Ecosystem Service Delivery by Urban Prairie Patches

Charlotte Peele, Brooke Stiffler, Linsey Swanson, Morgan Wills
NRES Capstone Research Report
Research Advisor: Dr. Trisha Moore

Kansas State University
Fall 2015

Table of Contents

Introduction

Grasslands have served as a preface for understanding the interactions between humans and the natural world. Urban development has not only fragmented the structure and function of these ecosystems, but it is the main contributor to the decline in native prairie patches. As urban development continues to expand, impermeable pavements and pollutants will interfere with the ecosystem services that can potentially be delivered to urban settings. Ecosystem services are defined as “any positive benefit that wildlife or ecosystems provide to people” (National Wildlife Federation, 2015). Urban sprawl can lead to the loss of native habitats, biodiversity, and regulating services. The objective of this paper is to examine the potential for native prairie patches within urban areas to provide ecosystem services. The pervious areas in urban developments today are typically planted with low diversity turfgrass systems, and urban prairie patches can provide greater biodiversity in vegetation. Topics regarding biodiversity include pollinator relationships, prairie biota, soil formation, as well as microbial decomposition. The nutrient cycling component of this report will include an overview of nutrient cycling potential in prairie and turfgrass systems, which aid in runoff water treatment. Water treatment is mainly performed by microbial communities within the soil through processes such as nitrification, denitrification, carbon sequestration and storage, as well as microbial-mediated sorption of heavy metal pollutants. Prairie grasses are an ideal place for microbial activity, they increase water storage due to a dense root structure and largely aggregated soils. Turfgrass patches can provide these services; however, they may yield less functionality than a native ecosystem.

Another aspect of ecosystem service delivery, which will be addressed within this report, includes the microclimate and carbon sequestration of urban prairie patches in comparison to turfgrass systems in urban environments. Urban environments can lead to an increase of greenhouse gas emissions from human activities. Case studies will be demonstrated to quantify that native systems provide greater ecosystem service delivery in relation to commercially implemented landscapes such as turfgrass. With each passing era, landscape development has progressed and transformed. The industrialization era saw the spread of industry and transformation of native landscapes into concrete. Similarly, the U.S. emergence out of WWII and into a new phase of economic stability yielded turfgrass as an iconic symbol of the “American Dream.” This report aims to address environmental stewardship. The present era must confront the fact that former procedures and protocols used to develop urban communities are no longer sustainable.

Furthermore, an unprecedented accumulation of carbon dioxide (CO_2) in the atmosphere, water scarcity, and exponential population growth reiterate the need for political and environmental reform. The fragmentation of naturally-functioning ecosystems results in a net loss of ecosystem services, including biodiversity, regulating services, and carbon sequestration. With the promotion of cultural benefits, urban prairie patches can serve as a way to promote an individual’s unique ideological, social, physiological, and sociocultural norm to conform to the aesthetics of a more natural system. The interpretation of what is or is not aesthetically pleasing, as well as the individual’s knowledge and educational awareness can allow for this transition to more sustainable land-use practices. Both restoration and management practices will play a key role in promoting prairie conservation in North America. Understanding the value of ecosystem services provided by grasslands prairie can play a vital role in understanding the ecological and conservation implications that entail for these declining ecosystems. This report will examine and supply significant information to quantify that urban prairie patches can deliver and sustain ecosystem services.

Promoting Ecosystem Services through Conservation

Prairie conservation will play a vital role in the promotion of ecosystem services. The decline and fragmentation of grasslands results in the need to address future landscaping agendas, create environmental initiatives, and design sustainable urban communities.

Native Landscaping Agenda

Native plants are promising candidates for urban environments, because they are hardy and have adapted to the local conditions along with that comes less maintenance as well as providing excellent choices for large land areas, (Pooya, Tehranifar, Shoor, Selahvazi, Ansari, 2013). A mixture of low-growing native grasses can act as a native turf mixture and turf breeders are searching to develop these grasses so they can grow in a wide range of climate types, soils and harsh environmental conditions, (Pooya, Tehranifar, Shoor, Selahvazi, Ansari, 2013). Low-growth native grasses are thought to be comparable aesthetically to commercial turf-grass systems because of their low growth giving them the look of a polished commercial turf-grass system, (Pooya, Tehranifar, Shoor, Selahvazi, Ansari, 2013). A mixture of native grasses can provide complementary benefits to one another to support each other's functions because of different growth patterns. There is strong evidence for long lifespans of prairie grasses, seasonal temperature and precipitation play a major role in their growth rates and some positive and negative growth rates in individual species occur under different climate scenarios. Prairie grasses show that climate variability plays an important role in the development of their coexistence. Native prairie grasses could take the place of commercial turf-grass systems because they demonstrate that they can recover from environmental variability and they require low maintenance, (Adler, Hillerislambers, Kyriakidis, Guan, Levine, 2006). Many types of native landscaping do not require the usage of combustion equipment, allowing owners to be more in tune with their landscape and decreasing greenhouse gas emissions. It is actually not necessary to mow native lawns unless they are interfering with neighboring lawns, and reducing mowing allows for native landscape to become more diverse resulting in more ecosystem services, (Smith, Fellowes, 2015). Native landscaping can be the environmentally friendly equivalent to commercial turf-grass systems.

Ecological and Conservation Implications

In "Rapid decline of a Grassland System and Its Ecological and Conservation Implications," Gerardo Ceballos recognizes the deteriorating state of grasslands, particularly drawing focus to the prairie grasses in the Janos region of northwestern

Mexico. The desertification of land, loss of vital populations of native plants and/or species, and land conversion have drawn attention to the complex environmental problems as a result of these changes over time (Ceballos, 2010). The documented losses in biodiversity have happened in a short period of time and call for the commitment of humans to protect and conserve. In total, grasslands cover approximately 40% of Earth's land surfaces (Ceballos, 2010). Without conservation initiatives, the losses could impact a large portion of the world's food supply. It was noted that 20% of grasslands have not been developed or converted into cropland, which is a number that has most likely increased since the release of this article in 2010 (Ceballos, 2010). As the human population continues to grow, the services provided by prairie ecosystems will become even more essential.

Land-use change and ecosystem functioning

One of the articles included in this literature review is titled, "Influence of Shrub Encroachment on the Soil Microbial Community Composition of Remnant Hill Prairies" by Anthony Yannarell. An introduction into this article defines that "Hill prairies are remnant grasslands perched on the bluffs on major river valleys, and because their steep slopes make them unsuitable for traditional row crop agriculture, they have some of the lowest levels of anthropogenic disturbance of any prairie ecosystems in the Midwestern USA" (Yannarell, 2014). The topics brought forth in this paper mentioned the contrasts between grassy and woody environments. The changing habitats due to shrub (invasion) encroachment face changes ranging from plant composition, soil microbial decomposition, increasing C and N mineralization rates, as well as disturbance in ecosystem functioning. The significant changes in habitats, mostly correlated to the shift in the activity of microbes within the soil, characterize the detrimental effects of species invasion (Yannarell, 2014). In the context of remnant hill prairies, one must take into account the anthropogenic effects on the water composition in river channels. Shrub encroachment has been linked to adverse changes in downstream water quality. This may be due to reduced soil microbial activity in areas that have transitioned from grassland to shrub vegetation. The microbes being affected may have a lower productivity and/or survival in soils that are altered by the human-environment. This writing helped to raise questions and increase awareness of the changes to natural remnant prairies in relation to anthropogenic change. Long-term effects could place irreversible damage to the health of the soil, grasses, and overall ecosystem functioning. This is just one of the many impacts of land-use change, and we can use this research as a means of understanding the consequences of species encroachment.

As land-use change occurs in prairie systems, resource availability is among the topics of discussion. The remnant prairie study helps to address "trade-offs" among ecosystem functions. As the water quality is altered, this can cause a change in the structure and resource availability provided by the soil. This translates to species encroachment and/or species decline, thus impacting long-term production potential due to compromised growing pressures (Laliberte, 2012). These limitations could thus be related to soil microbial community composition, for the decomposition rates will vary amongst grasslands and forests (Yannarell, 2014). Invasive species can greatly challenge the relationships of plant-microbe interactions, as well as all aspects of ecosystem functioning.

Prairie Conservation in North America

Of the many ecosystems in the world, the prairie is always one that is discussed in the streamline of environmental protection and conservation. In North America, most of our food production has been placed in the vegetative providence of the Midwest region due to the value of our soil. On the other hand, the prairie continues to be faced with rapid declines and extinction of species. As a society, our national economic well-being is highly dependent upon grasses, for the grasses have altered the food system and human population as a whole (Samson, 1994). One could infer that maintaining a large diversity of grasses in prairie ecosystems in important, for it can reduce the stress on particular species and promote microbial processes. Restoration of such ecosystems would take centuries to recover if they were to be lost. Many of the plant species native to the prairie require longer periods of time to germinate and grow.

The prairie assumes the role of providing habitats for breeding and wintering of birds, movement of reptiles and mammals from the east to the west, as well as facilitating nutrient cycling and soil formation. The loss of these ecosystem services can pose a serious environmental threat from an ecological perspective. Incorporating long-term solutions to prairie conservation and implementation can aid in the continuation of local and regional habitat formation, for the many plants and animals relying on the grasslands (Samson, 1994). An astonishing estimate that was made in 1994 stated that 60% of Great Plains prairies have been lost to small towns and increasing populations (Samson, 1994) It is reasonable to conclude that this number has certainly changed over the time span of the last twenty years. A shift to more sustainable community planning can help to conserve this valuable ecosystem and the many services that it provides to mankind.

The Role of Prairie Grasses for Urban Settings

Prairie grasses assume the role of facilitating biodiversity. This includes, but is not limited to pollinator interactions, native biota, soil formation, and microbial decomposition. The biodiversity within an ecosystem creates the foundation for nutrient cycling and can be used to address local environmental health.

<u>Biodiversity</u>

Defining Biodiversity and Ecosystem Services

Grasslands are important terrestrial ecosystems that are dominated by native prairie grasses, and they encompass an array of plants ranging from trees or shrubs, to herbaceous vegetation. The fertile soil, microbial decomposition, pollinator interactions, and abundance of biological diversity are key ecosystem services provided by grasslands. The literature reviewed in this report provides an analysis of grassland biodiversity in efforts to identify potential ecosystem services yielded as a byproduct of natural ecosystem functioning. Biodiversity can be defined as “the variability among living organisms including genetic, species, functional group, and ecosystem diversity." An ecosystem service is defined as a benefit that is yielded to society as a consequence of ecosystem functioning (Wall, 2004). Ecosystem functioning is "the activity of an ecosystem process." The quantitative research outlined in this review should provide linkages to the abundance of ecosystem services naturally supplied to sustain human health and well-being.

Pollinator relationships

Pollination is a process that has evolved over the past 225 million years, although insects such as butterflies, bees, and moths first appeared in this co-evolutionary process 28 million years ago. Pollination occurs as the pollinator seeks out pollen or nectar from different plant species. The primary pollinators in a prairie ecosystem "include pollinators such as beetles, butterflies, moths, bugs, flies, and leafhoppers" (Risser, 1981). Greater plant diversity displayed in a landscape can have an impact on the various types of pollinators that an ecosystem may attract. In some scenarios, micro-environments are needed for successful pollination, such as a relationship between the plant communities and/or the conditions of the ground in order for butterflies to perform ovipositon (Runas, 2010). A butterfly is typically dependent upon a specific habitat, thus management strategies would need to be devised in urban prairie patches for optimal butterfly diversity.

There was a study conducted in 2014, throughout the summer and into the early fall, to assess the composition of bees in a restored prairie located in Illinois. Bees were collected via traps, pan traps, malaise traps, and vane traps to compile a diverse and abundant sample of bees from this given site. Some of the treatments used in this field experiment included elevation, trap types, and location. The methods behind conducting this experiment proved successful, for there was a total of 4,622 bees representing genera from 31 different backgrounds and 111 different kinds of species (Geroff, 2014). The correlation between the tallgrass prairie and bees is an important subject of interest within the research of biodiversity in natural ecosystems. One can acknowledge the decrease in overall colonies locally and globally, due to CCD (Colony Collapse Disorder). The projections of such diversity found just within this particular restored prairie can serve as a benchmark for potential ecosystem services, in terms of having a greater abundance of pollinators. Pollination, as an ecologist would know, is essential in the overall ecological functioning for any ecosystem. The loss of such pollinator interaction can pose a great threat to the plants, people, and the planet. In urban settings, prairie patches could potentially serve as a refuge for native bees. Their presence in urban settings could lead to a greater cultural awareness of their beneficial nature, which is crucial to ecosystem functioning.

Biota of the true prairie

Nestled right outside of Manhattan, Kansas, the Konza Tallgrass Prairie claims home to over 200 bird species, 27 mammals, 25 reptiles, and perhaps over 3000 species of insects. This comes to show the variety of biodiversity that could be brought into our urban ecosystem setting (Rowe 2013). On the other hand, it is among the most endangered in North America due to a significant alteration in habitats and species. Habitat losses can be attributed to European settlement within the Americas, for many of the regions have been converted for agricultural uses. This conversion is has greatly impacted grasses in the tallgrass (Figure 2), such as bluestem and eastern mixed-grass, and bluestem-grana (Sieg, 1999). This "loss and fragmentation of grasslands is causing the extinction of uncounted populations and species, changes in the structure and function of ecosystems, depletion of environmental services, and decline in human well-being (Ceballos, 2010). Prairie dogs are among one of the notable species that has been greatly affected by changes to the environment. They have an important role on the transformation processes in grasslands, for they burrow and create habitats for a variety of other animals and predators. Their presence in the ecosystem exhibits unique functioning, for they contribute to species richness and composition (Ceballos, 2010). The nature of invertebrate species ranges with size, morphological characteristics, life cycles, and function. In this ecosystem, invertebrates provide the foundation for nutrient cycling and heterogeneity amongst habitats (Samson, 1996). The biota can be used to address local environmental health, and perhaps aid in the transition to increasing development of suitable habitats to facilitate biodiversity.

Soil Formation, Characteristics, and Benefits

When assessing prairie grasses, half of the biodiversity located within this biomass is beneath the ground. The formation of soil is a complex and slow process that requires the inputs of both physical and biological factors. The soil order that is typically found in a prairie-grass ecosystem is primary a Mollisol, with suborders such as Udolls and Ustolls. This profile is comprised of nutrients necessary for the growth of grasses, as well as other plant species native to this eco-region (Risser, 1981). The A-horizon measures 20-40 cm thick, and the B-horizon is usually 30-60 cm thick. The influence of abiotic factors, such as temperature and moisture, enhance the ability of decomposition and weathering, thus directly impact the process of soil formation (Risser, 1981). There are many ecosystem services that are yielded as a result of this rich soil (see Table 1), and many of these services are critical for successful ecosystem functioning.

Table 1: Ecosystem services provided prairie patches
Regulation of major biogeochemical cycles
Invertebrates provide the foundation for nutrient cycling
Regulation of plant and animal populations
Retention and delivery of nutrients to plants
Generation and renewal of soil and sediment structure and soil fertility
Provision of clean drinking water
Modification of the hydrological cycle
Regulation of atmospheric trace gases
Modification of anthropogenic driven global change (e.g. carbon-sequestration,)
Efficient cooling to environments yielded by native tree
Provides cultural well-being
Contribution to landscape sustainability and stability
Aesthetics of a more natural habitat
Promotion of education and awareness
Table derived from: (Wall 2004)

Prairie patches have been used for a wide variety of research studies related to experiments in biodiversity and ecosystem functioning. The soils in these systems are what control the resource availability for the biota, and are highly dependent upon biodiversity (Laliberte, 2012). Many studies specifically highlighted the importance of species richness and evenness as driving factors in decomposition (Ceballos, 2010) & (Dickson, 2009). Habitat loss has been a concern due to the implications of a declining biodiversity. Furthermore, decomposition rates are greatly impacted by the diversity of litter species, as well as the evenness of their distribution (Dickson, 2009).

Is community persistence related to diversity?

In "Is community persistence related to diversity," a test of prairie species in a long-term experiment introduced the relationship between diverse plant communities and higher overall productivity (Huang, 2013). The research that was conducted included an analysis of biomass found within planted plots of "restorative prairie communities" versus "monoculture." The findings, as one would expect, favored towards the native plant communities. The measurements associated with this research included persistence measures, species richness, net primary productivity, and invasive species. The research helped to suggest that prairie grasses have a higher "natural" control against weedy species, as well as a higher resistance to invasion by way of dominant species. Diversity within ecosystems is a leading factor in stability, resilience, and persistence over time (Huang, 2013). It was noted that tallgrass prairie systems are amongst the most endangered ecosystems in the world, yet they are providers of exceptional biodiversity (Huang, 2013). An underlying goal within this writing was to convey a message of how the prairie grasses will provide a community with lower invasive species, thus preventing local extinctions. It was a convincing approach to inform people of the reasons behind creating a restored prairie community. The approaches to research, as well as the incorporation of cultural values, helped to successfully prove the positive relationship between diversity and productivity.

Microbial decomposition

One of the key components to fertile soils in grasslands is the high turnover rate associated with biomass (Wall, 2004). Grassland diversity can be greatly impacted by the role of soil microbes and invertebrate detritivores. The decomposition processes that are driven by these organisms impact primary productivity with an upwards of 50%. This contributes to plant growth and ecosystem functioning (Mariotte, 2014). Overall, the organisms found within grasslands determine the overall productivity and biodiversity of grasslands. As the litter is returned to the soil surface, the accumulation is eventually converted into organic matter (Risser, 1981). As organisms break down the organic matter, they are making chemical compounds available to plants that would otherwise be unavailable without this nutrient cycling (Mariotte, 2014). The biotic contributions are thus a major contribution to the ecosystem by creating nutrient pools for higher plants, as well as delivering ecosystem services that are vital in the support of human society.

Regulating services of urban prairie patches

Prairie Grass Nutrient Cycling

Quantifying regulating services of an ecosystem is a tough task and is most commonly done by measuring microbial activity in soils. When evaluating microbial activity it is essential to consider management techniques as well as "consideration of seasonal variation in temperature and precipitation" (Bach, 2015). Seasonal changes of the area must be considered because, "there is an optimum level for [temperature and moisture] at which microbial growth and activity are greatest, and above or below which growth and activity decline" (Yao, 2011). In one study conducted at Iowa State University three different ecosystems were compared based on microbial activity; no-till continuous corn, planted tallgrass prairie and fertilized tallgrass prairie. The study also varied in sampling times to account for seasonal effects on microbial activity. The goal was to determine if this situation remained true with the thought that there is "highest denitrification rates during the summer months and lowest denitrification rates in winter" (Wall, 2005). The results of the study are shown in Table 2 and Figure 1 below.

	2011			2012		
	Corn	Prairie	PrairieFert	Corn	Prairie	PrairieFert
TC (g C kg^{-1} soil)	21.92^{B*}	24.66^{AB*}	25.80^{A*}	21.95^{B*}	23.78^{AB*}	26.72^{A*}
SE	±1.69	±1.67	±1.71	±1.72	±1.72	±1.72
TN (g N kg^{-1} soil)	1.74^{B*}	1.92^{AB*}	2.01^{A*}	1.76^{B*}	1.80^{AB*}	2.01^{A*}
SE	±0.12	±0.12	±0.13	±0.12	±0.12	±0.12
TC (kg C m^{-2})	3.32	3.57	3.66	2.60	2.67	2.80
SE	±0.21	±0.21	±0.21	±0.17	±0.17	±0.17
TN (kg N m^{-2})	0.26	0.28	0.29	0.21	0.20	0.21
SE	±0.02	±0.02	±0.02	±0.01	±0.01	±0.01
CN	12.58	12.91	12.84	12.48^{B**}	13.19^{A**}	13.23^{A**}
SE	±0.15	±0.15	±0.15	±0.16	±0.16	±0.16
Extractable C (μg C g^{-1} dry soil)				26.20^{AB*}	20.68^{B*}	28.65^{A*}
SE				±2.90	±2.90	±2.77
Extractable N (μg N g^{-1} dry soil)				8.37^{A***}	4.04^{B****}	4.77^{B***}
SE				±0.57	±0.55	±0.55
Extractable C (g C m^{-2})				3.03^{AB*}	2.43^{B*}	3.14^{A*}
SE				±0.31	±0.31	±0.30
Extractable N (g N m^{-2})				0.98^{A***}	0.48^{B***}	0.52^{B***}
SE				±0.07	±0.07	±0.07

Table 2 (Bach, 2015). *Comparison of the three different ecosystem's microbial yields based on management techniques. The results are shown in amounts of total carbon and nitrogen as well as extractable carbon and nitrogen. In most instances the fertilized prairie yielded the most biological activity.*

Fertilized prairie grass ecosystems yielded the highest amounts of microbial activity, in other terms, regulating services. This was due to the greater amount of nutrients available to the microbial communities. More studies need to be conducted to determine if the nutrient rich stormwater runoff present in urban systems can act as a fertilizer and help yield higher microbial activity in urban prairie patches. There was high variability between the management systems on each seasonal testing date, which is likely due to seasonal fluctuation in precipitation. This study provides evidence that prairie ecosystems "show promise for harnessing microbial communities to meet ecological goals of C storage and N retention" (Bach, 2015).

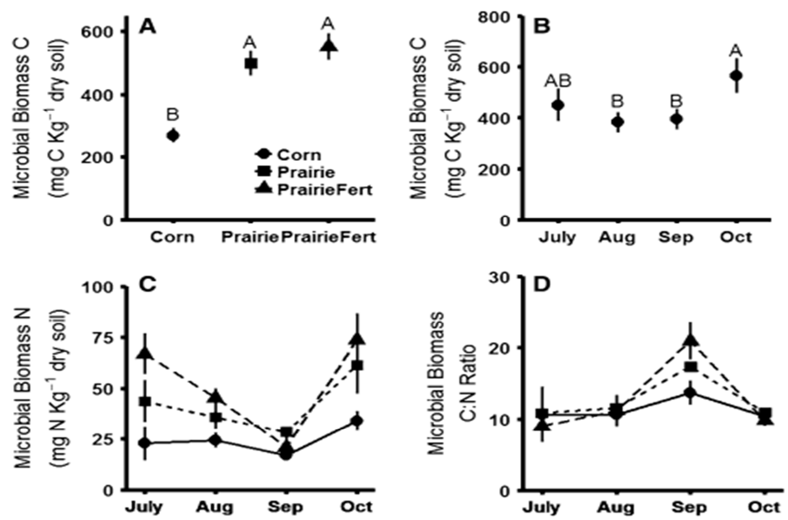


Figure 1 (Bach, 2015). *Graph A shows the differences in microbial biomass carbon depending on management strategy. Graph B shows the variation of microbial biomass carbon depending on sampling date. Graph C shows the changes in microbial biomass nitrogen depending on both management and sampling date. Graph D shows the changes in carbon to nitrogen ratio based on sampling date and management strategy.*

Turfgrass Nutrient Cycling

When evaluating turfgrass ecosystems, it is important to consider that "soil microbial biomass, activity and N transformations could be affected by a number of factors associates with the age of a turfgrass system" (Shi, 2006). Long-term intense management, fertilizer application and soil compaction are a few factors that turfgrass ecosystems may undergo. A study in North Carolina sampled four golf course turfgrass systems and compared their microbial activity to that of native pine tree areas in close proximity. The four golf courses were 95-, 23-, 6- and 1-years-old. The sites were planted with hybrid Bermuda-grass, which is typically found in urban areas. The results of the study are shown in Table 3 and Figure 2 below.

	Soil C (mg C or N g^{-1} soil)	Soil N (mg C or N g^{-1} soil)	Soil C-to-N	NH_4^+–N (μg N g^{-1} soil)	NO_3^-–N (μg N g^{-1} soil)	pH
0–5 cm depth						
Native pines	26.2c	0.9d	28.9a	1.5a	0.0d	4.7c
1-yr turf	9.5d	0.6d	15.2b	0.2a	8.1c	6.4ab
6-yr turf	30.4bc	2.3c	13.4bc	0.1a	25.6b	6.4a
23-yr turf	38.4b	3.1b	12.6bc	0.2a	24.9b	6.4a
95-yr turf	72.5a	7.0a	10.4c	0.9a	50.8a	6.1b
5–15 cm depth						
Native pines	9.5b	0.4bc	26.7a	0.5a	0.2d	5.0d
1-yr turf	2.3c	0.2d	11.3bc	0.2a	1.2cd	5.6c
6-yr turf	2.8c	0.3cd	9.2c	0.0a	2.4c	6.3a
23-yr turf	8.2b	0.5b	18.1b	0.0a	4.6b	6.2a
95-yr turf	13.3a	1.1a	12.3bc	0.0a	6.8a	5.9b

Table 3 (Shi, 2006). *Selected soil properties of each study site at two different depths. In most categories, the 95-yr turf contained the most evidence for the highest amount of microbial activity. This could be due to the microbial communities' better ability to cope with changes, because they have had long exposure time to the changes.*

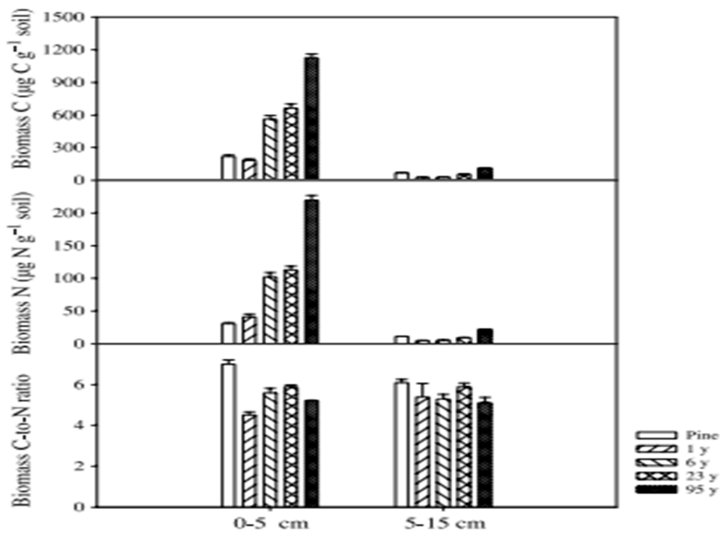


Figure 2 (Shi, 2006). *Differences in biomass C and N depending on age of the turfgrass. The 95-yr again yields the highest evidence of microbial activity. C:N ratios are all closely related while biomass amounts vary greatly. The 95-yr old system if significantly older than the other areas, which again, has given the systems much more time to adjust to external factors.*

The high levels of microbial activity in the turfgrass systems in this study show that although there is "widespread public concern that turfgrass systems are environmentally problematic due to use of fertilizers, pesticides, and irrigation" (Shi, 2006), there are benefits to using turfgrass systems. This study proved "the addition of fertilizer […] accelerates the subsequent restoration of the soil ecosystem in terms of re-establishing pre-impact N cycling and microbial diversity" (Sublette, 2007). In terms of regulating services, turfgrass systems provide a significant amount nutrient cycling and nitrogen and carbon harnessing. The older the system, the better ability its microbial communities have to adjust to management practices and varying inputs of nutrients.

Prairie Grass vs. Turfgrass

The following two data manipulations were conducted to try to make a direct comparison of the two studies previously discussed in this literature review. The samples from the prairie grass study were taken from planting areas that were 3.5-years-old, so an average of the 1-year-old and 6-year-old turfgrass system were calculated. An average of the seasonal samples of microbial biomass N was taken for the prairie grass results, because there was no average data given over the entire growing season. Both unfertilized and fertilized prairie grasses were included to show the difference that excess nutrients inputs, like the nutrients present in urban stormwater, play on the amount of microbial activity. The two studies were conducted in different parts of the United States, Iowa for prairie and North Carolina for turf, but it is assumed that the climates are similar enough to be comparable. Also, it is noted that 1 µg/g is equivalent to 1 mg/kg, so no conversion needed to be made to the results. The direct comparison of their regulating services is shown in Figure 3 below.

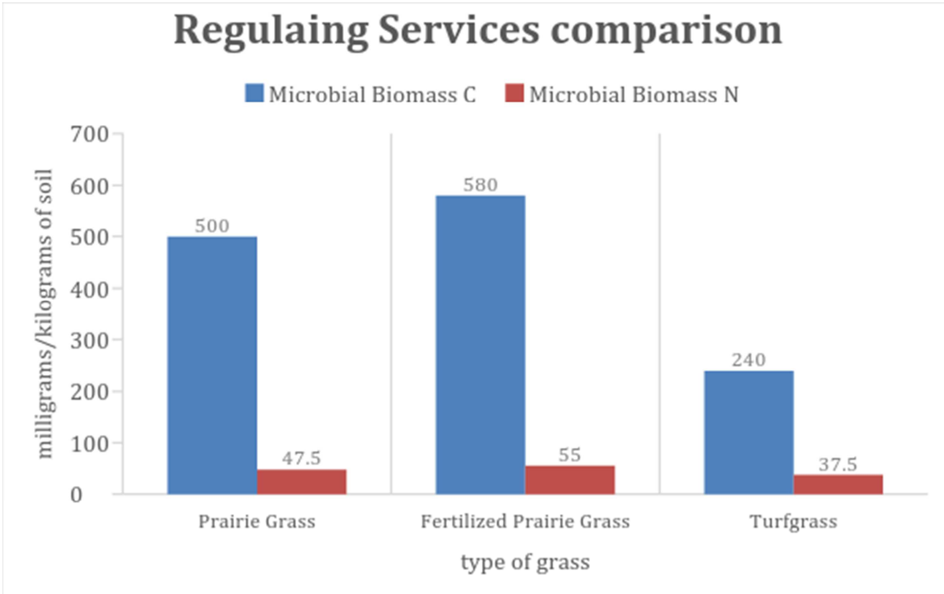


Figure 3. *Direct data comparison of prairie, fertilized prairie and turfgrass ecosystems. Fertilized prairie contains the most microbial biomass C and N, therefore provides the most regulating services and turfgrass provides the least. This gives evidence that incorporating prairie grasses instead of turfgrasses will yield more microbial benefits. (Bach, 2015) & (Shi, 2006).*

Prairie Grass Performance in an Urban Setting

Although we have quantified microbial activity of prairie grasses in a study environment, it is crucial to determine if the same benefits are achieved in the urban setting. This section reviews the use of prairie grasses directly in an urban setting. A bioretention cell is a designed urban prairie patch that consists of “a vegetated soil filter, with a planning layer overlying a porous medium and, often, an underdrain for effluent collection” (Chen, 2013). A study in Lenexa, Kansas examined a bioretention cell receiving stormwater runoff from a storm sewer. The bioretention cell contained prairie cord grass and sumpweed and functionality was measured in terms of nitrogen removal of influent stormwater. It was found that the sewer to bioretention cell treatment system produced a total 56% decrease in total nitrogen. That 56% was then broken down into two areas; storm sewer to the inlet of the cell and inlet to outlet of the cell. The results showed “the average decrease in total N between the storm sewer and the bioretention cell inlet (45%) was larger than that between the cell inlet and outlet (20%)” (Chen, 2013). It can be assumed then that a significant portion of nitrogen removal was achieved by removing particulate-associated, which occurs in the storm sewer catch basin insert.

This study helps give evidence that prairie grasses maintain their microbial functionality in an urban setting. To make this design more sustainable and achieve more regulating services, the prairie grasses dense root structure and thick vegetative cover of soil could be used as a filter of particulate matter, where the storm sewer catch basin is used in the above system. It is important to consider that in a prairie patch there may be “clogging by the combined and overlapping processes of pore occlusion by fine particles and excessive biofilm growth" (Gette-Bouvarot, 2015). Maintenance and design strategies must be applied to prevent clogging and allow for water to be infiltrated into the soil profile. Without infiltration, both the nutrient cycling and flood reduction regulating services will not be achieved.

Microbial activity is just one of the many regulating services urban prairie patches provide. With a large amount of impervious pavement in urban setting, there is more nutrient rich stormwater runoff that needs a place to be stored and treated. Urban prairie patches have a greater potential for microbial activity and a denser root structure than turfgrass, therefore have a greater chance to treat and store the runoff water. The impervious pavement in urban settings also affects the microclimate and soil carbon sequestration abilities. Prairie grasses are a way to improve the microclimate and increase carbon sequestration.

Microclimate and Soil Carbon Sequestration

It is clear that the expansion of urban sprawl can lead to the loss of native landscape areas, habitat, biodiversity and environmental connection. More importantly, urban environments can lead to an increase of greenhouse gas emissions from human activities. While turf-grass systems do bring benefits to an urban environment, when compared to native landscaping systems one can see the microclimate and carbon storage advantages. The evapotranspiration of native trees can cool an urban area more efficiently along asphalt roads while a green roof equipped with native prairie grass can recovery from harsh climatic events while effectively cooling off the microclimate within an urban heat island. Plant productivity and microbial decomposition are the primary sources of controlling soil carbon storage in ecosystems and landscaping with prairie grasses have the potential to offset rising atmospheric carbon dioxide due to the high microbial activity of a prairie landscape.

Microclimate

Microclimate is essentially the climate of a local area that is different from the surrounding area. Microclimate is very important to understand in order to know the affect it has on ecosystems. Temperature acts as a fundamental framework and since it can be measured for change this creates a concern regarding the urban heat island affect in these urban environments.

Soil carbon sequestration

The soil carbon sequestration mechanism is a vital ecosystem service. It is essentially the process in which carbon dioxide from the atmosphere is transferred into the soil as part of the carbon cycle. Grass landscapes can act as a carbon sink and in urban environments it is extremely important to have a good landscape that can sequester carbon emissions from both natural and anthropogenic sources. Understanding the root systems of native species and commercial turfgrass helps to understand the differences they pose in terms of soil carbon sequestration. With concerns regarding climate change, native landscapes do have the potential to mitigate rising carbon dioxide atmospheric concentrations.

Commercial turf-grass concerns

Commercial turf-grass systems have been referred to as “green deserts” and “industrial lawns” because of the extensive management that is needed for maintenance, (Smith, Fellowes, 2015). Urban residential and commercial lawns hold the majority of intensely managed turf-grass systems, covering an estimated 1.9% of the land in the United States and increasing at a 800,000ha annual rate, (Gu, Crane, Hornberger, Carrico, 2015). Maintenance of a typical commercial turf-grass system consists of mowing, fertilization and irrigation. Some fertilization rates of commercial turf-grass systems are close to golf courses and agronomic row crop rates, (Gu, Crane, Hornberger, Carrico, 2015). Intense turf-grass management can also result in an increase in soil emissions of greenhouse gases, such as nitrous oxide. “Nitrous oxide is a greenhouse gas with 310 times greater global warming potential than carbon dioxide on a per molecular basis over a 100-yr time frame. Rainfall or irrigation, especially right after fertilizer N applications, enhance nitrous oxide emissions, because the water inputs provide soil moisture contents essential for enhancing the nitrification and denitrification process,” (Gu, Crane, Hornberger, Carrico, 2015). It was noted that nitrous oxide emissions were larger than those of natural ecosystems, (Li, Hu, Bowman, Shi, 2013). Better management practices on commercial turf-grass systems have the potential to reduce their global warming potential and obtain better soil organic carbon sequestration, (Gu, Crane, Hornberger, Carrico, 2015). Commercial landscapes require an extensive amount of maintenance and the use of heavy combustion lawn equipment that produce significant greenhouse gas emissions.

<u>The role of native landscaping and commercial turf-grass systems</u>

Role of microclimate

Temperatures in urban environments are typically associated with higher averages as described previously regarding the urban heat island phenomenon. It is predicted that in the future this will only worsen because of an increase in greenhouse gas emissions. Urban air temperatures experience this dramatic temperature shift due to landscape changes. The surface energy and radiation balance are not in equilibrium when compared to natural or vegetated environments, the buildings and concrete absorb more solar radiation as a result cites tend to be much warmer then rural environments, (Klein, Coffman, 2015).

Townsend-Small, Czimczik, 2010.

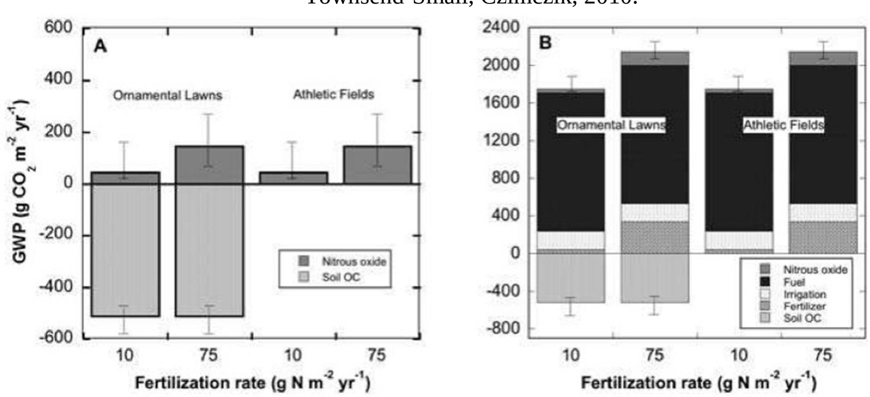
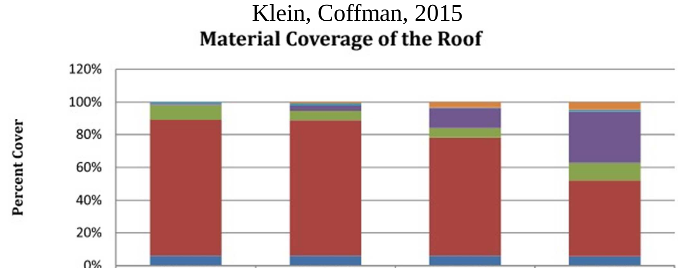


Figure 4. Global warming potential, fuel emissions, soil organic carbon sequestration and nitrous oxide emissions in commercial turfgrass systems.

One major concern for turf grass is the fertilization of the grass system as a main driver of increasing atmospheric nitrous oxide, (Townsend-Small, Czimczik, 2010). Studies have shown that commercial turf-grass systems emit nitrous oxide during or after irrigation, but nitrous oxide emission rates depend on the on the amount of fertilization applied, (Townsend-Small, Czimczik, 2010). “In managed turf-grass systems, irrigation and fertilization enhance plant productivity and organic carbon storage, but can also increase soil emissions of other greenhouse gases, including nitrous oxide,” (Townsend-Small, Czimczik, 2010). Fertilizer-derived nitrous oxide emissions can overcompensate for carbon dioxide uptake by the plants and storage in soils, which results in a positive contribution to global warming, (Townsend-Small, Czimczik, 2010). This publication states that “high organic carbon sequestration rates in some turfs are dwarfed by soil nitrous oxide emissions and carbon dioxide released during management, with a total global warming potential of -108g CO_2 m^{-2} yr^{-1} for low fertilization rates and +285 g CO_2 m^{-2} yr^{-1} for a high fertilization application rate, depending on fertilizer application rates,” (Townsend-Small, Czimczik, 2010). This has deep relations with soil organic carbon storage, but releasing excessive amounts of greenhouses have a major effect on the microclimate of an area.

Landscaping with native green roofs can help to stabilize an energy imbalance within an urban heat island and help maintain a relatively comfortable microclimate. Green roofs planted with native vegetation can act as a native landscape patch in urban areas that are densely populated. Vegetation studies were done regarding air temperature, radiation balance, relative humidity and buoyancy fluxes during April-October and the vegetation study ran for a total of 791 days in Norman, Oklahoma. Prairie grasses were the dominant choice of vegetation for these green roofs. In Norman, Oklahoma at the National Weather Center a green roof was installed. It consisted of perennial wildflowers, native and non-native grasses. The wildflowers and native grasses were placed in large trays, but each tray within the larger tray had a different native wildflower or grass and non-native grass. This was for experimental purposes. Everything was irrigated 3 times a week by hand and also by natural rainfall occurrences. For the atmospheric studies a meteorological station monitored the effects of the green roof on the surface energy balance. Sensors would collect the data. Out of the thirty-two prairie species, only eleven of them remained after month twenty-six due to both limited germination of short grass prairie seeds and the death of the sedum species.

Klein, Coffman, 2015



	Month 6	Month 15	Month 18	Month 26
Weeds	0.00%	0.84%	3.21%	4.49%
Wildflowers	0.87%	1.32%	0.30%	1.10%
Grasses	0.79%	3.24%	12.60%	31.63%
Succulents	9.25%	5.93%	5.70%	10.61%
Bare Soil	82.98%	82.66%	72.20%	46.43%
Black Plastic	6.00%	6.00%	6.00%	5.71%

Figure 5. The data is showing an increase in native grass coverage on the green roof throughout the experiment. Norman, Oklahoma.

Overall, native species exceeded the other types of grasses and herbs planted. Even with this plant mortality the air temperatures showed an obvious difference. The overall maximum and minimum temperatures over the green roof were lower than over the concrete roof. The air temperature and relative humidity were lower/higher at the green roof location; the differences were only slight not dramatic. Certain grass and wildflower types are thought to contribute to a more enhanced cooling effect.

Klein, Coffman, 2015

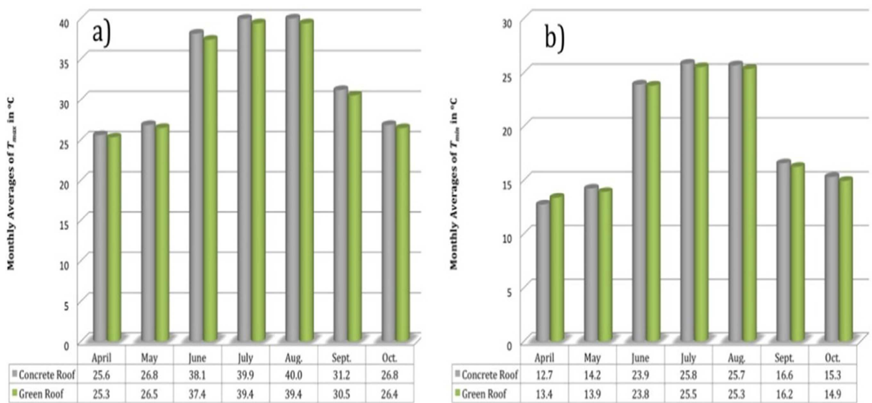


Figure 6. Comparison of the monthly daily temperature averages between the concrete and green roof scenario.

Increasing temperatures in urban environments are also in relation to asphalt streets. "Increasing urban vegetation, particularly street trees, may help alleviate higher temperatures as street trees play an important role in providing shade," (Aguiar, French, Chisholm, 2014). Although this publication is regarding the usage of native trees to offset high temperatures from urban infrastructure, the study actually uses 3 native tree species and 3 non-native tree species. This study was conducted in the metropolitan area of Wollongong, Australia. The surfaces under the native trees were dramatically lower than that of the non-native, (Aguiar, French, Chisholm, 2014). Native trees should be taken into consideration when developing urban native landscape patches. Thermal infrared readings and temperature data all read that native trees out performed the non-native tree species at cooling the surface temperature during "hot days." This is extremely important to consider regarding areas that are expecting warming due to climate change.

A.C. Aguiar et al./Urban Climate 10 (2014) 56–62

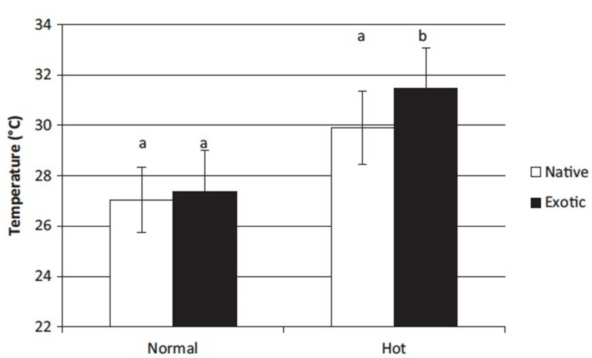


Figure 7. Temperature averages of an asphalt road surface under native and non-native trees during normal and hot days.

Aguiar, French, Chisholm, 2014.

Mean (standard deviation) of shaded and unshaded regions for both native and exotic species on hot and normal days. $n = 8$

Native/exotic	Species	Hot/normal days	Shaded	Unshaded
Native	*Melaleuca quinquenervia*	Hot	28.4 (2.7)	32.1(4.4)
		Normal	25.7 (2.3)	28.5 (2.6)
	Melia azerdarach	Hot	27.8 (1.7)	31.0 (2.7)
		Normal	25.4 (1.1)	28.0 (2.0)
	Tristaniopsis laurina	Hot	30.1 (2.7)	30.0 (3.6)
		Normal	25.1 (2.9)	28.4 (2.1)
Exotic	*Platanus x hybrida*	Hot	30.0 (1.6)	32.5 (2.8)
		Normal	27.8 (2.4)	27.6 (1.0)
	Liquidambar styraciflua	Hot	32.2 (2.3)	33.2 (4.7)
		Normal	27.3 (1.6)	28.0 (2.1)
	Jacaranda mimosifolia	Hot	28.4 (1.6)	33.5 (3.2)
		Normal	26.1 (3.6)	26.8 (1.9)

Figure 8. Mean standard deviation of shaded and un-shaded regions for both native and non-native tree species on normal and hot days.

Robust climate variability characterizes all of the ecosystems and in many regions around the world this climate variability is sought to increase over the next century due to extreme droughts and storms. The condition under which climate variability will either end up having a stabilizing or destabilizing effect on species coexistence is known as the “storage effect” theory. The theory requires that three specific conditions must be met. In order to meet condition 1, species must have long lifespans to buffer their populations against unfavorable climate variability. In order to meet condition number 2, species must show differences in their responses to the climate variation. Each species response to the climate condition will cause each species to endure relativity more intraspecific competition during the favorable climate condition years and under go relatively more interspecific competition during the unfavorable climate condition years. The 3rd condition states that the effect of species competition on each species has to be more severe during the favorable years than the unfavorable years for that specific species.

Research was done in western Kansas testing the 3 conditions on the native prairie grasses in the area. Databases that contain maps showing individual plants dating clear back to 1930s giving them at least 30 years of data. Sideoats grama, hairy grama and little bluestem were the perennial grasses analyzed (bouteloua curtipendula, bouteloua hirsuta, and schizachyrium scoparium). Climate and species competition were adjusted to test the different conditions under severe scenarios.

The results showed that there is strong evidence for long lifespans, some positive growth rates in individual species, seasonal temperature and precipitation also play a major role in growth rates and positive and negative growth rates happened for all species under different variable conditions, (Adler, Hillerislambers, Kyriakidis, Guan, Levine, 2006). These results however show that climate variability has an important role in the development of coexistence (Adler, Hillerislambers, Kyriakidis, Guan, Levine, 2006). Climate variability highly increased the 3 species capabilities of recovering from low densities. For the hairy grama and little bluestem, results showed that switching from a negative to a positive growth due to climate variability is necessary for their long-lifespans. The three prairie grass species could be used in urban prairie patches or replace commercial lawns. The species demonstrate that they can recover from environmental variability and they show potential for low maintenance landscape systems.

Adler, Hillerislambers, Kyriakidis, Guan, Levine, 2006, pg. 12793.

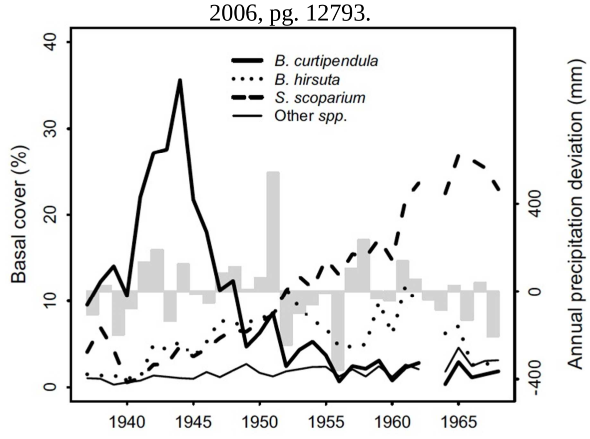


Figure 9. Means for perennial grasses. The vertical bars show deviation from the mean annual precipitation of 580mm and includes both of the wettest years in Hays, Kansas along with the driest. (1,122mm wettest, 1951, 226mm driest, 1,956).

Role of soil carbon sequestration

Soil organic carbon sinks are so important because they store approximately 75% of the carbon in their soils, (Edmondson, O'sullivan, Inger, Potter, Mchugh, Gaston, Leake, 2014). Organic carbon sequestration rates and emissions of N_20 in southern California were taken and studied. The location of the study took place in Irvine, California at four park sites located within a 7km radius. Each of the parks had an athletic type of field along with ornamental lawns. In order to conduct the research 8-12 soil core samples were taken from each park and soil bulk density was measured for every sample. The total organic carbon and nitrogen accumulation were calculated with an elemental analyzer and the stocks were calculated by using the elemental analyzer data and bulk density measurements. The N_2O fluxes in all of the turfs were calibrated using 3 randomly placed static chambers atop the turf for 28 minutes with air samples taken through the top of the chamber at intervals of 7 minutes. Samples were analyzed within 24 hours. Background fluxes of N_2O were sampled at each of the turfs once a month for about a year happening on separate days for each of the parks. Soil and air temperatures were also taken during the course of the research.

They found that park maintenance uses roughly 2700 gallons of gasoline each month in order to keep an area of 2 X 10^6 m^2 maintained (Townsend-Small, Czimczik, 2010). For a low fertilization application the global warming potential for ornamental lawns ranges from-108 g CO_2 m^{-2} yr^{-1} to +285 g CO_2 m^{-2} yr1 for high fertilization applications (Townsend-Small, Czimczik, 2010, pg. 1 on correction paper).
There is a positive global warming potential for athletic fields because they do not store organic carbon. This value ranges from +405 to +798g CO_2 m^{-2} yr -1 for a low fertilization, (Townsend-Small, Czimczik, 2010, pg. 1 on corrected paper). The ornamental lawn was found to have an organic carbon sequestration that ranges from -513+37 to -513 -73 g CO_2 m^{-2} yr^{-1}, (Townsend-Small, Czimczik, 2010). This research indicates that if we attack lawns with a more sustainable approach of management then they can become better at CO_2 sequestration. Nonetheless, up keep and intense maintenance of ornamental lawns continue to decrease the likelihood of this landscape to minimize air pollution in an urban area.

Plant productivity and microbial decomposition are the primary sources of controlling soil carbon storage in ecosystems, (Williams, Rice, Omay, Owensby. 2004). Carbon dioxide enrichment in the Tallgrass prairie resulted in greater root carbon inputs and is likely to have played a key role in the enhancement of potentially mineralized nitrogen pools, (Williams, Rice, Omay, Owensby. 2004). Greater water contents enhance rates of microbial activity and this tends to happen during the growing season in the Tallgrass prairie. Microbial activity is heavily tied to the decomposition rates in the soil and when the water contents are great the microbial activity responds positively, (Williams, Rice, Omay, Owensby. 2004).

Native grass mixtures such as C3 and C4 types along with big bluestem were the dominant plant types in the study area. Sedge and forbs also appeared in some of the study area. In early May circular open-top chambers were placed in the study field. The treatments included: CO_2- no chamber, ambient CO_2 – chamber, and two times ambient CO_2 – chamber. These treatments were then replicated three times using a randomized system. The carbon dioxide was supplied from April to October and a total of 20 random soil samples were collected in the months of August and October. A fumigation-incubation procedure was used on the soil samples to analyze microbial biomass C. Mathematical calculations were used and various soil laboratory experiments were conducted.

The conclusion was that the carbon dioxide enrichment lead to a greater root carbon input in the Tall grass Prairie and also may have helped with the enrichment of potentially mineralized carbon. This paper shows that urban prairie patches could potentially help mitigate rising carbon dioxide atmospheric concentrations. This research could easily transfer over to urban environments with the usage of native landscaping.

Trees, specifically native trees can influence the biological, physical, and chemical properties of soils through their deep roots and the quality and quantity of their leaf litter, (Edmondson, O'sullivan, Inger, Potter, Mchugh, Gaston, Leake, 2014). Even though we live in the Tallgrass Prairie there are still trees native to this area. From pervious knowledge I understand that trees in urban settings have the potential to provide great organic carbon storage. There is a significant difference in soil organic carbon concentration between different tree species and grasslands.

Edmondson, O'sullivan, Inger, Potter, Mchugh,
Gaston, Leake, 2014.

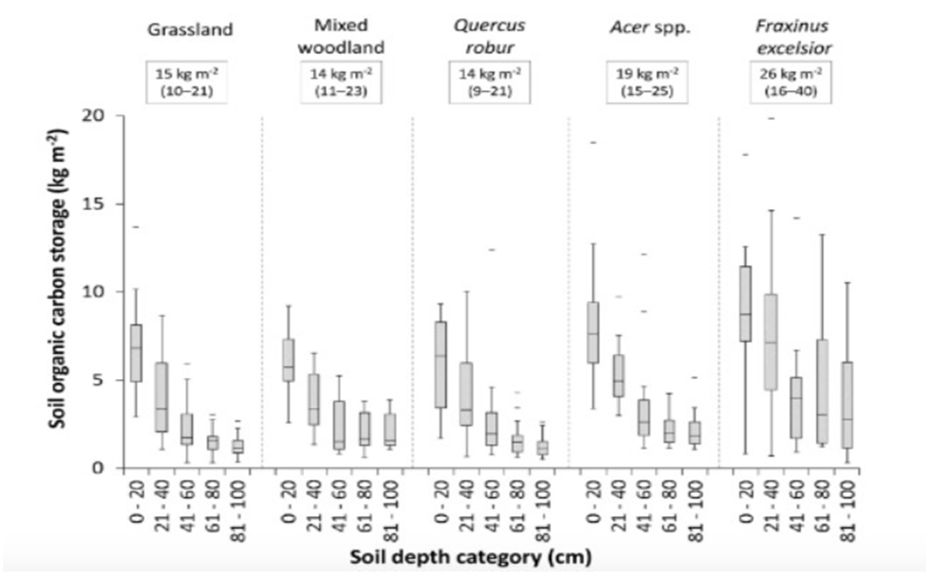


Figure 10. Soil organic carbon storage .The horizontal lines within the box indicate the median, box boundaries indicate the 25th and 75th percentiles, whiskers indicate the highest and lowest values, and the horizontal lines above and below whiskers indicate outliers.

At each of the parks, tree assessments were taken and the selected trees ranged in various diameters. At each of the sites within the parks, the tree species height and biomass were recorded. Soil samples from the grassland sections of the parks were taken 50m away from any individual tree to make sure that no trees influenced the samples. Mowing at each park site was found to be 25 times a year, but the parks were not irrigated or fertilized. Soil samples were also taken around the tree areas so that they could be directly compared with the grassland soil samples. There were 8 woodland sites and 15 grassland sites. The soil samples were then analyzed for SOC, C: N ratio and soil bulk density. The samples were dried, weighed, ball milled to sameness and then passed through a sieve. The bulk density was measured after the removal of the dry weight and soils were also analyzed in a dilution for total N concentration with a CN analyzer. The inorganic carbon was removed by adding HCI and dried; following CN analyses to determine the concentration of the soil organic carbon. All though the results are very modest, this publication demonstrates the importance of tree genus selection to maximize the long term below ground ecosystem service benefits when plating trees in an urban area with regards to soil organic carbon, (Edmondson, O'sullivan, Inger, Potter, Mchugh, Gaston, Leake, 2014).

Upkeep and maintenance of commercial turf-grass systems continue to decrease the likelihood of these landscape capabilities to minimize an urban heat island in the urban environment. More studies need to be done over soil carbon sequestration and its relation to the nitrogen cycle in commercial turf-grass systems and native prairie landscapes. Extensive research needs to also be conducted regarding prairie landscaping and its correlation with climate change. However, native prairie patches in urban environments hold a promising future to help mitigate a changing climate.

Native Grass vs. Non-native: The human element

Personal Preference and Physiological Responses

Personal preference directly impacts the development of native landscapes because humans enjoy being in the presence of those things, which they find pleasing and or personally gratifying; therefore, this innate human trait is relevant even in the discussion of native landscapes. The following empirical research documents the existence of this phenomenon by pointing directly to human natures subconscious ability to gravitate toward innate preferences. Similarly, in the following data, a connection is made between personal preference for protection, and prosperity and in turn certain biomes. Therefore, personal preference can also enlighten scientist as to how strongly humans tend to gravity toward native landscapes.

The purpose of the study, "*Responses to Six Major Terrestrial Biomes in Terms of Scenic Beauty, Preference, and Restorativeness,*" by Ke-Tsung Han, is to examine how individuals respond to the six different biomes: desert, tundra, grassland, coniferous forest, deciduous forest, and tropical forest. Han suggests, "Contemporary research on evolution, habitat selection, and landscape aesthetics raises the question of whether there is a specific natural setting most suitable for humans." During the duration of his article

Han relied heavily on the data currently available within this field of research. Specifically, Han has considered R. Kaplan & Kaplan, 1989; Balling & Falk, 1982; and Ulrich, 1993 as the leading social scientist within this field.

In the same respect, Han strategically designed his study to compensate for gaps or inconsistencies in the present empirical research. Han's primary purpose is to address the tendency for scientist in this field to administer surveys that are narrow or limited in scope. In other words, previous research in this field only includes one or two biomes, rather than all six. Similarly, previous studies generally focus on an individual's preference for a given biome. Han argues "preference" is only one of many psychological mechanisms, which are altered or evoked as a result of ones environmental surroundings. Not only does this study extend itself beyond one or two biomes, it also evaluates multiple emotional responses to these biomes. Han has accounted for the following emotional responses within his study. These include: preference to scenic beauty, recovery from mental fatigue, and physiological stress. This study was particularly relevant to the discussion of native grass versus non-native, because it identifies how individuals respond in a number of ways to a number of environments. Therefore, it provides a holistic look at the affect of biomes on humans, specifically one relative to another. (Biome is simply referring to any environment present on earth that posse's consistency within a given range i.e.) (Han, 2007).

Han employed the use of four commonly accepted theories as the basis for his specific procedural decisions and research question. First, he considered Orians & Heerwagen theory stating, "natural selection should have favored individuals who were motivated to explore and settle in environments likely to afford the necessities of life but to avoid environments with poorer resources or posing higher risks." He then went further by backing this theory with the support of de Menocal's theory, which states, "Natural selection is regarded as a major mechanism by which organisms change adaptively and persistently in response to their environment." Similarly, he considered the habitat selection theory, which claims, "Selecting proper settings in which to live is an essential and necessary activity for both animals and human beings because habitat selection is closely related to the successful survival, prosperous reproduction, and well-being of a species." (Orans & Heerwagen, 1992). Lastly, he accepted that emotional response is a parameter for behavioral decisions, and in turn a contributor to human survival (Orians & Heerwagen, 1992). (Han, 2007)

Within his research, Han identified two acceptable operational approaches to the study of environmental aesthetics. The first approach focuses on human response to biomes in which Homo sapiens have evolved; where as the other approach is not confined to any specific habitat. Each specific approach contains three varying hypothesis, all of which Han considered viable potential outcomes in his personal study. Within the "habitat specific approach" the three potential hypotheses included the savanna hypothesis, which "proposes the spread of savanna grasslands in Africa resulting in hominids," the forest hypothesis, which "argues that human evolution took place in closed forest settings," and finally the grassland-woodland hypothesis, which "states that a mosaic of both settings was the adaptive environment for hominids." (Han, 2007)

The three theories related to a nonhabitat-specific approach include the prospect refuge theory, which states “people prefer locations similar to the savanna grasslands in Africa where grasses provide easy lookouts for spotting prey and threats, and scattered tress offer hiding places from enemies and predators.” (Han, 2007)

This study evaluated 274 college students’ psycho-physiological responses to the six major terrestrial biomes (desert, tundra, grassland, coniferous forest, deciduous forest, and tropical forest), while taking into account the influences of three perceived physical variables (complexity, openness, and water features). They obtained their data by administering three different experiments. The first experiment employed the use of 92 participants, of which 47 were male and 45 were female with an average age of all participants being 19.30. (HAN) This experiment tested the respondent’s preference and perception of the landscape on a 9-point Likert scale, 9 being highly preferred and 1 being not at all preferred.
Experiment 2 tested the responses of 93 participants. Specifically this experiment evaluated their cognitive ability upon viewing certain landscapes. They employed the use of the Perceived Restrictiveness Scale (SRPRS) to test the respondent’s cognitive ability upon viewing certain landscapes. Within this study there were 45 males and 48 females with an aver age of 18.87. Experiment 3 tested 93 respondents consisting of 43 males and 46 females, with an average of 18.9.
Experiment three surveyed their recovery from stress due to viewing certain landscapes using, Hartig’s Short-Version Revised Perceived Restoratives Scale. (Han, 2007)

Table 1
Hartig's Short-Version Revised Perceived Restorativeness Scale

Imagine you were in the presented landscape. How would you agree with the following statements?

Being Away:

It is an escape experience.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

Spending time here gives me a good break from my day-to-day routine.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

Fascination:

The setting has fascinating qualities.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

My attention is drawn to many interesting things.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

I would like to get to know this place better.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

There is much to explore and discover here.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

I would like to spend more time looking at the surroundings.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

Compatibility:

I can do things I like here.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

I have a sense that I belong here.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

I have a sense of oneness with this setting.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

Being here suits my personality.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

I could find ways to enjoy myself in a place like this.

(not at all) 1____2____3____4____5____6____7____8____9 (a great deal)

Source: Hartig, Korpela, Evans, & Garling, 1997. Reprinted from "A measure of restorative quality in environments" by Hartig, T. A., Korpela, K., Evans, G. W., & Garling, T. from *Scandinavian Housing & Planning Research* 1997, Volume 14, pp. 175-194, by permission of Taylor & Francis.

(Han, 2007)

Table 2
Han's (2003) Short-Version Revised Restoration Scale

Imagine you were in the projected scene. How would you describe your emotional response?

Grouchy — Good natured
(very much) 1____2____3____4____5____6____7____8____9 (very much)

Anxious — Relaxed
(very much) 1____2____3____4____5____6____7____8____9 (very much)

Imagine you were in the projected scene. How would you describe your physiological response?

My breathing is becoming faster.
(not at all) 1____2____3____4____5____6____7____8____9 (very much so)

My hands are sweating.
(not at all) 1____2____3____4____5____6____7____8____9 (very much so)

Imagine you were in the projected scene. How would you describe your cognitive response?

I am interested in the presented scene.
(not at all) 1____2____3____4____5____6____7____8____9 (very much so)

I feel attentive to the presented scene.
(not at all) 1____2____3____4____5____6____7____8____9 (very much so)

Imagine you were in the projected scene. How would you describe your behavioral response?

I would like to visit here more often.
(not at all) 1____2____3____4____5____6____7____8____9 (very much so)

I would like to stay here longer.
(not at all) 1____2____3____4____5____6____7____8____9 (very much so)

(Han, 2007)

The results indicated that tundra and coniferous forest were the most favored biomes, whereas desert and grassland were the least favored. Their findings supported the forest hypothesis rather than the long-held savanna hypothesis, which simply imply human's preference for varied depth and complexity within landscapes. (Han, 2007)

Upon completion of multiple regression analyses, Han found that a non-habitat-specific approach accounted for 9% more variance of the respondents' reactions than the biome classification. This communicates that in general human responses to different environmental settings are more accurately evaluated when they are not confined to specific biomes. Instead, future studies should evaluate humans based on nonhabitat-specific criteria. (Han, 2007)

Table 3
Mean Scores of the Four Measures for the Six Biomes

	Scenic Beauty		Preference		Short-Version Revised Perceived Restorativeness Scale		Short-Version Revised Restoration Scale	
Biome	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Desert								
M	4.496	4.792	4.369	4.684	3.848	4.192	5.031	5.249
SD/SE[a]	0.473	0.310	0.361	0.304	0.421	0.224	0.298	0.166
Rank	6	6	6	6	6	5	6	6
Tundra								
M	6.351	6.440	6.252	6.350	5.563	5.739	6.470	6.526
SD/SE[a]	1.312	0.310	1.363	0.303	1.362	0.223	0.857	0.166
Rank	2	1	2	1	2	1	1	1
Grassland								
M	5.071	5.018	4.917	4.873	4.135	4.154	5.489	5.411
SD/SE[a]	0.490	0.332	0.484	0.325	0.369	0.239	0.344	0.178
Rank	5	5	5	5	5	6	5	5
Coniferous								
M	6.477	6.349	6.344	6.205	5.617	5.466	6.372	6.283
SD/SE[a]	1.525	0.307	1.533	0.301	1.195	0.221	0.879	0.165
Rank	1	2	1	2	1	2	2	2
Deciduous								
M	5.491	5.408	5.412	5.315	5.042	4.857	5.763	5.729
SD/SE[a]	0.993	0.318	0.988	0.312	0.950	0.230	0.796	0.171
Rank	4	4	4	4	4	4	4	4
Tropical								
M	6.056	5.936	5.871	5.738	5.214	5.011	6.046	5.973
SD/SE[a]	1.197	0.310	1.233	0.304	1.010	0.224	0.761	0.166
Rank	3	3	3	3	3	3	3	3

(Han, 2007)

"*Biodiversity in the Front Yard: An Investigation of Landscape Preference* in a Domestic Urban Context," by Tim Kurz and Catherine Baudains explores the preferences of community members regarding native landscapes in urban settings. Kurz and Baudains research is founded in their belief that the protection and restoration of sustainable ecosystems is planet earth's most pressing issue, to date. Similarly, Kurz and Baudains point out that while the importance of designing ecological sustainable landscapes is acknowledged among members of the scientific community, its reality hinges on the perception of human members of urban landscapes. (Kurz, Baudains, C. 2012).

Kurz also states that the protection of biodiversity in urban areas is a multidisciplinary problem including both an ecological and psychological study of landscape design. Within the body of his paper Kurz addresses the psychological element of sustainable ecosystem expansion by considering human perception, attitudes, and behavioral responses to native landscapes. (Kurz, Baudains, C. 2012).

Kurz and Baudains research worked to understand the factors influencing preference for high-versus low-habitat-providing garden landscapes among residents currently living in two separate areas of the southern suburbs of Perth, Western Australia. Specifically Kurz and Baudains evaluated the influence of garden landscapes as a function of demographic variables, local gardening norms, current gardening practices, and a set of gardening-relevant attitudinal variables.

Their sampling procedure consisted of questionnaires had delivered to the postboxes of all households within each of the two geographically defined sample areas. Sample areas included 1,000 residents from the city of Melville and 1,000 individuals from the city of Fremantle. Two hundred and fifty Melville residents responded to the survey, while 237 Fremantle residents responded. This response rate allowed for an overall sample size of 487 respondents out of the original 2,000 potential respondents a percentage of approximately 25%. Kurz and Baudians reported a small gender bias, with female respondents accounting for 63% of the sample.

The first portion of the questionnaire consisted of 24 photographs of varying
Gardens upon viewing the pictures respondents were asked to rate the photographs on a scale of 1-10. One indicating a strong dislike for the given garden landscape, and 10 indicating the respondent like the respective garden very much. They were also asked on a scale of 1-10 how much they would enjoy having the garden in their front law.

The next portion of the survey consisted of a series of questions evaluated using a 5-point Liker type scale ranging between 5 = strongly agree and 1 = strongly disagree.

These questions were designed so as to gain a clear understanding of participants' attitudes toward urban biodiversity and their general attitudinal position regarding the overall merits of native plants in the domestic urban landscape.
Kurz and Baudians data communicated little bias toward traditional, orderly, low-habitat-providing urban landscapes images. Instead preference actually fell slightly toward the high-habitat-providing side of the scale midpoint. (Kurz Baudains, C. 2012).

Kurz and Baudains conclude that neither environmental ethic nor an appreciation for urban biodiversity contributed to respondents' preference for high-habitat landscapes. Rather, residents' specific stance regarding "planting native" had the biggest impact. Kurz and Baudians also found that garden landscape preferences were highly related to an individual's current gardening practices. Those respondents who were currently engaged in "native" gardening had a high visual preference for high-habitat gardens. Similarly, residents who reported planting a mixture of native and exotic plants in their garden (and who constituted 60% of the respondents) showed a high mean preference for high-habitat gardens. Kurz and Baudians note that these findings are very encouraging for those who are actively engaged in the promotion of "gardening for habitat" in urban areas, because it indicates that a fairly broader sect of society (more than simply native gardeners) are supportive of high-habitat garden landscapes. (Kurz, Baudains, C. 2012).

Upon completion of their study, Kurz and and Baudains were able to infer that if attitudes determine reactions to landscapes, the "key focus of efforts by policy makers, practitioners, and researchers should be developing ways of changing attitudes toward the merits of native plants."

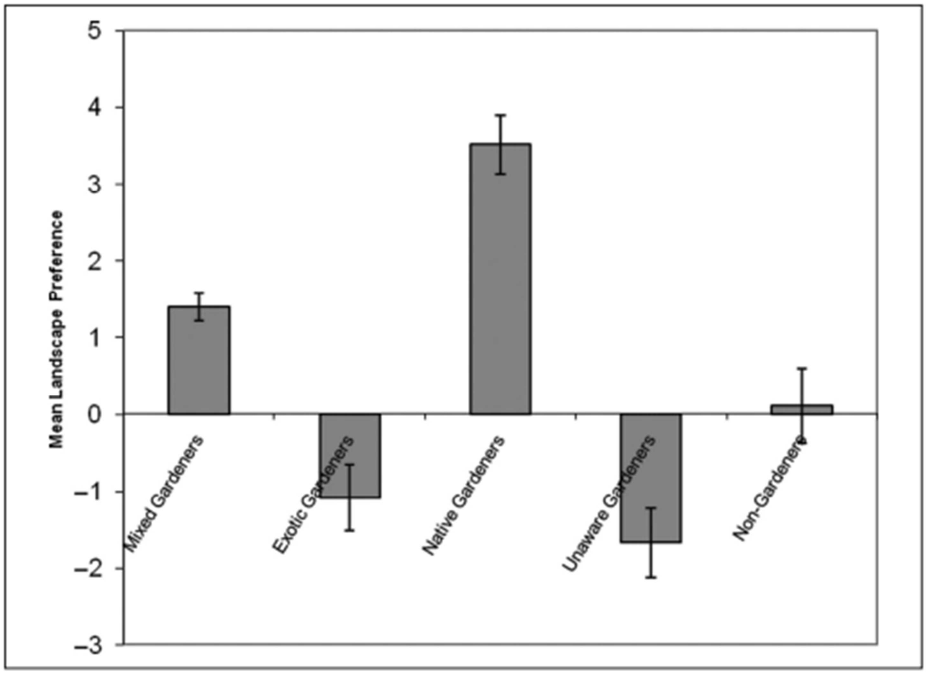


Figure 3. Mean level of landscape preference, as a function of respondents' current gardening practices (positive scores denote net preference for high-habitat images, negative scores denote net preference for low-habitat images)

(Kurz Baudains, C. 2012).

While this study evaluate a slightly different landscape variable, high native gardens versus low native gardens, it parallels this research endeavors purpose, which is to identify why some individuals prefer native grass over prairie grass and vice versa. Both evaluate human perception of native landscapes and to what degree they are appreciated and or rejected. Therefore, the findings of this study support the continued furtherance of native prairie grass in the urban environment, and even suggest that support will be considerable. In contrast, it also indicates that while support is projected to be high for native landscape development, it is certainly not comprehensive. Kurz and Baudains findings indicate that this subject is highly polarized; therefore, one can expect to experience high degrees of support and resistance from local communities. (Kurz Baudains, C. 2012).

“Environmental Preference and restoration: (How) are they related?” By Agnes E. van den Berg and colleagues investigates why people tend to prefer natural over built environments. Van den Burg has identified Ulrich, 1983; Knopf, 1987; Kaplan & Kaplan, 1989; Hartig, 1993 to be the leading scientists in this field of study, and has used their empirical research as the basis for his team’s research. The entirety of their findings has been condensed into the following statement, regarding the relationship between preference and landscape. The team states, “Levels of self-reported preference for natural landscapes are so much higher than preference levels for urban landscapes that the

distribution of ratings for the two domains hardly overlap." Therefore, with such solid evidence for human preference toward natural environments, van den Burg and colleagues have decidedly taken responsibility for proceeded forward in the next logical phase of research. Specifically, Van den Burg and colleagues seek to answer the following question "why do people have such a ubiquitous fondness for nature? Van den Burg and colleagues hypothesized that human preference for natural over built environments is founded on ones understanding or perception of the given environments ability to provide them with a certain degree of restorative services. (Restorative service refers to mental and/or emotional restoration from stress an/or fatigue as well as increased cognitive ability). (Berg, Koole, Wulp, 2003)

The objective of van den Burgs research is to quantify the theorized relationship between preference and restoration. The team predicated that respondents would prefer natural over built environments, exposure to natural environments would result in higher degrees of restoration, and that preference would hinge on the degree of perceived restoration by the respondent.

They tested their predictions by recruiting 114 participants from Wageniengen University, The Netherlands. Of these students 67% were female and 33% were male, with a mean age of 21.9%. The team gauged participants emotional well being by using a questionnaire specifically designed to evaluate an individual's mood called the "profile of mood states scales," (POMS). Responses were recorded on a ten-point scale, 10 represented a very strong identification with the question, and 1 indicating very weak identification. The participants evaluated their moods a total of three times. They evaluated their emotions once prior to the study, once after watching a scary clip, ("Faces of death") which was included in order to create a standard base line of emotions, and again after viewing the clip of their respective environment (of which they were randomly assigned). The respondents were randomly assigned to one of the four unique natural video clips, each of which were designed so as to simulate walking through the landscape. In an effort to test the restorative nature of water, one of the two natural video clips contained a view of water. In the same way, one of the two built video clips also possessed a view of water. (Berg, Koole, Wulp, 2003)

After viewing their respective environment the respondents were surveyed on a scale of 1(not at all beautiful) to 9 (very beautiful). Following this test the respondents were then asked to take another POMS survey in order to reevaluate their emotional state. Finally, following the POMS survey respondents were asked to take a mental concentration test.

The results of this study indicate that participants who viewed natural environments

Table 1
Mood states as a function of environment type and time of measurement

		Urban			Natural		
		*t*1	*t*2	*t*3	*t*1	*t*2	*t*3
Depression (1–10)	*M*	2.7	4.0	3.4	2.3	3.7	2.3
	S.D.	1.5	2.0	1.8	1.3	1.5	1.3
Anger (1–10)	*M*	2.5	3.9	3.2	2.2	3.7	2.0
	S.D.	1.3	1.9	1.8	1.3	2.0	1.0
Tension (1–10)	*M*	3.0	3.6	3.2	2.9	3.7	2.5
	S.D.	1.5	1.9	1.7	1.5	1.9	1.4
Overall happiness (1–100)	*M*	74.5	66.3	66.5	77.1	71.4	76.5
	S.D.	13.3	17.0	16.6	14.5	16.3	14.9
Overall stress (1–100)	*M*	34.5	40.0	36.4	27.5	37.2	25.3
	S.D.	22.3	23.8	22.8	23.1	24.2	21.5

Note: *t*1 = baseline measure; *t*2 = pretest measure (after viewing stressful movie, before viewing environmental movie); *t*3 = post-test measure.

. (Berg, Koole, Wulp, 2003)

experienced greater restoration on all five measures including: depression, anger, tension, overall happiness, and overall stress. Interestingly, those who only viewed the built environment experienced zero restoration in regard to overall happiness and stress. Similarly, participants who viewed natural environments scored higher on the cognition test than those participants who viewed the built environment. Finally, respondents rated the natural environment more beautiful than the built environment. Therefore, van den Burgs experiment confirms that there is indeed a clear correlation between preference and restoration. Specifically, the parallel between beauty ratings and the overall improved emotional well being of respondents reinforces this correlation between the restorative affects of the natural environment and preference. (Berg, Koole, Wulp, 2003)

The relationship identified here between the restorative effects of natural environments and humans' preference for natural environments, further affirms the effectiveness and appropriateness of prairie grass in urban environments. Not only do humans by nature prefer to be in the presence of natural landscapes, they also experience cognitive, and emotional improvement simply by being in the presence of nature. Therefore, although previous studies have identified a clear polarization in regard to the alternation of built environments to native landscapes, it is irrefutable that the larger majority will experience an enhanced quality of life emotional and mentally as a result of such changes. (Berg, Koole, Wulp, 2003)

Van den Burg and colleagues conclude their article by making a clear connection between the quantitative findings of their study and the physical world. First, the team notes that by ignoring public preferences for natural over built environments serious public health consequences may be incurred. He also points to the reality that not only will unabated urban sprawl damage natural biodiversity and ecology, it will also remove the landscapes natural potential to preform its restorative capabilities on human species. Therefore, it is critical that land management and spatial planning is altered/impacted to some degree, as a result of this data.

Municipal Support from Local Leaders

Van den Burg is certainly not the only one aware of the role urban politics should play in the expansion of native landscapes. On the contrary, green policy is of rising concern among municipal leaders. As the call for carbon control grows local municipalities are feeling the pressure to stand out as leader in this regard. "The New Urban Politics as a Politics of Carbon Control," by Andrew E. G. Jonas explains that as urban municipalities are presented with new forms of development under the umbrella of "climate-change neutral zero emissions and outright carbon reduction" they will need to reconsider former policies and procedures. In an effort to help facilitate this transition from Fordism to low-carbon alternatives, various collations have been created. For instance, the US Conference of Mayors Climate Protection Agreement, which encourages cities to meet or beat the emissions reduction target suggested by the US in the Kyoto Protocol. (Berg, Koole, Wulp, 2003)

Similarly, "Performing Leadership: municipal green building policies and the city as a role model," by Julie Cidell addresses the need for municipalities to team up in their effort to develop as leaders of green infrastructure and stewardship. Within her article she works to understand the extent to which "relationships with other cities, and the performance of cities play into the development of green building policies." Cidell does her research via two avenues including the evaluation of the current policy texts, and the use of online surveys.

As a supplement to Cidells research she administered two online surveys. Both were developed using a Likert scale of 1-5, high to low. The first survey asked respondents how important various resources were in promoting green building policy as well as the actual development of a given policy. Evaluation of the responses clearly identify other cities that already had a green policy in place were the most useful resources for those municipalities in the development stages. Cidell explains that this finding indicates that early adopters of green policies are seen as leaders and resources for later adopters to draw from and or copy. Specifically, Austin, Portland, and Chicago have all developed reputations for successfully designing and implementing green infrastructure policy in their respective cities. (Cidell, 2015)

Table 1. Survey results for resources used in promoting and developing municipal green building policies.

Source	Importance in promoting the idea	Importance in developing the policy
Other municipalities	3.81	4.09
USGBC website	3.48	3.41
Private sector	3.22	3.19
Nonprofit sector	3.22	3.08
USGBC workshops/training	2.54	2.30
Other	1.60	1.73

Note: USGBC = US Green Building Council.

(Cidell, 2015)

Her second survey considers the motivational factors involved in developing the city's green policy. This survey is founded in the convention theory, which explains how individuals of varying background come to an agreement despite possessing different motivation for entering into the transition itself. Among the motivations listed the most influential were, "benefiting the environment" and "being known for environmental friendliness." (Cidell, 2015)

Table 2. Survey results for the importance of different reasons for developing a green building policy.

Justification	Importance in developing the policy
Benefiting the environment	4.42
Benefitting the community in general	4.24
Becoming well known as a role model for other cities in how to be green	3.91
Saving money for taxpayers or building inhabitants	3.82
Being able to use established, third-party standards	3.41
Encouraging people to 'think outside the box' and build creatively	3.21
Establishing or strengthening personal contacts with builders and developers	2.56
Other, please specify	1.81

(Cidell, 2015)

Cidell concludes from these surveys that local leaders have a huge opportunity and responsibility to influence their constituency positively in regard to environmental stewardship. She points out that " by using ones own facilities as a demonstration project, a municipality is performing another aspect of the appropriate role of local government: taking on the risks of new technologies and demonstrating their feasibility, encouraging the private sector to then adopt those technologies rather than requiring it through regulation." (Cidell, 2015)

Cidells findings bring to light another human element involved the advancement of prairie grass into the urban environment. The support of local municipality leaders is vital for the successful transition to native landscapes. However, Cidell points out that local leaders are feeling the affects of pure pressure from their peers, the media, and their constituency alike, to begin the process of transitioning to more environmentally friendly policy standards.

Similarly, the expansion of prairie grass also hinges heavily on municipal leadership because they are key players in gaining the trust, support, and acceptance of community member, of which account for the majority of voters and voices involved in the advancement of native landscapes. As local leaders approve and model acceptance of new innovative landscapes their communities will be more inclined to follow suite, and offer their vote in favor of more sustainable practices.

Furthermore, Cidell points out that local leaders often have a multiplying affect as a result of their clout and visibility. In other words, when one locality tangibly endorses the presence of native landscapes in their urban environments their neighbors take note and begin to feel the pressure to "keep up with the Jones." It is interesting to note that the advancement of green infrastructure and landscape begins at the local level. While state and local government can certainly play apart in its advancement, true change hinges on the decision and actions of local leaders. (Cidell, 2015).

Promoting Education

However, even local officials are products of the people they serve. In other words, if their constituency is not supportive of his or her agenda it will not go forward. *"Lawn-Watering Perceptions and Behaviors of Residential Homeowners in Three Kansas (USA) Cities:Implications for Water Quantity and Quality,"* by Bremer, D. J., Keeley, S. J., Jager, A., & Fry, J. D. conducted a survey of Kansas residents in three major cities including Olatha, Wichita, and Salina. The purpose of their research was to "understand the perception, knowledge, and behavior of residential lawn owners regarding irrigation of their lawns during the summer months." They conducted their survey via mail, and used a five-point Likert-scale containing multiple-choice questions ranging from 1-5, low to high. Thirty Thousand surveys were mailed of which the return rate was 11.4% for Wichita, 13.1% for Olatha, and 11.1% for Salina for average to a total return rate of 11.6% across all three cities.

Bremer's findings indicated that approximately 75% of most homeowners across three cities did not know how much water they were administering to their lawns. What is more, the residents of all three cities admitted to being unsure how much water their lawns required. Bremer points out that this data is an indication that a major problem is a lack of knowledge or understanding regard the parameters for proper upkeep of turgrass. This is a clear indication that if citizens are unaware of how to maintaining their turfgrass, they are certainly not aware of the harmful ecology affects it is having on their environment let alone their psyche.

Interestingly, 64-77% of respondents in all three cities marked water conservation as moderately (4-5) important. In contrast, 75-85% said they found keeping their lawn green all the time was somewhat (3) important. This indicates that while a larger percentage of lawn owners valued having a green lawn all year around, they did not prioritize it more than water conservation. This casts useful insight into the objectives and steps to be taken in regarding to gaining community support for prairie grass in urban environments. First and foremost, there is clearly a lack of empirical research done on the benefits of education in gaining community support for native landscape development.

In light of this deficiency the following survey was formulated and administered with the purpose of filling a gap in the current empirical research available on this subject. The purpose of this data is to assist administrators and scientist in their efforts to advance sustainable urban environments through the use of native landscape design. Specifically this data is meant to provide insight regarding the impact of an education. In other words, this data seeks to answer the question, how does providing an education to community members on the affects of sustainable infrastructure change or alter their support of such things? This survey was designed based off of the journal, "*Responses to Six Major Terrestrial Biomes in Terms of Scenic Beauty, Preference, and Restorativeness,"* by Ke-Tsung Han. This article surveyed a number of college students using photos in the form of a slide show in order to test their preference toward six different biomes. They administered the survey using a Likert scale. Upon recognizing the attainability of this survey method, we decide to replicate each of these steps as closely as possible, simply on a smaller scale.

Student Body Reaction

One hundred Kansas State University students from four different educational departments were surveyed to gather information on their opinions of native and non-native landscaping. In an effort to obtain a representative data set we selected 25 students from the largest departments. These included: College of Engineering, College of Education, College of Agriculture, as well as a number from various social science disciplines. In comparing Kansas State University Undergraduate Students, those who had been educated on the benefits of prairie grass tend to have higher overall acceptance and approval ratings toward this type of native landscape. This hypothesis was tested using aLikert Scale (1 to 5, high to low) consisting of three questions:

1. Is this landscape aesthetically pleasing?
2. Would you enjoy being surrounded by this landscape?
3. Is this landscape environmentally friendly?

The students were instructed to rank prairie grass and turfgrass 1-5 based on the above questions, twice. Once, before knowing anything about ecosystem services provided by native species. Therefore, they provided answers based solely on images of both turfgrass and prairie grasses. The second time, the repsondents were exposed to a few facts about the benefits native systems provide to humans, then they were asked to take the survey again. The results are shown in the tables and graphs below.

Interpretation of prairie grass as aesthetically pleasing by exposure to educational facts Kansas State University Undergraduates, Fall 2015

		Non-educated Respondents	Educated Respondents
PRAIRE GRASS ASETHTICALLY PLEASING	Oppose (1)	6%	5%
	Oppose Somewhat (2)	12%	7%
	Indifferent (3)	26%	22%
	Approve Somewhat (4)	33%	33%
	Approve (5)	23%	33%
Total (N)		100.0% (100)	100.0% (100)

Support for being surrounded by prairie grass
by exposure to educational facts
Kansas State University Undergraduates, Fall 2015

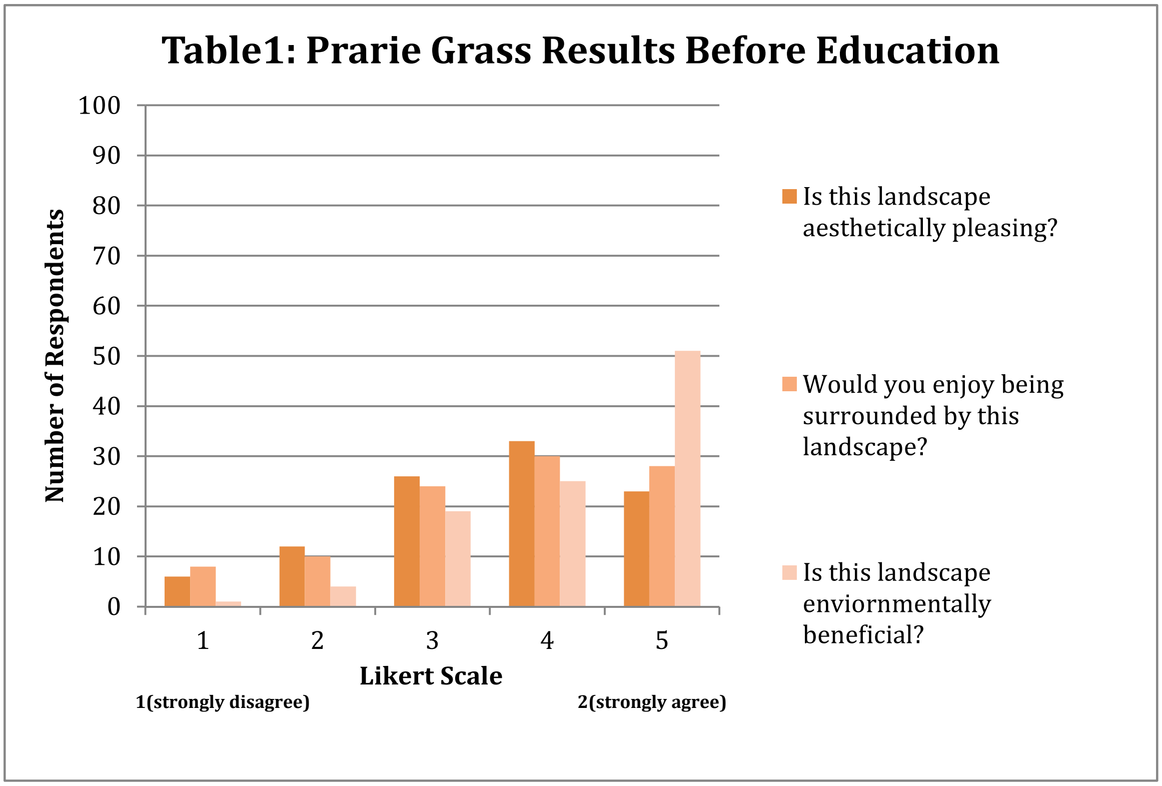
		Non-educated Respondents	Educated Respondents
WOULD ENJOY BEING SURROUNDED BY PRAIRIE GRASS	Oppose (1)	8%	20%
	Oppose Somewhat (2)	24%	20%
	Indifferent (3)	28%	60%
	Approve Somewhat (4)	30%	33%
	Approve (5)	28%	39%
Total (N)		100.0% (100)	100.0% (100)

Prairie Grass as Environmentally Friendly
by exposure to educational facts
Kansas State University Undergraduate Students, Fall 2015

		Non-educated Respondents	Educated Respondents
PRAIRIE GRASS AS ENVIRONMENTALLY FRIENDLY	Oppose (1)	1%	1%
	Oppose Somewhat (2)	4%	1%
	Indifferent (3)	19%	3%
	Approve Somewhat (4)	25%	19%
	Approve (5)	51%	76%
Total (N)		100.0% (100)	100.0% (100)

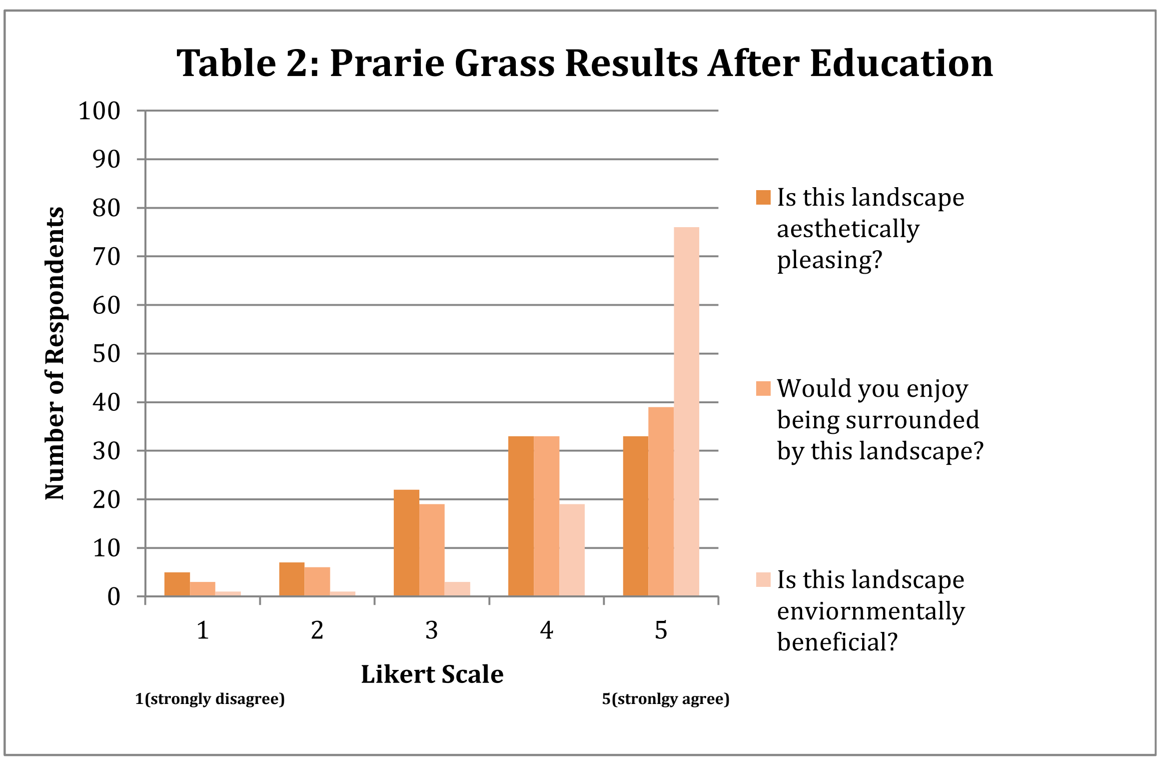
+Bar graphs

The results prove our hypothesis to be true. With more education, people are more accepting and feel a greater connection to native landscaping. In order to increase the implementation and of urban prairie patches, people must receive proper education.



(This table indicates that most people have an above average appreciation for prairie grass prior to receiving any education.) table 1

(This chart indicates an overall increases across all three questions upon receiving an education) table 2



Conclusion

Ecosystem services provided by urban prairie patches can promote biological biodiversity and maximize the well being of a society. When considering that "half of the world's population lives in cities and this number predicted to reach 60% in 2030" (Gette-Bouvarot, 9936), it is important to develop a more sustainable solution going forward into the future. As presented, it is clear that there are many benefits by going native when designing urban landscaping in terms of microclimate, soil carbon sequestration, biodiversity, stormwater storage and economics. Changing from commercial landscaping to native landscaping will become more necessary as biodiversity, climate change, water, and economic strain increase throughout the country and world. The facilitation of land-use changes to incorporate prairie patches will not only lead to future ecosystem services yielded, but will promote greater cultural awareness of their beneficial nature and role in society.

References

Adler, P. B., J. Hillerislambers, P. C. Kyriakidis, Q. Guan, and J. M. Levine. "Climate Variability Has a Stabilizing Effect on the Coexistence of Prairie Grasses." *Proceedings of the National Academy of Sciences* (2006): 12793-2798.

Aguiar, Axton C., Kris French, and Laurie A. Chisholm. "A Comparison of the Ameliorating Effects of Native and Exotic Street Trees on Surface Heat Retention at Dusk." *Urban Climate* (2014): 56-62.

Bach, Elizabeth M., and Kirsten S. Hofmockel. 2015. Coupled carbon and nitrogen inputs increase microbial biomass and activity in prairie bioenergy systems. *Ecosystems* 18 (3) (APR): 417-27.

Bremer, D. J., Keeley, S. J., Jager, A., & Fry, J. D. (2013). Lawn-Watering Perceptions and Behaviors of Residential Homeowners in Three Kansas (USA) Cities: Implications for Water Quantity and Quality. *International Turfgrass Society Research Journal*, *12*, 23-28.

Ceballos, G. 2010. Rapid decline of a grassland system and its ecological and conservation implications. *PloS One* 5 (1)

Chen, Xiaolu, Edward Peltier, Belinda S. M. Sturm, and C. Bryan Young. 2013. Nitrogen removal and nitrifying and denitrifying bacteria quantification in a stormwater bioretention system. *Water Research* 47 (4) (MAR 15): 1691-700.

Cidell, J. (2015). Performing leadership: municipal green building policies and the city as role model. *Sage Journals*, *33*(3), 556-579.

Crewe, K. (2013). Arizona native plants and the urban challenge. *Landscape Journal: Design, Planning, and Management of the Land*, *32*(2), 215-229.

Dickson, Timothy L., and Brian J. Wilsey. 2009. Biodiversity and tallgrass prairie decomposition: The relative importance of species identity, evenness, richness, and micro-topography. *Plant Ecology* 201 (2) (APR): 639-49.

Edmondson, Jill L., Odhran S. O'sullivan, Richard Inger, Jonathan Potter, Nicola Mchugh, Kevin J. Gaston, and Jonathan R. Leake. "Urban Tree Effects on Soil Organic Carbon." *PLOS ONE* 9.7 (2014).

Geroff, Ray K., Jason Gibbs, and Kenneth W. McCravy. 2014. Assessing bee (hymenoptera: Apoidea) diversity of an illinois restored tallgrass prairie: Methodology and conservation considerations. *Journal of Insect Conservation* 18 (5) (OCT): 951-64.

Gette-Bouvarot, Morgane, Laurence Volatier, Laurent Lassabatere, Damien Lemoine, Laurent Simon, Cecile Delolme, and Florian Mermillod-Blondin. 2015. Ecological engineering approaches to improve hydraulic properties of infiltration basins designed for groundwater recharge. *Environmental Science & Technology* 49 (16) (AUG 18): 9936-44.

Gu, Chuanhui, John Crane, George Hornberger, and Amanda Carrico. "The Effects of Household Management Practices on the Global Warming Potential of Urban Lawns." *Journal of Environmental Management* (2015): 233-42.

Huang, Y., L. M. Martin, F. I. Isbell, and B. J. Wilsey. 2013. Is community persistence related to diversity? A test with prairie species in a long-term experiment. *Basic and Applied Ecology* 14 (3) (MAY): 199-207.

Han, K.-T. (2007). Responses to Six Major Terrestrial Biomes in Terms of Scenic Beauty, Preference, and Restorativeness. *Environment and Behavior*, *39*(4), 529-556.

Jonas, A. E.G., Gibbs, D., & While, A. (n.d.). The New Urban Politics as a Politics of Carbon Control. *Urban Studies*, *48*, 2537-2554.

Klein, Petra M., and Reid Coffman. "Establishment and Performance of an Experimental Green Roof under Extreme Climatic Conditions." *Science of the Total Environment* (2015): 82-93.

Kurz, T., & Baudains, C. (2012). Biodiversity in the front yard. *Environment and Behavior*, *44*(2), 166-196. doi:10.1177/0013916510385542

Laliberté, Etienne, and Jason M. Tylianakis. 2012. Cascading effects of long-term land-use changes on plant traits and ecosystem functioning. *Ecology* 93 (1) (January): 145-55.

Li, Xuechao, Feng Hu, Daniel Bowman, and Wei Shi. "Nitrous Oxide Production in Turfgrass Systems: Effects of Soil Properties and Grass Clipping Recycling." *Applied Soil Ecology* (2013): 61-69. Print.

Mariotte, Pierre. Grassland Biodiversity and Conservation in a Changing World. New York: Nova Science Publishers, 2014.

McKinney, M. (2002). Urbanization, Biodiversity, and Conservation.BioScience, 52(10), 883-890.

National Wildlife Federation. 2015. Ecosystem Services. *NWF.org.*

Ostlie, F. 2004. Great plains ecosystems: Past, present, and future. *Wildlife Society Bulletin* 32 (1): 6-15.

Pooya, Elham Saeedi, Ali Tehranifar, Mahmoud Shoor, Yahya Selahvarzi, and Hossein Ansari. "The Use of Native Turf Mixtures to Approach Sustainable Lawn in Urban Landscapes." *Urban Forestry and Urban Greening* (2013): 532-36.

Risser, Paul G. The True Prairie Ecosystem. Stroudsburg, Pa.: Hutchinson Ross Pub,1981.

Rowe, Helen I., Joseph Fargione, and Jeffery D. Holland. 2013. Prairie restorations can protect remnant tallgrass prairie plant communities. *American Midland Naturalist* 170 (1) (07): 26-38.

Runas, Johan. Grassland Biodiversity Habitat Types, Ecological Processes and Environmental Impacts. New York: Nova Science Publishers, 2010.

Samson, Fred B. Prairie Conservation: Preserving North America's Most Endangered Ecosystem. Washington, D.C.: Island Press, 1996.

Samson, F. 1994. Prairie Conservation in North America. *Bioscience* 44 (6): 418-21.

Schroder, Hans G. Grasslands: Ecology, Management and Restoration. New York: Nova Science Publishers, 2008.

Shapiro, Chan, Carson, Tayag, K., Andrew, Elliot, Romina. (n.d.). Outdoor Water Use Conservation through Native Plants.

Shi, W., HY Yao, and D. Bowman. 2006. Soil microbial biomass, activity and nitrogen transformations in a turfgrass chronosequence. *Soil Biology & Biochemistry* 38 (2) (FEB): 311-9.

Sieg, C. H., Flather, C. H., & McCanny, S. (1999). Recent Biodiversity Patterns in the Great Plains: Implications for restoration and management. *Great Plains Research*, *9*(2), 277-313.

Smith, Lionel S., and Mark D.e. Fellowes. "The Grass-free Lawn: Floral Performance and Management Implications." *URBAN FORESTRY & URBAN GREENING* (2015): 490-99.

Sublette, Kerry L., J. Bryan Tapp, J. Berton Fisher, Eleanor Jennings, Kathleen Duncan, Greg Thoma, Josh Brokaw, and Tim Todd. 2007. Lessons learned in remediation and restoration in the oklahoma prairie: A review. *Applied Geochemistry* 22 (10) (OCT 2007): 2225-39.

Townsend-Small, Amy, and Claudia I. Czimczik. "Carbon Sequestration and Greenhouse Gas Emissions in Urban Turf." *Geophys. Res. Lett. Geophysical Research Letters* 37 (2010).

Wall, Diana H. Sustaining Biodiversity and Ecosystem Services in Soils and Sediments. Washington: Island Press, 2004.

Wall, LG, JL Tank, TV Royer, and MJ Bernot. 2005. Spatial and temporal variability in sediment denitrification within an agriculturally influenced reservoir. *Biogeochemistry* 76 (1) (OCT): 85-111.

Van den Berg, A. E., Koole, S. L., & van der Wulp, N. Y. (2003). Environmental preference and restoration: (how) are they related? *Journal of Environmental Psychology*, *23*(2), 135-146.

Yao, Huaiying, Daniel Bowman, and Wei Shi. 2011. Seasonal variations of soil microbial biomass and activity in warm- and cool-season turfgrass systems. *Soil Biology & Biochemistry* 43 (7) (JUL): 1536-43.

Williams, M. A., C. W. Rice, A. Omay, and C. Owensby. "Carbon and Nitrogen Pools in a Tallgrass Prairie Soil under Elevated Carbon Dioxide." *Soil Science Society of America Journal* (2004): 148.

Yannarell, Anthony C. 2014. *Influence of shrub encroachment on the soil microbial community composition of remnant hill prairies electronic resource*. Vol. 67. New York.