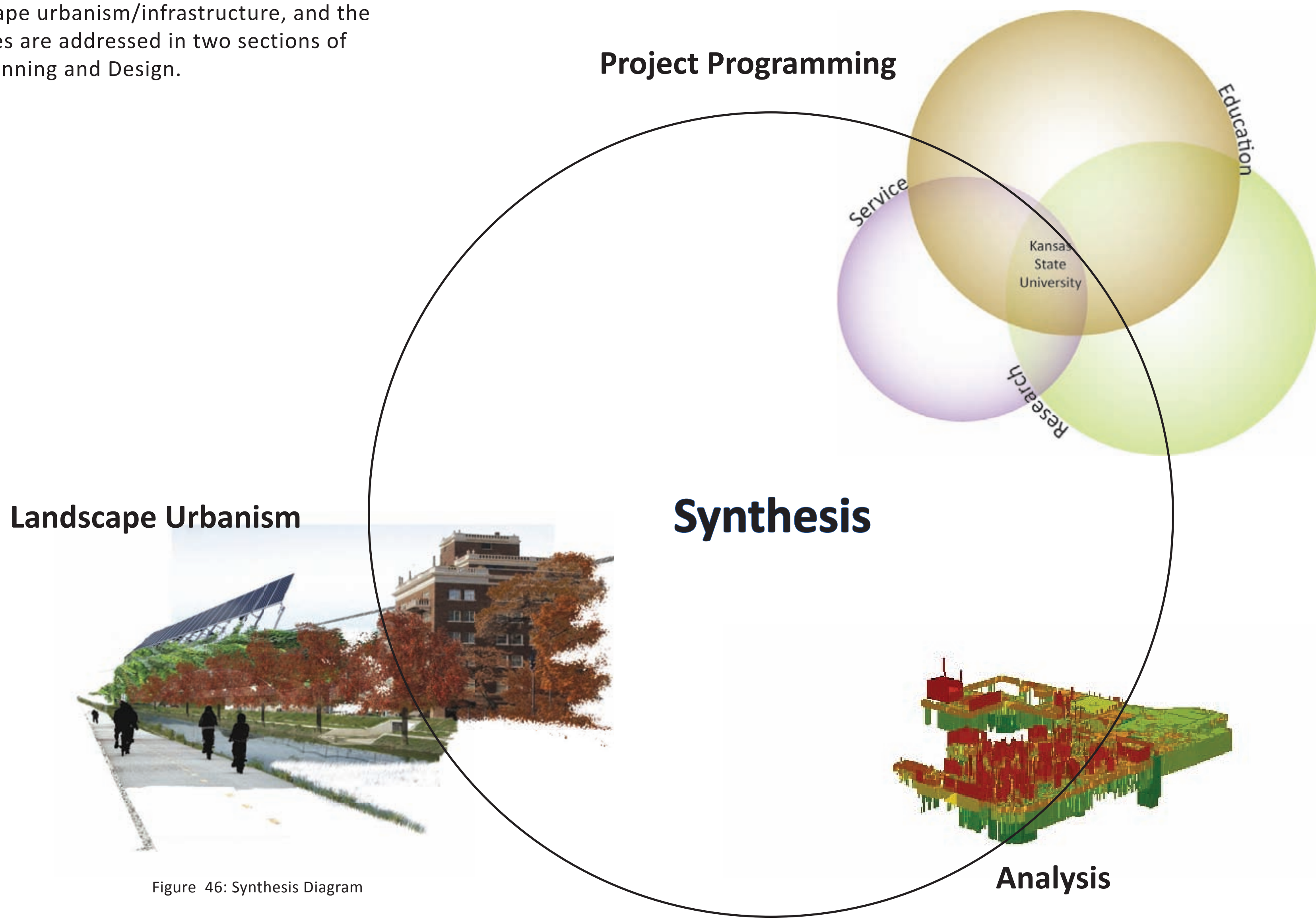


Figure 46: Synthesis Diagram

Synthesis:
Opportunities from Analysis

Key Sites that are well suited for reduction in management and implementation of low maintenance vegetation were identified through the analysis process. Such opportunities fall under two categories: Management Change and Vegetation Change.

Management Change Opportunity Locations
- Recreation Fields
- Secondary Softscape Space

Vegetation Change Opportunity Locations
- Proposed Natural Areas
- Parking Islands
- Proposed Gardens
- Secondary Softscape Space

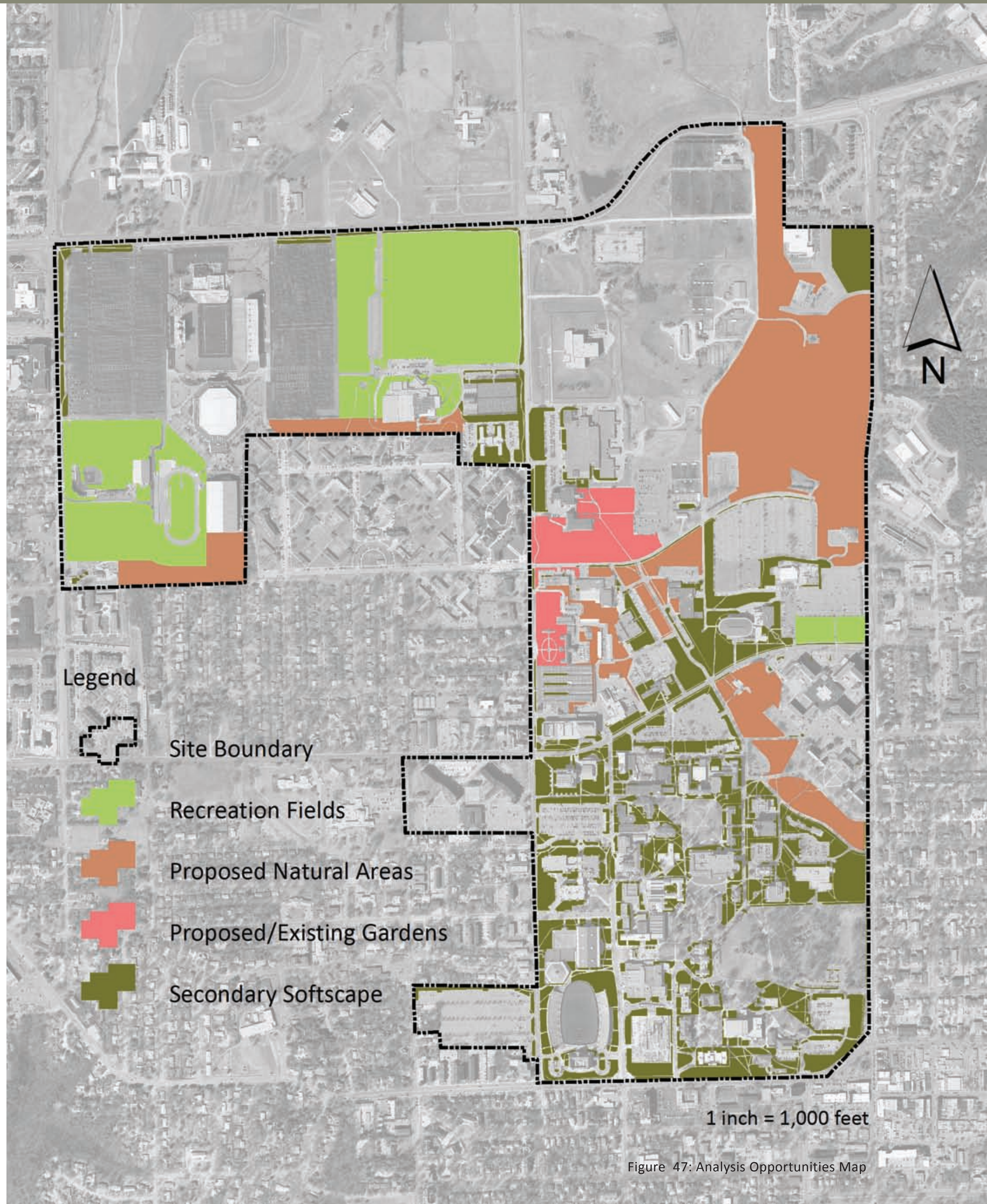


Figure 47: Analysis Opportunities Map

Synthesis: Opportunities from Project Program

The Project Program suggests that campus space should be designed and managed in a way that lends to the mission of the university: education, research, and service. These KSU mission related objectives focus on human related opportunities. Human related opportunities include:

Learning in the Landscape
The campus should provide learning in the landscape. This type of experiential learning space should be provided in all carbon-friendly landscape areas. There should be an emphasis in areas experienced by students and faculty. A series of educational signs strategically placed along a primary circulation route will provide necessary information to understand the carbon cycle in the campus landscape.

Sustainable Impressions
The campus should provide an impression that the university is striving to create sustainable landscapes. Initial impressions of KSU efforts toward sustainability can be made at campus gateways and visitor routes through campus. Carbon-friendly softscape development should be embraced and used as features in the landscape for way finding and spatial recognition.

Recreation Trails
The campus should provide different types of recreation space. Carbon-friendly softscape corridors should be designed to accommodate recreational uses such as jogging and running. These corridors can also provide major circulation through campus and encourage students, faculty, and staff to ride bikes or walk to work. The connection between Aggieville and the Athletics Complex is an important link through campus that KSU should enhance.

Natural Areas
Quiet, natural settings for mental restoration and private areas embracing the natural aesthetic of carbon-friendly softscape should be developed. These areas show evidence to restore people who are feeling mental fatigue and stress (Kaplan, 1998).

Figure 48: Project Program Opportunities

Synthesis:
Landscape Urbanism Theory

Concepts of landscape urbanism and green infrastructure suggest that the design and management of Key Sites could simultaneously provide human and environmental benefits. Because the natural area is a key site and parallels Campus Creek, it is a most opportune location for landscape infrastructural concepts to be implemented. Other environmental opportunities fall under five categories:

Stormwater Runoff Reduction
Low maintenance landscapes can also serve as stormwater management areas. These types of systems can range from large resorted wetland areas that can retain floodwaters, treat polluted stormwater to small rain gardens, such as the rain garden installed at the International Student Center.

Groundwater Recharge
Increased vegetation coverage in low maintenance landscapes slows stormwater runoff and allows it to infiltrate into the ground.

Soil Structure Improvement
The overall health of the soil improves in low maintenance landscapes. Soil compaction is reduced due to decreases in the use of mowers.

Soil Erosion Resistance
Increased vegetation coverage in low maintenance landscapes also improves the resistance of soil erosion by slowing runoff and improving soil structure.

Prairie/Woodland Habitat Restoration
Networks of low maintenance vegetation can serve as habitat for many indigenous prairie and woodland species.

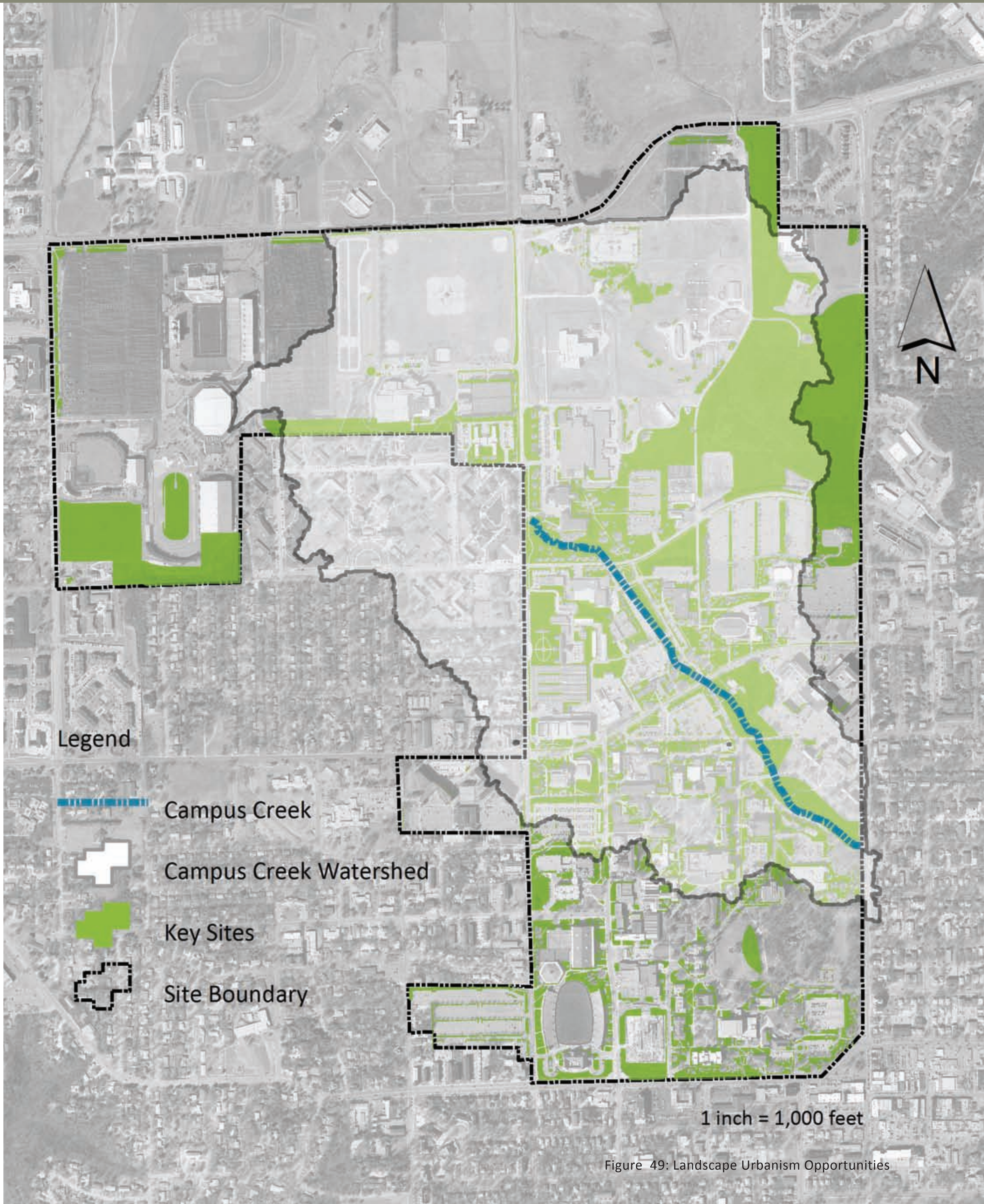


Figure 49: Landscape Urbanism Opportunities

Campus Plan:
Greenway Development

Plan Introduction

This section shows how the objectives delineated in the Synthesis section can be implemented into the campus landscape. The plans highlight key places on campus that can become carbon-friendly places and corridors that can serve the people and the environment.

Design Concept

The establishment of native and other appropriate green space networks on Kansas State University's Campus can provide settings for education, research, and infrastructural services creating a more carbon-friendly campus landscape. The proposed landscape will educate and promote carbon neutrality with experiential landscapes functioning as extensive carbon mitigating landscapes. Likewise softscape areas have the potential to reduce negative environmental impacts from stormwater, restore critical ecological processes, engage and inform faculty, students, staff and visitors. The proposed landscape would also reflect many of the ecosystems associated with the Flint Hills Tallgrass Prairie Eco-region.

Experience and Education

The diverse lands of Kansas State University (KSU) contain many of opportunities for education. As an institution for research and learning, KSU should embrace these opportunities. The landscape that is used day to day by students, faculty, and staff can be a setting for all to gain a better understanding of the natural world that we are a part of. Prior to settlement KSU's main campus was a vast stretch of tallgrass prairie and maintained a relatively stable set of ecological, hydrological, and atmospheric systems. The natural landscape sustained these interacting systems. Currently on the KSU campus, someone gets little to no sense of the pre-settlement environment, nor of its essential functions. As environmental scientists suggest, natural systems are critical to nearly every aspect of human society and culture. KSU has an opportunity to weave natural systems into the fiber of campus. Re-introducing well functioning prairie and woodland type landscapes at KSU will provide opportunities for experiential learning and research, as well as admiration for the services and beauty that they provide.

Figure 50: Design Concept

Figure 51: Experience and Education

Campus Plan

Three greenways are depicted in the campus plan: The Tallgrass Prairie Loop, The Campus Creek Corridor, and The Woodland Recreation Area. All three are designed to incorporate restored prairie in the existing campus landscape. General descriptions of how these spaces should be developed follow.

The type of prairie developed in these spaces varies depending on the degree of canopy coverage. Few trees are in an area where regular prairie restoration is being developed. In a savanna prairie-type setting trees may be placed across the site, creating shaded areas for people, cars, and vegetation.

Savanna prairie-type restoration consists of scattered trees. A woodland area has tree canopies covering at least 80 percent of the site. [Packard and Mutel, 1997]

Ideally, all of these landscape types should be managed to reduce or eliminate invasive species (especially shrub honeysuckle, buckthorn, and other species that tend to reduce the hydrological functions of the system by shading out grasses and forbs).

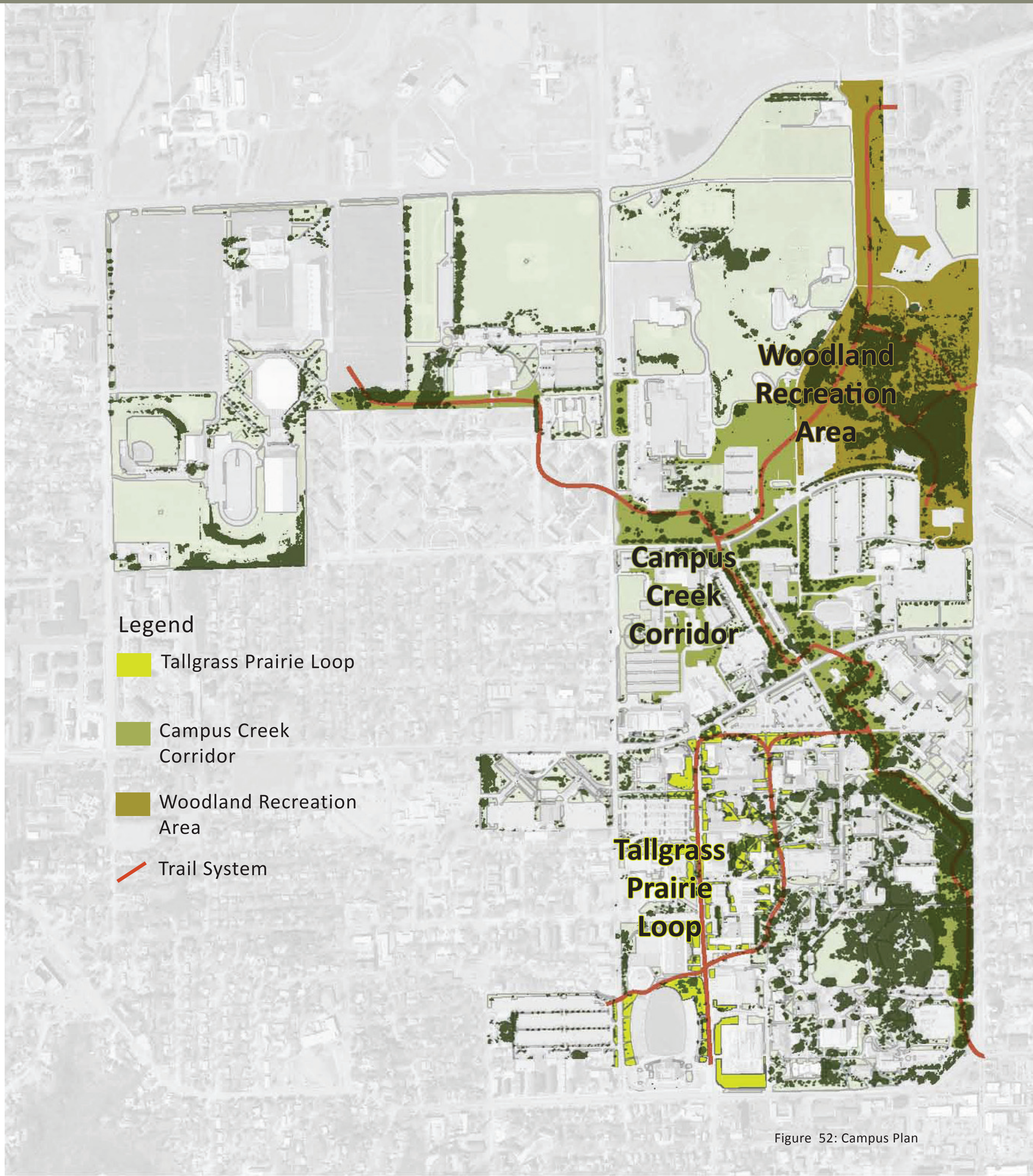


Figure 52: Campus Plan

Campus Plan:
Campus Creek
Corridor

The Campus Creek Corridor can connect the Athletics Complex and Aggieville, providing a navigable and interesting path to and from KSU athletic events and the historic community center. The amount of prairie and woodland restoration would be large and provide human and environmental services at a grand scale. Prairie, savanna, and woodland landscapes would also provide substantial areas of more diverse with improved stormwater management. The patchwork of these different types of natural environments will provide a perfect setting for recreational trails that could be linked to main campus, Manhattan, and Tuttle Creek Lake trail systems.

This greenway contains relaxation and restoration space that is quiet, natural, and has framed views. Introducing these types of landscapes into main campus would provide space for mental restoration. Scientific evidence suggests that humans subject to natural environments experience a decrease in mental strain and distraction. One's ability to focus allows higher levels of productivity and accuracy in the work place (Kaplan, 1998).

Existing canopy area along this greenway would suggest three different types of restoration in upland settings:

- Prairie
- Savanna
- Woodland

As upland areas are improved, Campus Creek can see extensive hydrologic restoration, including:

- Widening the floodplain
- Wetland development
- Meandering Stream Restoration
- Improved Stormwater Holding Capacity
  – Reducing flooding downstream

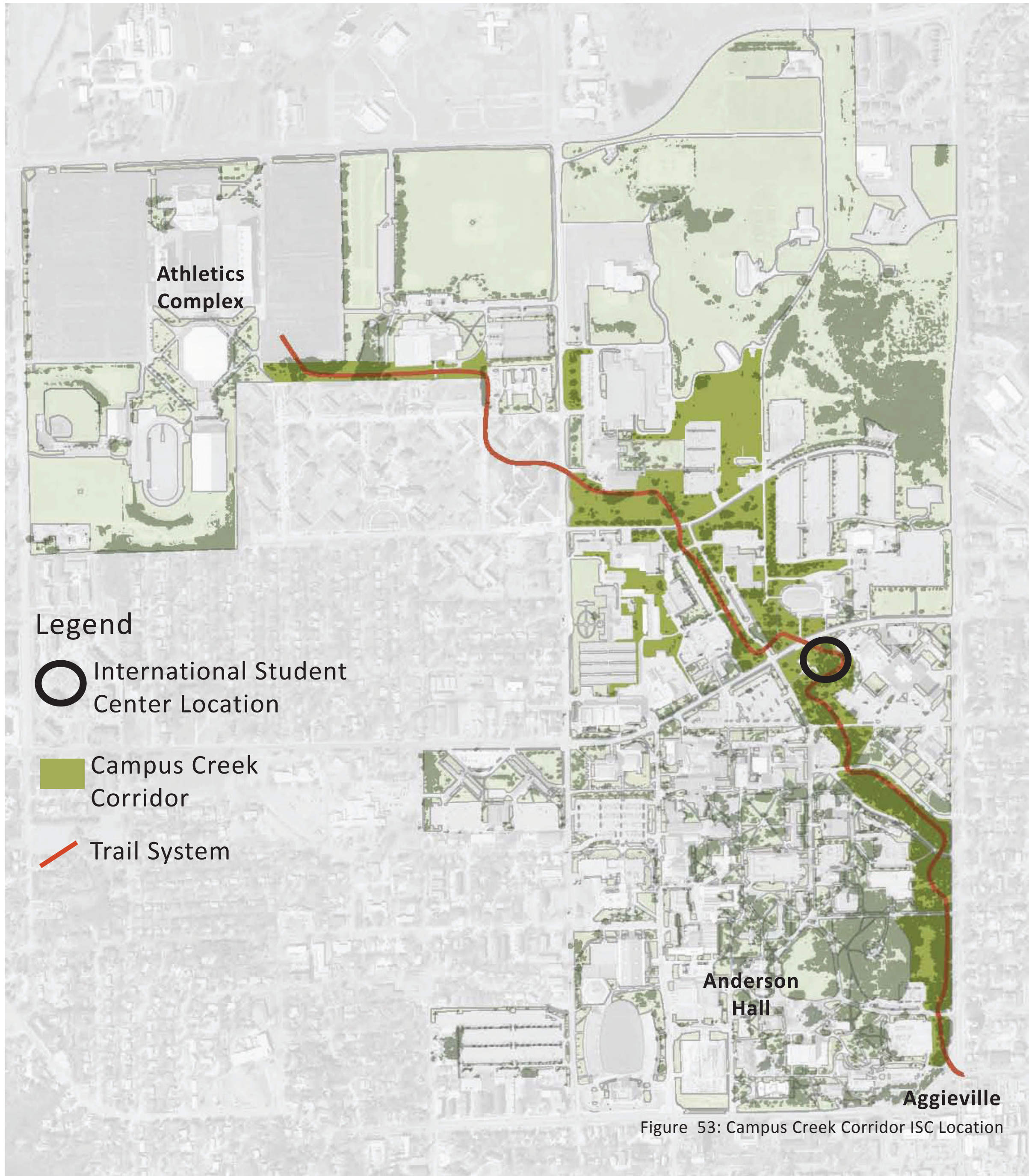


Figure 53: Campus Creek Corridor ISC Location

Figure 54: Campus Creek Corridor ISC

Campus Plan: Campus Creek Corridor

In the proposed garden district large stream restoration and wetland developments occur. These improvements provide space for stormwater management, garden displays, educational signage, and research studies. This space could be a rich outdoor learning space.

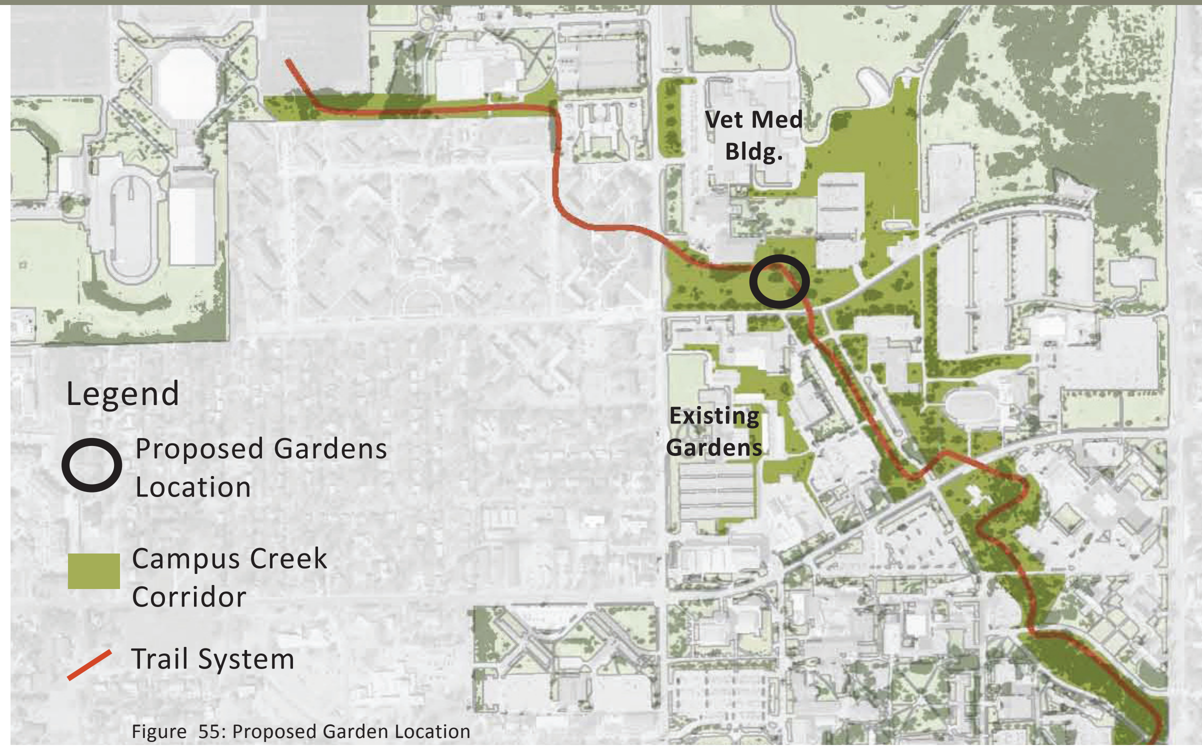


Figure 55: Proposed Garden Location


Figure 56: Proposed Gardens Wetland

Campus Plan: Campus Creek Corridor

This rendering shows opportunities for restoration of prairie in unused interstitial space. A large number of spaces like this one exist across campus. Collectively they have the potential to significantly reduce management costs and emissions while also sequestering carbon.

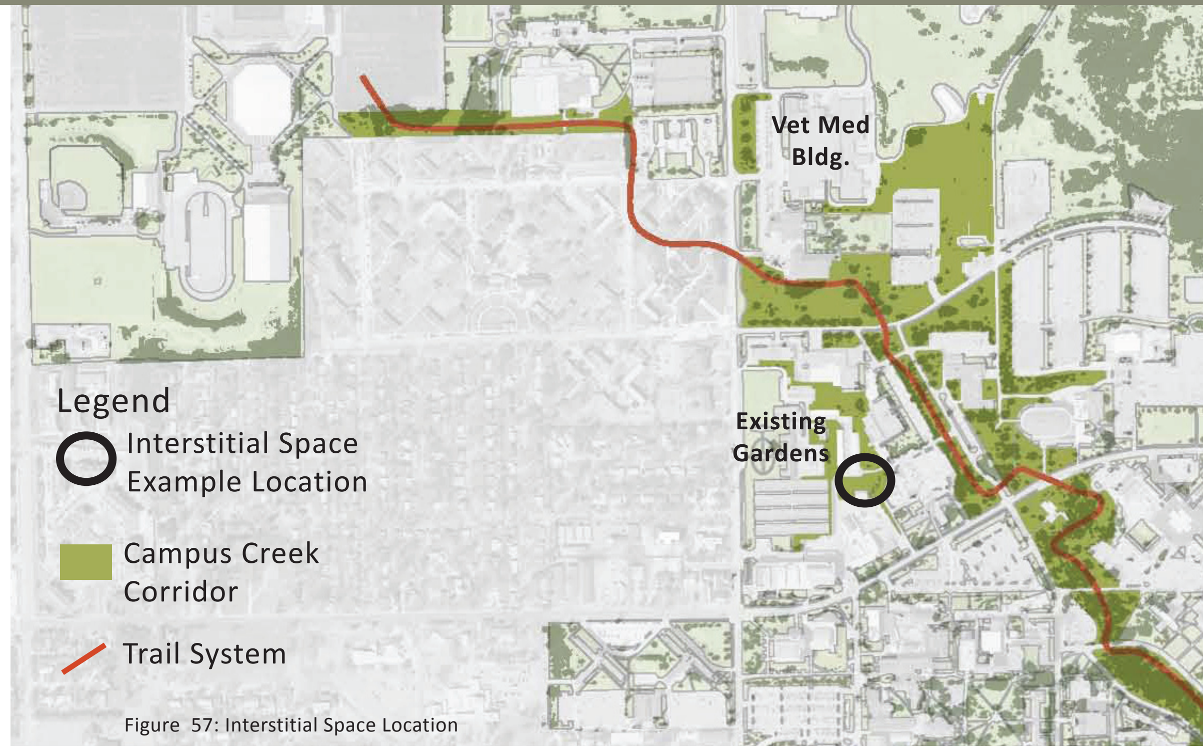


Figure 57: Interstitial Space Location

Figure 58: Interstitial Space

Campus Plan: Tallgrass Prairie Loop

This pedestrian-oriented space is located along major campus circulation routes. Restored prairie makes up the low maintenance softscape. After the establishment of this plan a person driving or walking through the KSU campus would experience a beautifully arranged patchwork of natural and groomed landscapes. The natural landscapes would provide opportunities for experiential learning, research, and recreation. These landscapes would also provide improved carbon management. These and other created prairie-like systems would promote learning and understanding of how ecosystems provide many vital functions and values.

Starting near the visitor entrance located on 17th Street and Anderson Avenue this green space gives an initial impression of sustainability to visitors and prospective students on campus. The slopes along the north, east, and west sides of Old Stadium would be ideal locations for grasses and wildflowers and would complement the anticipated stadium green roofs.

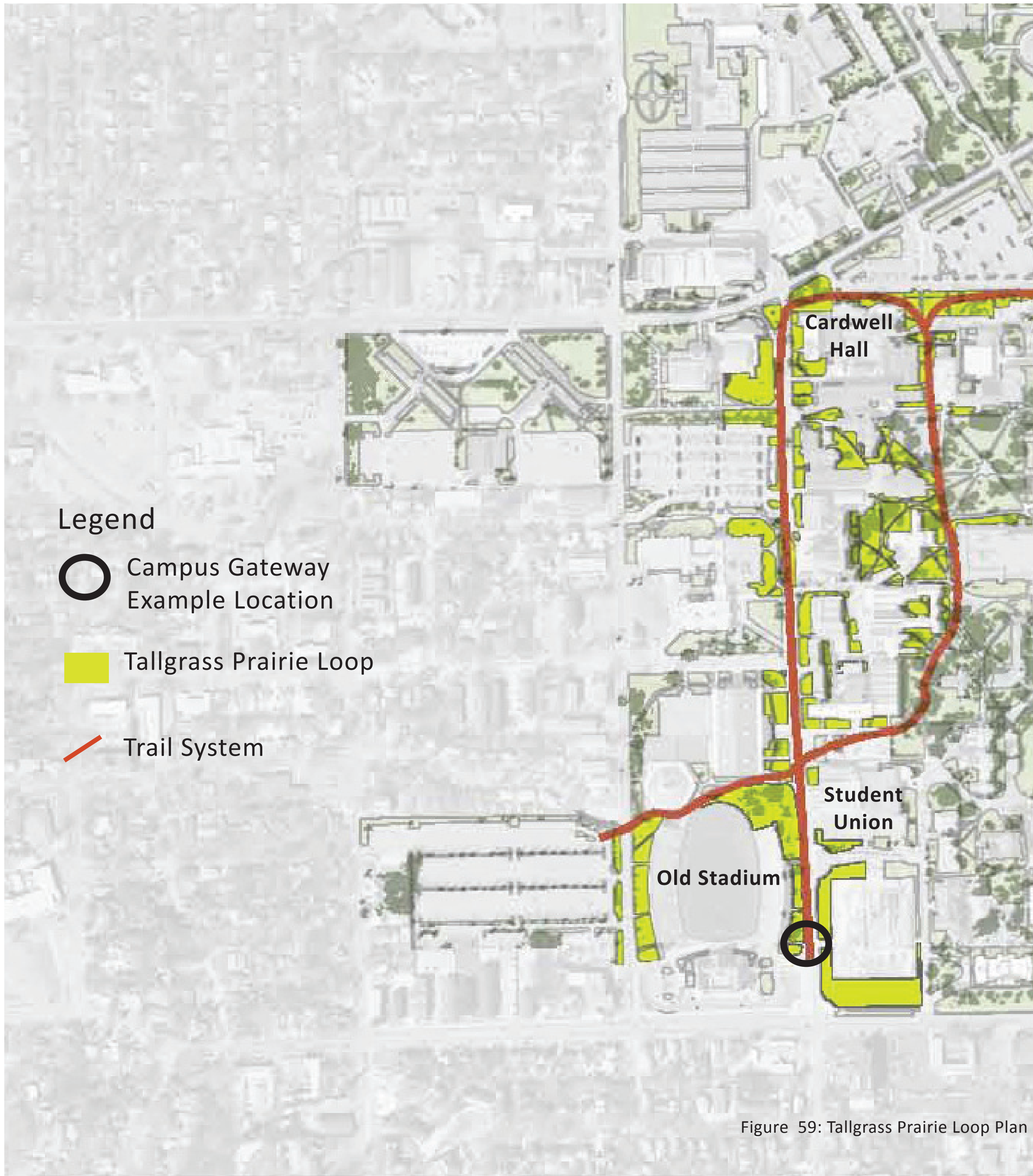


Figure 59: Tallgrass Prairie Loop Plan

The campus gateway at Anderson Ave. and 17th street is depicted here. The Senior Sidewalk could be lined with restored prairie (with ample wildflowers that bloom during spring, summer, and fall).

Figure 60: KSU ISC Rain Garden

Stormwater management landscapes, such as the award winning rain garden at the International Student Center, could be installed throughout the Tallgrass Prairie Loop. These landscape types could be beautifully arranged natural areas ranging from a small garden to a large restored or created wetland ecosystem.

Figure 61: 17th Street

Campus Plan:
Woodland
Recreation Area

The northeastern portion of proposed natural area should be developed as a woodland recreation area. The space could be threaded with running/walking trails that would link the residential buildings in the area to the rest of campus.

This area would be similar to the majority the Campus Creek Greenway. Expansive woodland prairie would provide peaceful space for both humans and wildlife to experience. This area would also act as a setting for savanna and woodland prairie research.

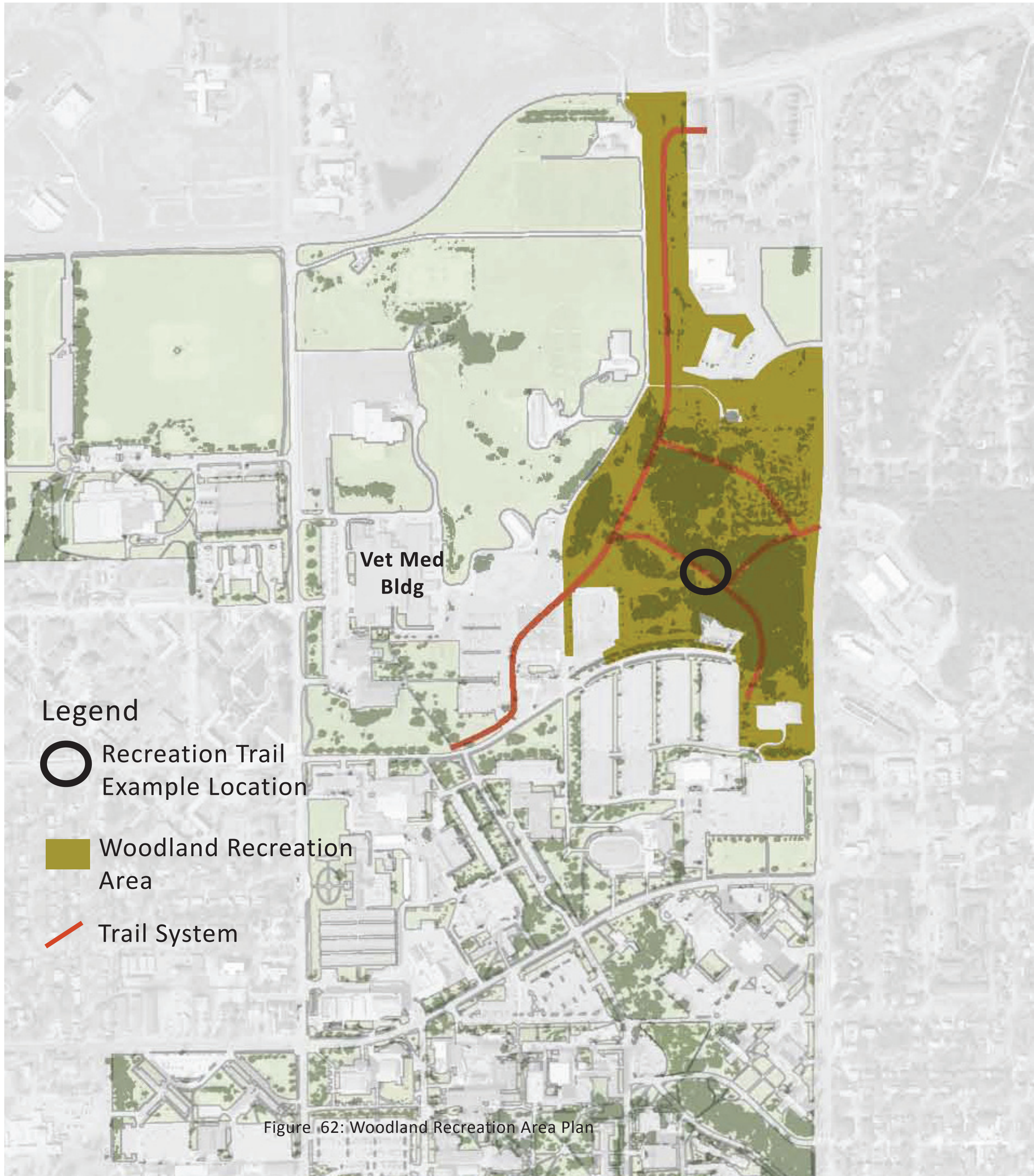


Figure 62: Woodland Recreation Area Plan

Recreation Trail

Figure 63: Woodland Recreation Area

Campus Plan:
Trail System

The “human use” aspect of greenways is embraced with circulation corridors. Linking the tree proposed greenways is a trail system that can be used by bicycles, joggers, strollers, students going to class-and even groups of exuberant K-State fans walking to a football game. Typically, along the sides of the pathway, a mowed strip of turf should be implemented. This strip of turf will keep a buffer space between the habitable space and the restored prairie and clearly indicate the cared for nature of the ecosystems that the path is adjacent to.

Figure 64: Trail System

Campus Plan: Management Reduction

Most of the existing landscape areas highlighted in this plan receive a high degree of management. These areas should see significant reductions in mowing and irrigation, while reducing carbon emissions. In most areas mowing frequency should be the primary concern. Softscape areas that see high degrees of human use should be the first priority when mowing is scheduled. Reducing the need for fertilizer can also be done with mulching mowers. These mowers mulch grass clippings and tree leaves where they fall and deposit them into the turf, returning the biomass back into the soil and promoting carbon sequestration. Mulch mowing could be implemented while funds are being secured and plans prepared for the transition to prairie, savanna, or other types of low-management vegetation.

Figure 65: Reduced Management Plan

Design Benefits

Introduction to Design Benefits

The proposed Campus Plan, which over time changes a large portion of campus softscape to restored prairie, will provide many benefits to Kansas State University. The design improves not only environmental systems and functions such as the carbon cycle, hydrologic cycle, soil health, and biodiversity (to name a few), but also benefits the university economically. Overall reductions in intensive turfgrass management reduce the cost of maintaining the campus landscape.

Figure 66: Plan Benefits

Management Associated Cost Benefits

The development of all three proposed greenways will significantly decrease the amount of area to be mowed on a regular basis. Although most restored prairie and savanna would be mowed once or twice per season, the total time spent mowing in a season is reduced tremendously. Reductions in mowing decrease the amount of money spent on fuel and carbon emissions. The proposed plan is estimated to reduce fuel consumption for mowing by 38.5 percent. This reduces the existing cost of $24,000 per year for mowing fuel to approximately $15,000 per year.

The actual cost of water for irrigation could not be calculated because water cost data could not be found. Although, the amount of water saved from the proposed plan is 29%. This will be critical as water conservation associated with irrigation becomes a serious issue.

Relationship to Labor Costs

If the 38.5 percent reduction factor for fuel use was applied to labor costs of mowing the existing campus per year, over $16,000 could be saved per year. In an effort to maintain employment for students, hours previously spent mowing could be re-directed to carbon-friendly management efforts; i.e. trimming, raking, weeding, or other prairie, wetland, or savanna management practices. There will also be an opportunity for classes, labs, and individual volunteers to play a role in the management of the campus.

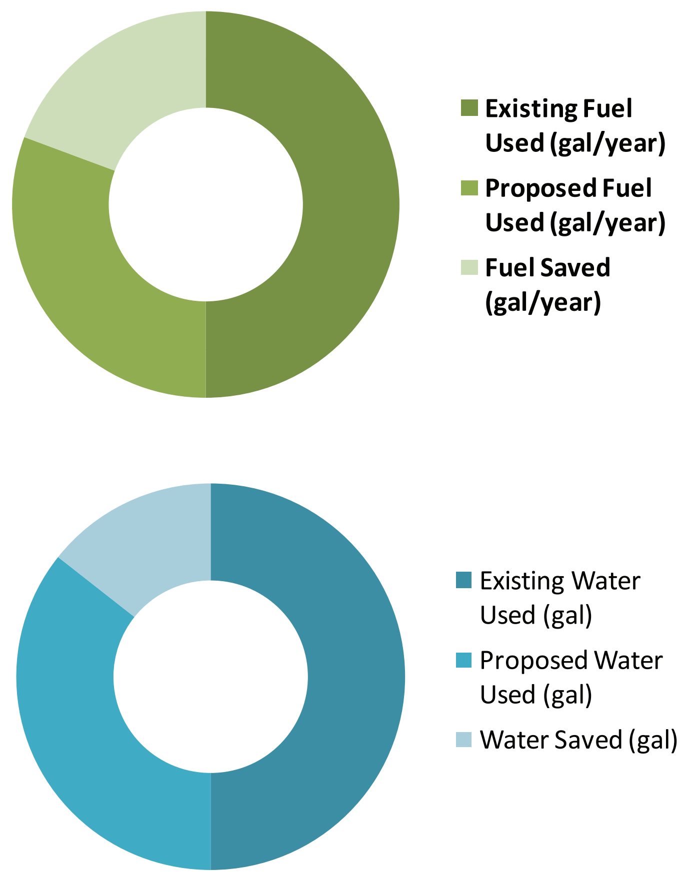


Figure 67: Fuel and Irrigation Savings

Phasing Benefits

Approaching prairie restoration on campus in phases would allow the cost savings from fuel use reductions to absorb the cost of implementation. The graph opposite shows savings through three phases, where each greenway is developed in a phase. Under this three phase scenario the costs of restoration would be recovered within 10 years. Reductions in fuel costs alone have the capacity to make up for the cost of restoring prairie in all three greenways proposed.

These costs are based off of restoration per acre. These costs also vary depending on the diversity and size of the plant materials used for the restoration. For a complete table of costs for each greenway and the actual costs used for this , refer to page 73 in the appendix.

Cost of Implementation:

- Tallgrass Loop [Phase One]: $26,625 - $183,180
- Campus Creek Greenway [Phase Two]: $61,375 - $422,260
- Woodland Area [Phase Three]: $57,250 - $393,880

Savings from Fuel Use Reduction

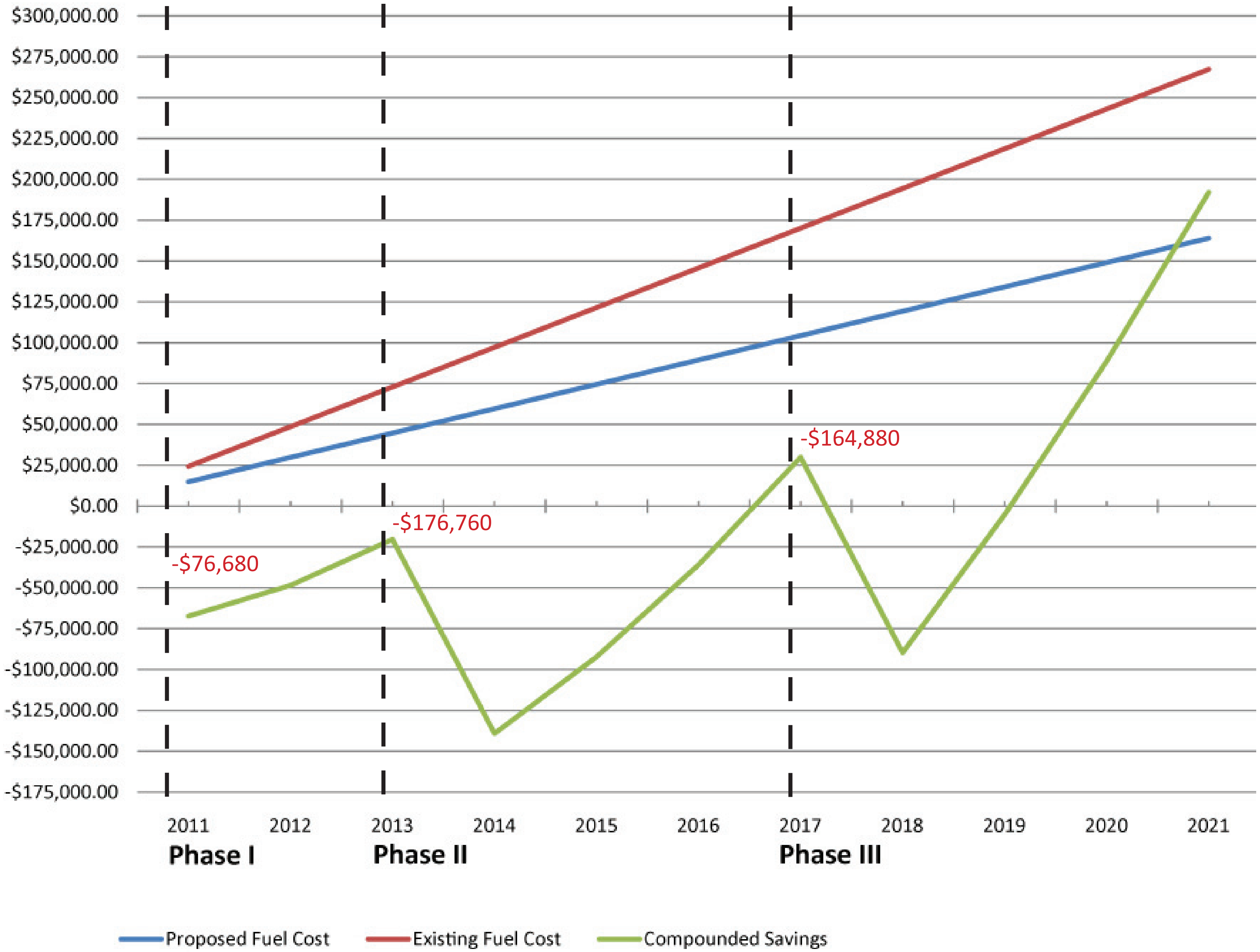


Figure 68: Compounded Savings Chart

Conclusion

Project Review

Carbon as a greenhouse gas is an undesirable element to be releasing into the atmosphere in large quantities. The vegetated parts of college campuses are a realm where carbon is both emitted and sequestered. Reducing emissions related to softscape management is one means that a university can use to reduce the carbon released into the atmosphere. Another way is to increase sequestration of carbon into the ground by increasing the amount of biomass that grows, dies, and decomposes on the surface. This project proposes both carbon emission reductions as well as increased carbon sequestration.

This report proposes that within carbon-friendly spaces, human discovery and experience will spread awareness of carbon related issues, giving Kansas State University a degree of equanimity in the field of "sustainable" higher education. It is recognized that many rich research, teaching, learning, and outreach opportunities related to this project could benefit the university.

The opportunities noted in this report only scratch the surface or open the door to deeper, more meaningful connections between the university and its landscape. It is important for the university to recognize that existing programs at Konza Prairie could help drive the student and volunteer training required to implement and maintain carbon-friendly landscapes on campus. In addition, if university stakeholders, such as alumni, faculty, and administrators were involved in a volunteer program associated with carbon-friendly landscapes, there is a good chance that they would better appreciate a carbon-friendly landscape aesthetic.

Assuming KSU was carbon positive (sequestering more carbon than emitting) there would be potential to sell carbon credits through a Cap and Trade Market. Inclusion of all carbon-friendly KSU property would be advisable, especially abundant pasture lands.

Seeking to develop a plan to make campuses more carbon-friendly is fraught with many challenges. These challenges are addressed in the following paragraphs.

Further Needed Research

Expand Campus Management Records and Databases

Developing more accurate assessments of carbon flux on campus necessitates the expansion of record keeping by Campus Grounds, Facilities, and other departments that oversee significant emission of carbon. Records relating to combustion engine use, such as mowing times, frequencies, and locations would enable more precise measurements of carbon emission in the landscape. These records would also have to include the carbon emitted from trucks and other vehicles that are used to transport mowers and other landscape maintenance equipment.

Figure 69: KSU ISC Rain Garden Volunteers

Further Needed Research

Expand KSU Campus Tree Database

Because large sections of campus were not included in the tree database, this database is less useful when determining the amount of carbon sequestered by campus trees. In order for the database to be used to measure carbon for the entire campus it would need to be expanded to cover the whole campus. In addition the university should further develop the tree database to include attributes that relate to carbon sequestration rates, particularly tree canopy width and caliper. This database could also be used by the Grounds Department to track tree maintenance and combustion engine use for trimming.

Other woody plant materials, like shrubs, sequester carbon as well. Creating additions to the database for shrubs would enable a more accurate measurement of carbon associated with woody plants on campus.

Expand Carbon Sequestration Research to Multiple Urban Vegetation Types

In this project grass and trees were the types of vegetation that carbon sequestration rates were measured from. Although trees and grass make up most of the campus vegetation, if a more accurate measurement were to be made, other vegetation types would need to be included. Carbon sequestration rates for these additional plants need to be researched and compared to prairie-like conditions.

- Perennial Gardens
- Annual Gardens
- Ground Covers
- Tree Species

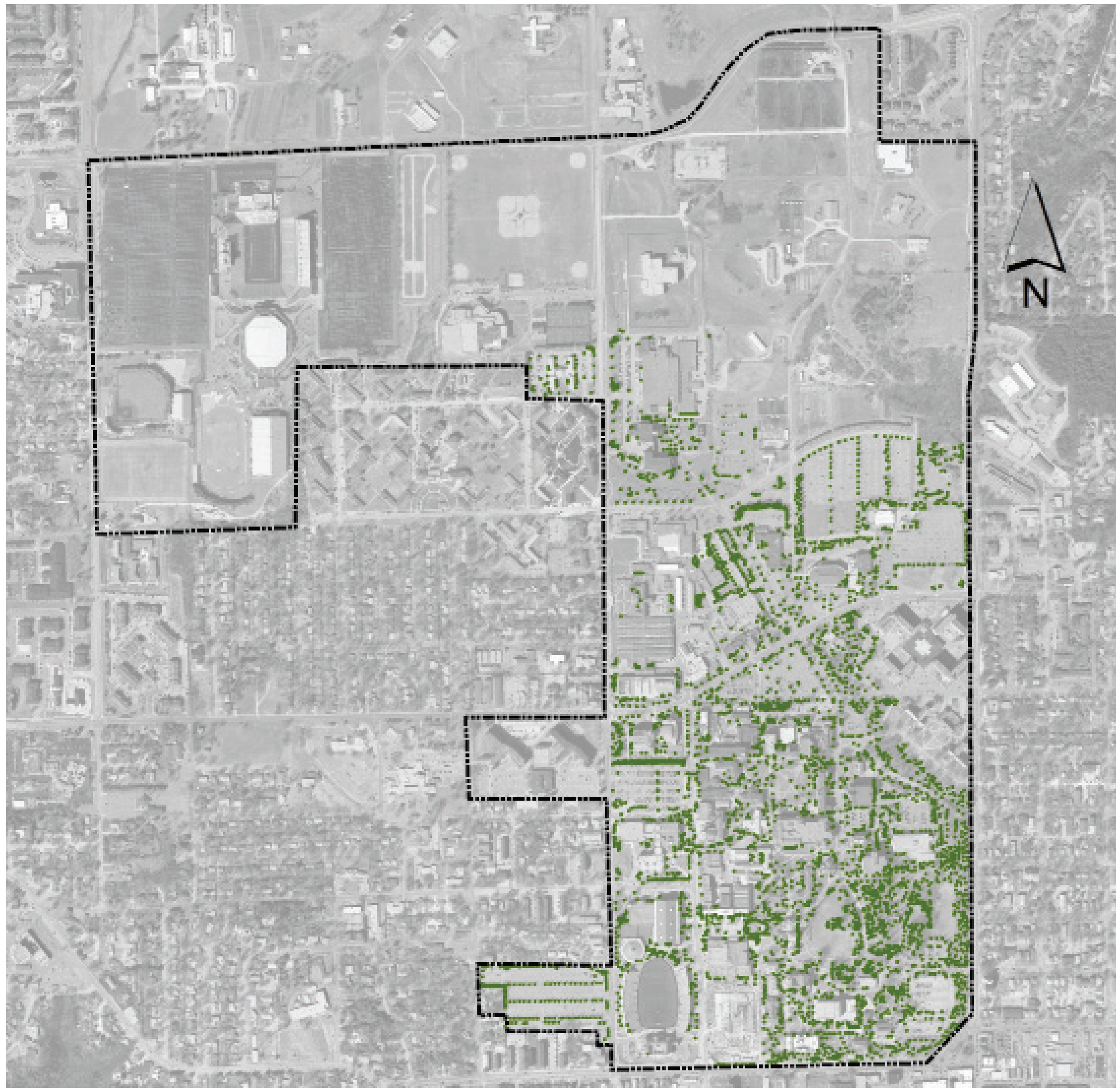


Figure 70: KSU Tree Database

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Glossary

Biomass - The total amount of living material in a given habitat, population, or sample. Specific measures of biomass are generally expressed in dry weight (after removal of all water from the sample) per unit area of land or unit volume of water.

Carbon Credit Trade Market - A global credit trading market for carbon emissions aimed at putting dollar values on carbon emissions with the goal of emission reduction.

Carbon Emissions - The carbon dioxide and carbon monoxide released by combustion engines and industry, increasing the amount of greenhouse gasses in the atmosphere.

Carbon Flux - The transfer of carbon from one carbon pool to another.

Carbon Footprint/Neutrality - The total amount of carbon dioxide, a greenhouse gas, produced from a person or organizations activities, usually expressed in tons of carbon dioxide (CO_2).

Carbon Pool - An entity with the capacity to accumulate or release carbon. Examples of carbon pools are biomass, soils, and earth's atmosphere.

Carbon Sequestration - The storage of the greenhouse gas carbon dioxide in natural sites, thus removing it from the atmosphere and reducing global warming.

Climate Change - Any change in global temperatures and precipitation over time due to natural variability and/or to human activity.

Ecological Method - A type of landscape architectural design that embraces environmental processes as the guide for design decisions.

Ecoregion - Regional areas of land that contain specific characteristics; geographically different groupings of natural systems, communities, and species.

Frameworks - Ideas, principles, or rules that provide the foundation or structure for something like a design project to be more fully developed from.

Green Complex - The network and connections of parks and green open spaces in the urban context.

Green Infrastructure - Designed, planned, and managed greenways of natural lands, functioning landscapes and spaces that are less harmful on the environment than traditional infrastructure and provide associated benefits to human populations.

Greenhouse Gas - Gases in earth's atmosphere that absorb and emit radiation from the sun. This process is the fundamental cause of the greenhouse effect. The main greenhouse gases in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Impervious Surface - The human made pavements and buildings that prevent infiltration of precipitation.

Infrastructural Landscape - Urban landscapes that function as ecological vessels and pathways serving the community with hydrologic, atmospheric, and other dynamic environmental processes important to the health and welfare of urban populations.

Infrastructure - The basic utilities, enterprises, installations, and services essential for the development, operation, and growth of a city, state, or country.

Landscape - Urban environment in which nature is predominant. The landscape is made up of both softscape and hardscape.

Landscape Aesthetic - The appreciation of a landscapes visual appearance.

Morphology - The form and structure of an organism regarded as a whole- when referring to cities meaning the understanding of the grown and development of the city-form.

Natural Environment - Land minimally impacted by human impacts and development.

Nature - A softly undulating pastoral scene, generally considered virtuous, benevolent, and soothing; forces and elements that are seen as an antidote to the corrosive environmental and social qualities of the modern city.

Net Carbon - The sum or balance of the values associated with the carbon flux of an area or entity. It accounts for outputs (emission) and inputs (sequestration). Net carbon differs from Carbon Footprint because it may only include a portion of the overall carbon related to a specific tree, entity, or softscape area.

Open Space - That portion of the landscape which has not been built over and which is sought to be reserved in its natural state or for agricultural or outdoor recreational use.

Pollution - The fouling of the air, water, or soil, by the introduction of injurious or corrupting elements.

Precedent - An example of an established or complete result or practice within a doctrine of study or work.

Project Programming - The research and decision-making process that identifies the scope of the project, and the elements to be designed.

Softscape - The vegetation elements in the landscape, as opposed to the hardscape, which is made up of stone, concrete and other “hard” elements.

Softscape Management - The landscape management practices associated with the types of vegetation in a softscape area, such as mowing, fertilization, and irrigation.

Stormwater BMPs - A technique, process, activity, or structure used to reduce the pollutant content of a stormwater discharge.

Stormwater Infiltration - The process of stormwater runoff soaking into the ground.

Stormwater Management - The management of stormwater runoff, often using water retention facilities, to reduce runoff and/or provide controlled release into receiving streams.

The Greenhouse Effect - A phenomenon that occurs in the earth’s atmosphere in the presence of greenhouse gasses that allow incoming sunlight to enter the atmosphere. But, when the heat is radiate back from the earth’s surface it is absorbed by the greenhouse gases.

Typology - A series of groups and subgroups categorized according to their qualitative, quantitative, functional attributes.

Appendix

A. Softscape Typology Values

Note: Some of these values are graphically represented on page 75 and 76.

These values were derived from research identified by the author in the Project Frameworks section of this report.

Values reflect the existing management practices on campus at Kansas State University.

	Carbon Emitted (t/ac/yr)	Carbon Sequestered (t/ac/yr)	Net Carbon (t/ac/yr)	Fuel Used (gal/ac/yr)	Water Used from Traditional Irrigation (gal/ac/yr)	Water Used from Smart Irrigation (gal/ac/yr)
Tree w/ No Ground Cover	0.000	1.480	1.480	0.000	0.000	0.000
Tree w/ Mowed x2, Fertlized, and Irrigated Grass	0.564	3.980	3.416	54.100	48.600	11.400
Tree w/ Mowed and Irrigated Grass	0.300	3.980	3.680	29.800	48.600	11.400
Tree w/ Mowed Grass	0.300	3.310	3.010	29.800	0.000	0.000
Tree w/ Restored Prairie	0.000	3.310	3.310	0.024	0.000	0.000
Mowed x2, Fertlized, and Irrigated Grass	0.564	2.500	1.936	54.100	48.600	11.400
Mowed and Irrigated Grass	0.300	2.500	2.200	29.800	48.600	11.400
Mowed Grass	0.300	1.830	1.530	29.800	0.000	0.000
Restored Prairie	0.000	1.830	1.830	0.024	0.000	0.000

B. Softscape Typology Values

Note: This chart illustrates the process of determining softscape suitability of campus districts.

Campus Softscape District	Softscape Suitability for Low Maintenance Vegetation **Low Maintenance Vegetation Changes May Include**: Changing turf to tall grass, Planting a denser coverage of trees, Planting native or low maintenance woody and herbatious plant materials, Installing raingarden/storm water bmp vegetation.	Prairie Vegetation Suitability Value: This value represents the softscape suitability for low maintenance vegetation.	Softscape Suitability for Reductions in Existing Management **Changes in Management may include:** Reduced Mowing, Reduced Fertilization, Reduced Irrigation, No Mowing, No Fertilization, No Irrigation.	Reduced Management Suitability Value: This value represents the suitability of the softscape space for reduced management.	Combined Suitability Value: This valu represents the overall suitability of the space fo both reduced manageme and low maintenance vegetation.
	High: No constraints for change in vegetation or management. **Medium:** Minor constraints influencing suitability to change vegetation or management. **Low:** Significant constraints for change in vegetation and management.	High=3 Medium=2 Low=1	**High:** No constraints for change in vegetation or management. **Medium:** Minor constraints influencing suitability to change vegetation or management. **Low:** Significant constraints for change in vegetation and management.	High=3 Medium=2 Low=1	This value is the sum of t Prairie Vegetation Suitability Value and the Reduced Management Value.
Quads	**Medium**: Open lawn areas used as gathering space should not see significant change.	2	**Medium**: Reduced management could take place as not to significantly change overall aesthetic appearance and function.	2	4
Presidents Resident Area	**Low**: Visibility screening with vegetation is evedent in this district. Maintaining this screen would not allow significant changes in vegetation.	1	**Medium**: Reduced management could take place as not to significantly change overall aesthetic appearance and function.	2	3
Presidents Field	**Medium**: Open lawn areas used as gathering space should not see significant change.	2	**Medium**: Reduced management could take place as not to significantly change overall functional quality.	2	4
Student Housing Areas	**Medium**: Open lawn areas used as gathering space should not see significant change.	2	**Medium**: Reduced management could take place as not to significantly change overall aesthetic appearance and function.	2	4
Athletics Complex	**Medium**: Large area with little programmed function. Although maintaining the existing park like aesthetic character is critical.	2	**Medium**: Reduced management could take place as not to significantly change overall aesthetic appearance and function.	2	4
Agriculture Area	**Medium**: Large vegetated areas between animal pins and roadways could be changed to low maintenance vegetation, other areas subject to varying agricultural uses.	2	**Medium**: Management of areas between animal pins and roadways could see reduced maintenance, other areas subject to varying agricultural forms of management.	2	4
Rec Fields	**Low**: Required vegetation types for functional use of the space. (Astro turf exception for intensively managed fields, i.e. Football Practice Field).	1	**Medium**: Reduced management could take place as not to significantly change overall functional quality.	2	3
Proposed Gardens	**High**: Opportunity for display areas showing the potential beauty of carbon friendly-low maintenance vegetation.	3	**High:** Irrigation reductions possible when converting turf to low maintenance veg.	2	5
Natural Areas	**High**: Opportunity for display areas showing the potential beauty of carbon friendly-low maintenance vegetation.	3	**High**: Reduced management practices in designated natural areas is significant opportunity.	3	6
Great/Anderson Lawn	**Medium**: Large area with little programmed function. Although maintaining the existing park like aesthetic character is critical.	2	**Medium**: Reduced management could take place as not to significantly change overall aesthetic appearance.	2	4
BioSecurity Area	**Medium**: Large area with little programmed function. Although maintaining level of security and existing park like aesthetic character is critical.	2	**Medium**: Reduced management could take place as not to significantly change overall functional quality.	2	4
Secondary Softscape: Gateways, Circulation Corridors, Building Approaches, Building Frontage, Parking Islands, and Other Interstitial Space	**Medium**: Small to Large areas with little programmed function. Although, these spaces may serve other function. Maintaining level of security and existing park like aesthetic character is critical.	2	**High**: Reduced management should take place as not to significantly change overall functional quality.	3	5

C. Prairie Restoration Costs Per Acre

Diversity	Level Description	0-1 acres	1-3 acres	3-10 acres	10+ acres	Woodland Area Acres	Woodland Installation Cost	Campus Creek Greenway Acres	Campus Creek Greenway Installation Cost	Tallgrass Loop Acres	Tallgrass Loop Installation Cost
1	4-7 native grass species seeded. No wildflowers seeded or planted.	$3,100	$2,400	$2,100	$1,250	45.8	$57,250	49.1	$61,375	21.3	$26,625
2	4-7 grass and 4-6 wildflower (1 lb/acre) species seeded.	$3,400	$2,700	$2,400	$1,550	45.8	$70,990	49.1	$76,105	21.3	$33,015
3	4-7 grass and 8-15 wildflower (1.5 lb/acre) species seeded.	$3,600	$2,900	$2,600	$1,750	45.8	$80,150	49.1	$85,925	21.3	$37,275
4	5-8 grass and 10-20 wildflower (2 lbs/acre) species seeded. 500 seedlings planted/acre. (10-15 added species.)	$4,700	$4,000	$3,700	$2,800	45.8	$128,240	49.1	$137,480	21.3	$59,640
5	5-8 grass and 10-20 wildflower (2 lbs/acre) species seeded. 1000 seedlings planted/acre. (15-20 added species.)	$5,500	$4,800	$4,400	$3,600	45.8	$164,880	49.1	$176,760	21.3	$76,680
6	5-8 grass and 10-25 wildflower (2.5 lbs/acre) species seeded. 1500 seedlings planted/acre. (20-25 added species.)	$6,500	$5,800	$5,300	$5,050	45.8	$231,290	49.1	$247,955	21.3	$107,565
7	5-8 grass and 12-25 wildflower (3 lbs/acre) species seeded. 2000 seedlings planted/acre. (20-30 added species.)	$7,400	$6,700	$6,150	$5,800	45.8	$265,640	49.1	$284,780	21.3	$123,540
8	5-8 grass and 12-25 wildflower (3.5 lbs/acre) species seeded. 2500 seedlings planted/acre. (20-30 added species.)	$8,450	$7,800	$7,150	$6,800	45.8	$311,440	49.1	$333,880	21.3	$144,840
9	5-8 grass and 12-25 wildflower (4 lbs/acre) species seeded. 3000 seedlings planted/acre. (25-35 added species.)	$9,400	$8,700	$8,050	$7,700	45.8	$352,660	49.1	$378,070	21.3	$164,010
10	5-8 grass and 12-25 wildflower (4 lbs/acre) species seeded. 3500 seedlings planted/acre. (30-45 added species.)	$10,300	$9,600	$8,950	$8,600	45.8	$393,880	49.1	$422,260	21.3	$183,180

Note: Cells that are highlighted green are the costs selected for this plan.

These values were derived from a report by the Portland Bureau of Environmental Services called A Sustainable Approach to Prairie Restorations: Cost Estimates for Prairie Restorations.

D. Phasing Benefit Calculations

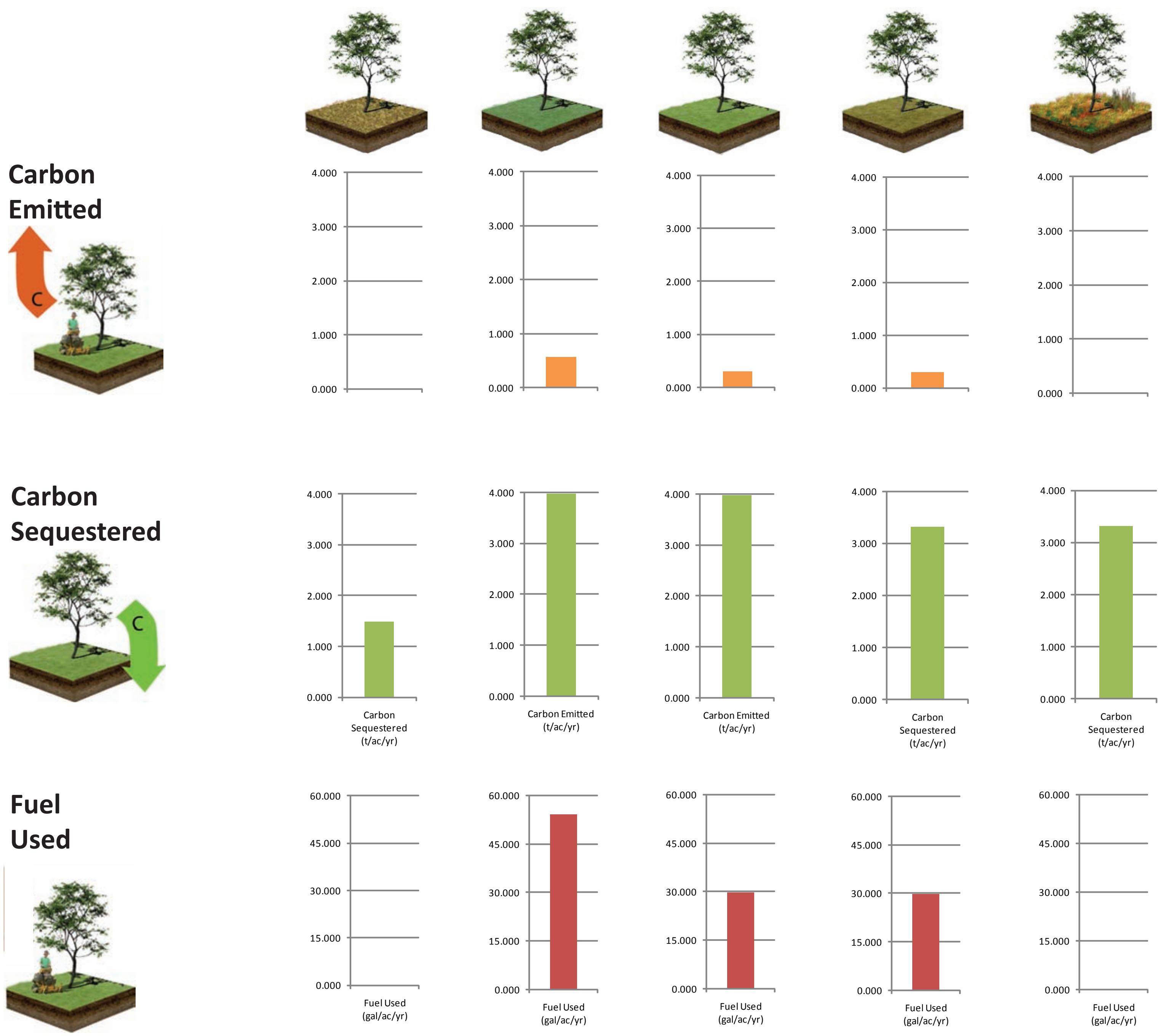
	Tall Grass Prairie Loop **Phase I**			Campus Creek Corridor **Phase II**				Woodland Recreation Area **Phase III**			
Installation Cost	$76,680.00			$176,760.00				$164,880.00			

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Proposed Fuel Cost	$14,907.00	$29,814.00	$44,721.00	$59,628.00	$74,535.00	$89,442.00	$104,349.00	$119,256.00	$134,163.00	$149,070.00	$163,977.00
Existing Fuel Cost	$24,300.00	$48,600.00	$72,900.00	$97,200.00	$121,500.00	$145,800.00	$170,100.00	$194,400.00	$218,700.00	$243,000.00	$267,300.00
Compounded Savings	-$67,287.00	-$48,501.00	-$20,322.00	-$139,188.00	-$92,223.00	-$35,865.00	$29,886.00	-$89,736.00	-$5,199.00	$88,731.00	$192,054.00

Note: The proposed fuel cost and existing fuel cost is compounded. The amount shown per year is the total from all years previous.

Ea. Campus Softscape Typologies

Tree w/ No Grass	Tree w/ Mowed x2, Fertlized, and Irrigated Grass	Tree w/ Mowed and Irrigated Grass	Tree w/ Mowed Grass	Tree w/ Restored Prairie

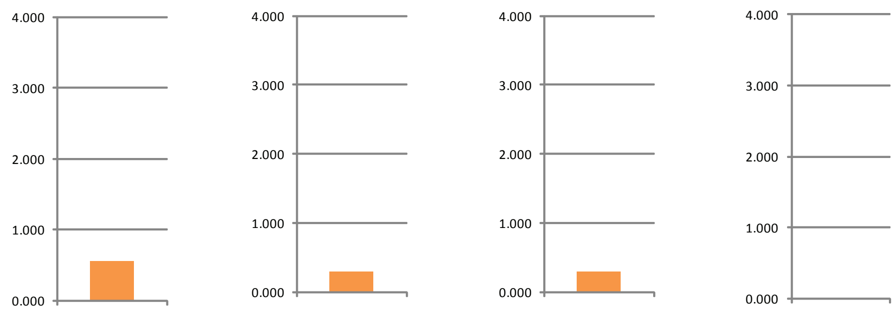


Eb. Campus Softscape Typologies

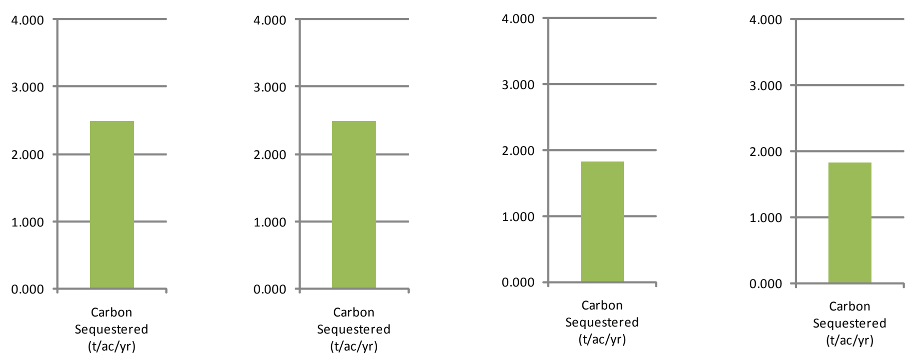
Mowed x2, Fertlized, and Irrigated Grass	Mowed and Irrigated Grass	Mowed Grass	Restored Prairie

Note: Softscape typologies that include restored prairie may involve mowing one or two times per season. This would result in a small amount of fuel use, but would not be a significant amount compared to the mowing requirements of traditional turf.

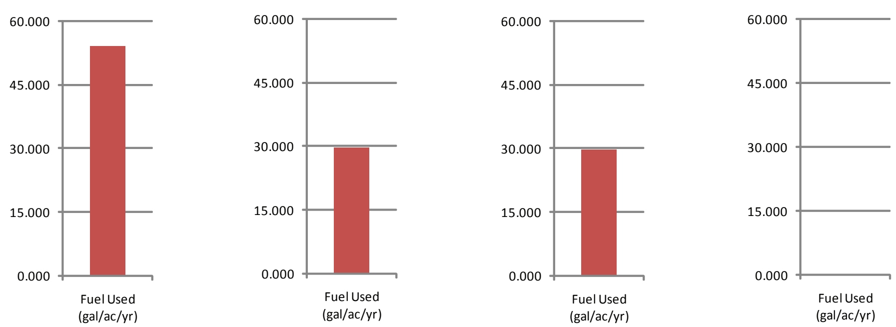
Carbon Emitted



Carbon Sequestered



Fuel Used



The Campus Carbon Convalescence:
Creating a Carbon Friendly University Landscape

A Masters Project Report by Jesse Benedick

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